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The Increasing Method of the Electric Output of the Field Driven Generator

Katsuo Sakai

ABSTRACT

Today, the sun is a very useful energy source because it continuously radiates energy. An electron is radiating energy continuously too. A new electrostatic generating method using this electron's electric field energy as a driving force of charge carriers was invented, and its success was presented on ESA 2017 and ESA 2019 by a bench model. This new electrostatic generator was realized by asymmetric electrostatic force, which is a new phenomenon. The electric output of the bench model was only a few ten micro-watt. However, it is expected to be kiro-watt when parts size are reduced to 1/100. This expect was confirmed with a simulation.

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I. INTRODUCTION

1.1 Two very useful energy sources: Sun and Electron

Today the most useful energy source to solve the environment problem is the Sun, because it is radiating a huge energy around it continuously as shown in figure 1. Like as the sun, an electron too is radiating an energy around it continuously. Of course, the radiated energy from an electron is very little. However, the number of an electron in our world is huge. An electret keeps electron on its surface very long time (100 years). Therefore, if a new electrostatic generator is driven by an electret only, this one will solve the environment problem perfectly. Because it does not produce CO_2, it is safety, it produces electric energy all time every where, it has long life time and its cost is low.

Fig. 1: There are two big renewable energy: the sun (used) and an electron (not used)

1.2 Asymmetric electrostatic force

For a long time, the electrostatic force has been calculated by the well-known Coulomb's Formula (1).

It is apparent from this formula that the magnitude of this electrostatic force does not change when the direction of the electric field turns over as shown in Figure 2.

$$f = qE \qquad (1)$$

where f: Electrostatic force that acts on a point charge.

q: Quantity of a point charge.

E: Intensity of the electric field in which a point charge is placed.
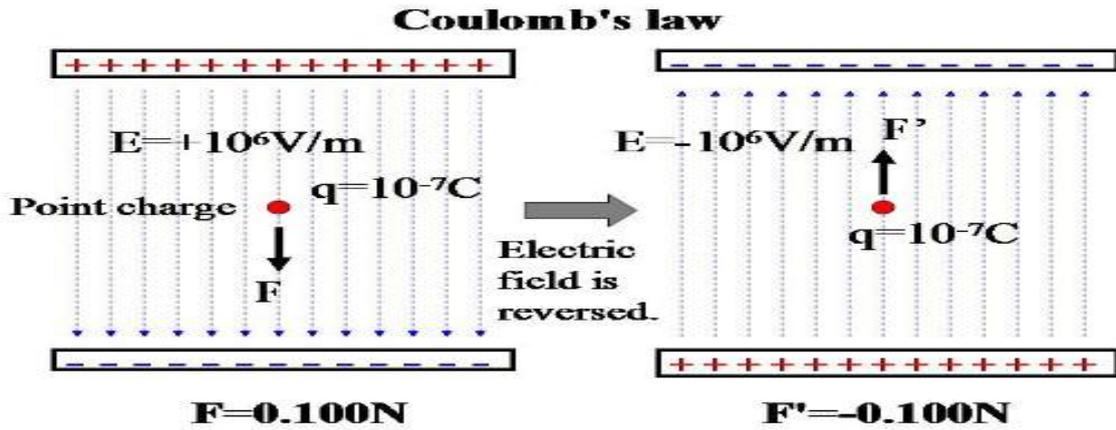
Fig. 2: the well-known Coulomb's Form

The application of this formula is limited to point charges and sphere-shaped charge carriers [1].

A new electrostatic generator driven by only an electric field using Coulomb's law was tried for several years. Many different ideas were tested by a simulation and simple experiment. However, a solution was not found, but a very useful phenomenon was found in those simulations by chance.

A new electrostatic generator driven by this new phenomenon was invented.

The electrostatic force that acts on an asymmetric charged conductor changes largely when the direction of the electric field reverses, as shown in Figure 3.
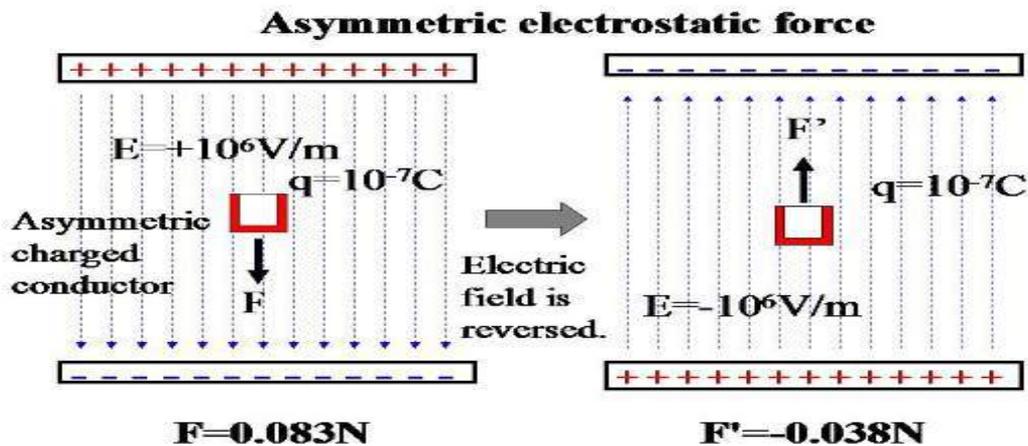
Fig. 3: Electrostatic force that acts on charged box conductor (Asymmetric electrostatic force)

This new phenomenon was named asymmetric electrostatic force [2],[3],[4],[5],[6],[7],[8]. The left side electric field of Figure 3 was named a forward electric field, and the right side electric field was named a backward electric field.

1.3 Basic theory of the new electrostatic generator

The basic theory of an electrostatic generator is defined by lifting the charge to a high potential by mechanical force against the electric force that acts on this charge.

It is impossible for the mechanical force to carry the charge directly. Therefore, the charge is packed into a suitable body. We call this body the charge carrier.

A basic unit of the new electrostatic generator that is driven by asymmetric electrostatic force is concretely shown in Figure 4.
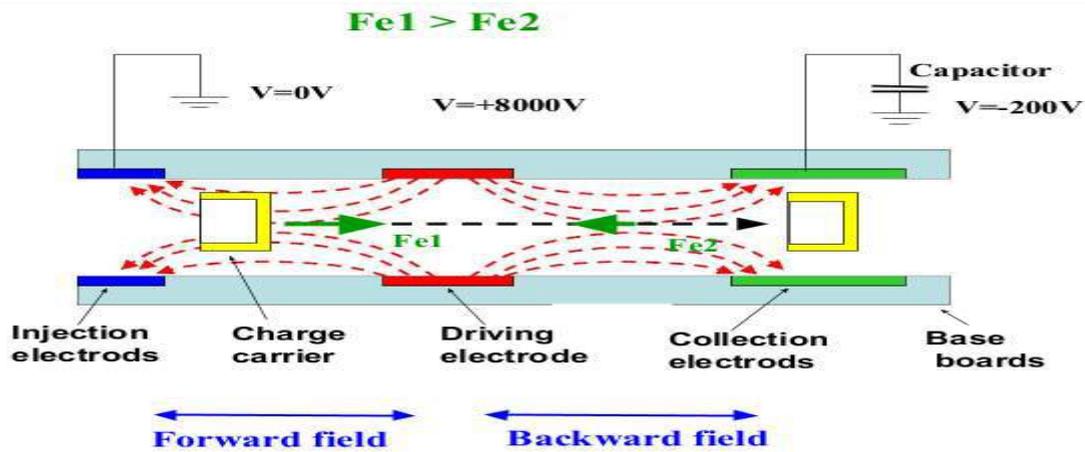
Fig. 4: Schematic layout of one unit of the new electrostatic generator

This generator mainly consists of a charge injection electrode, driving electrode, charge collection electrode, and charge carrier.

A positive high voltage was applied to the driving electrode. The injection electrode was grounded. The collection electrodes were kept at a negative low voltage.

As a result, the driving electrode and the injection electrode produced a forward electric field for a negative charge between them.

The driving electrode and the collection electrode produced a backward electric field for a negative charge between them.

A gutter-shaped conductor was used as a charge carrier that carries a negative charge (electron) from the injection electrode to the collection electrode through the driving electrode.

The asymmetric electrostatic phenomenon produces a large electrostatic force Fe1 in the forward electric field and a weak electrostatic force Fe2 in the backward electric field.

Therefore, the charge carrier gains large kinetic energy in the forward electric field. Then, it loses some of its kinetic energy in the backward electric field.

As a result, the charge carrier maintains extra kinetic energy when it arrives at the collection electrode.

The carried charge can be lifted to a higher potential by this extra energy.

This is the principle of the electric field-driven generator.

1.4 Experimental equipment of the electric field driven generator

Figure 5 shows the front view, Figure 6 shows a plane view and Figure 7 shows a photograph of the experimental equipment.
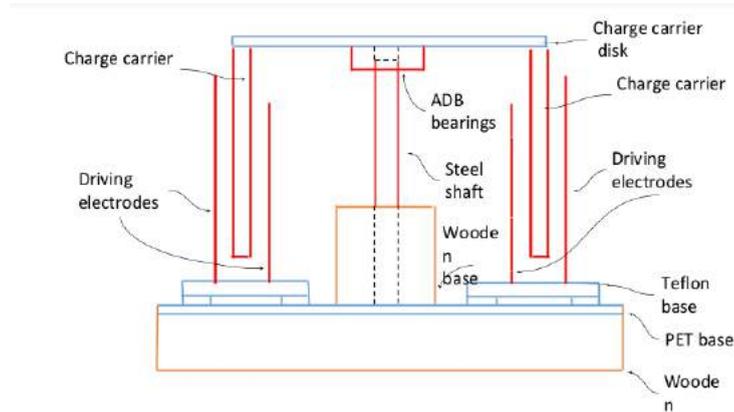
Fig. 5: Front view of the experimental equipment of the electric field driven generator
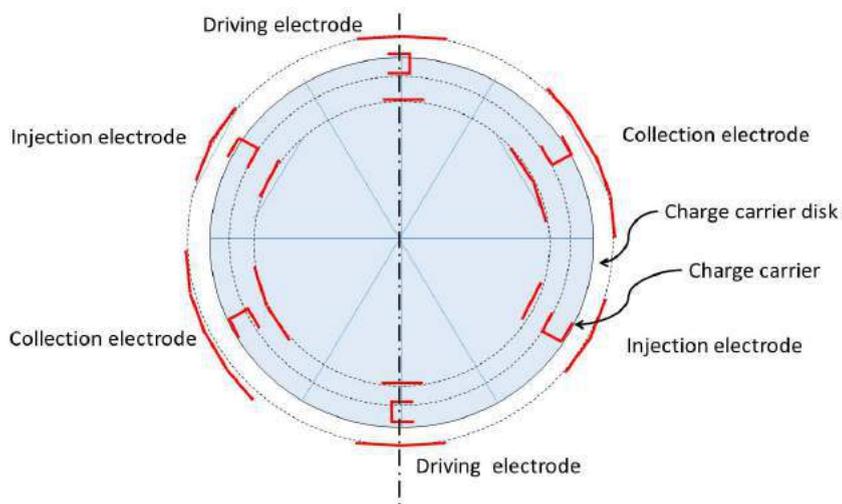
Fig. 6: Plane view of the experimental equipment of the electric field driven generator
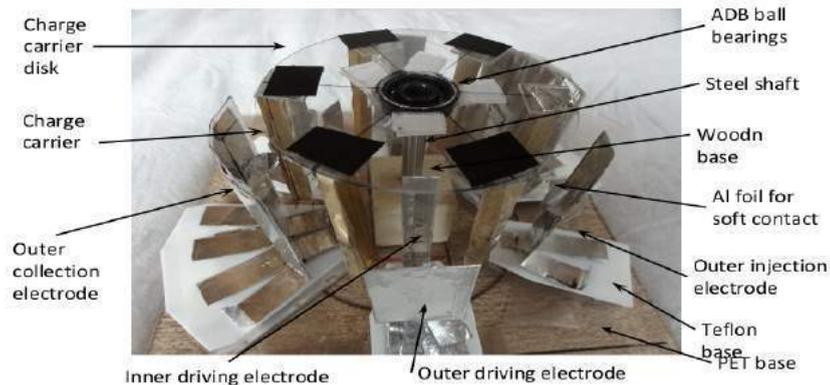
Fig. 7: Photograph of the main part of the electric field driven generator

This equipment mainly consists of a charge injection electrode, a driving electrode, a charge collection electrode, and a charge carrier disk that has six charge carriers.

The charge carrier disk is a 0.5-mm thick PET plate with a diameter of 95 mm. ADB (autonomous decentralized bearing) bearings were fixed on the center of the disk.

The six charge carriers were placed at 60 degrees intervals, as shown in Figure 6.

The two charge injection electrodes, the two driving electrodes, and the two charge collection electrodes were placed on the main PET base plate at 60 degrees intervals, as shown in Figure 6.

The injection electrode was always grounded, the driving electrode was connected to a high voltage power supply, and the surface potential of the collection capacitor was measured by a surface potential meter.

The collection electrodes could perform semi-Faraday gauges. When the charge carrier was connected to the collection electrode by the aluminum foil, more than 90% charge on the charge carrier was transferred to the collection electrode (simulation result).

A surface potential meter (SHISHIDO ELECTROSTATIC: STATIRON-DZ 3) was used to measure the surface potential of the collection capacitor.

1.4 Experimental result of the electric field-driven generator

When -7kV was applied to the driving electrode, the charge carrier disk start to rotate automatically slowly. Then the rotation speed increase gradually, and it becomes constant finally. https://youtu.be/y NwOOTq3N-0 You can see this movie, when you click here.

This result indicates that the charge carrier disk can rotate endlessly by the electrostatic force against the air resistance force and kinetic friction force.

When the charge carrier continues to rotate, the surface potential of the collection electrode capacitor becomes higher in the negative direction. These results mean that this experimental equipment continued to endlessly generate electric power.

Figure 8 shows the surface potential change of the collection electrode capacitor when the driving voltage was 7.0 kV.
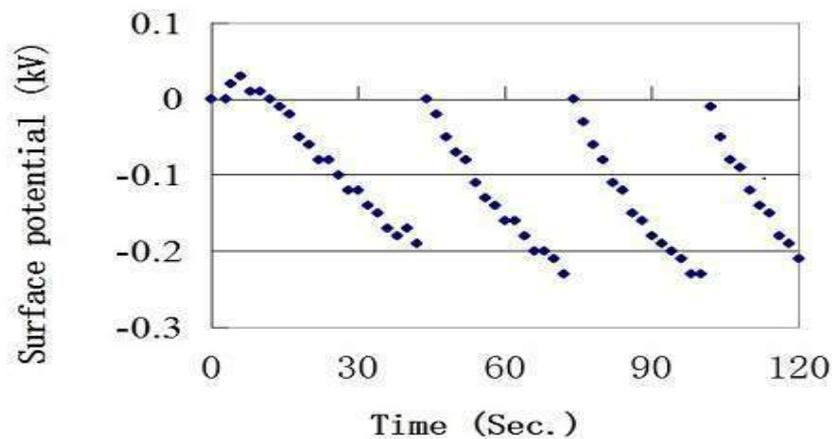
Fig. 8: The surface potential change of the capacitor of the collection electrode for the rotation time of the charge carrier disk

This result was presented in ESA 2017 [9],[10], and an improved result was presented in ESA 2019 [11] using the new charging method shown in Figure 9.
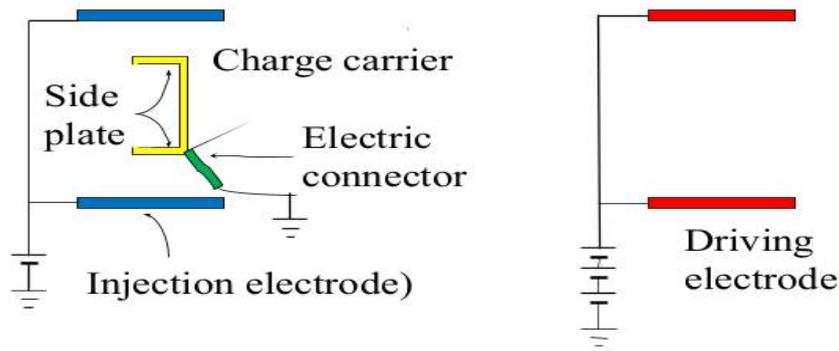
Fig. 9: The improved charge injection method

In Figure 9, the upper and lower back plates of the charge carrier and the injection electrode temporarily produce two capacitors.

Therefore, many injection charges (electrons) are injected into the side plates of the charge carrier from the ground through the electric connector.

The experiment of the new electrostatic generator succeeded. However, its electric output was only a few tens micro watt.

Therefore, the target of this paper is increasing the output to kW order from μW order.

II. INCREASING METHOD OF THE ELECTRIC OUTPUT

2.1 Structure of the commercial machine

The experimental machine explained former has a big useless space under the charge carrier disk. Therefore, a commercial machine must lay the charge carrier down as shown in Fig.10.
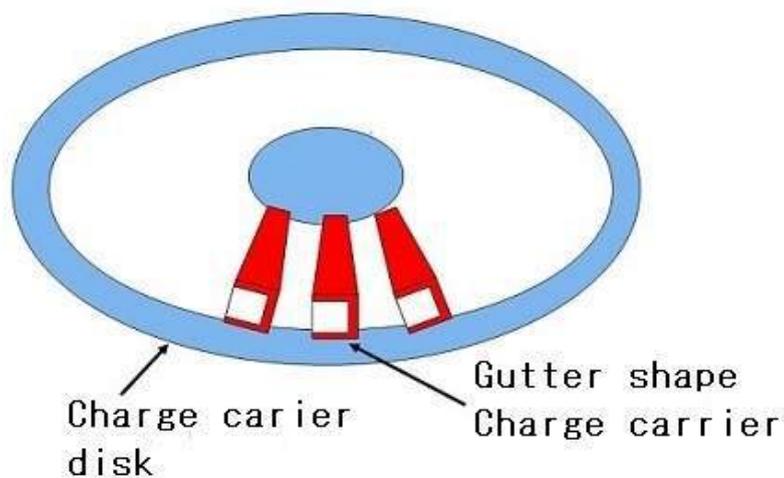
Fig. 10: Horizontally placed gutter shape charge carrier on the charge carrier disk

The injection (charging) electrode and the high voltage (driving) electrode on the experimental machine are changed to the injection (charging) electret and the high voltage (driving) electret on the commercial machine.

And also the injection (charging) electret, the high voltage (driving) electret and the collection electrode must be laid down too. They are placed face to face on back side of the upper electrodes disk and on surface side of the lower electrodes disk as shown in Fig.11.
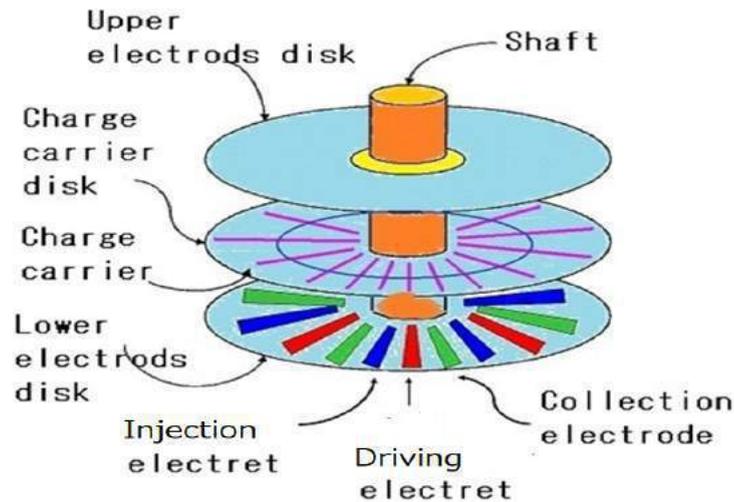
Fig. 11: One set of the new electrostatic generator consists of three disks and a center shaft

If the size of the charge carrier is 5*5*50mm like as the experimental machine, the radius of the disks become 90mm, and distance between the upper electrodes disk and the lower electrodes disk becomes 15mm.

This consist is named as 1 set. The size of 1 set become about same as CD cassette.

For high electric power, this set must be piled up as shown as Fig.12.
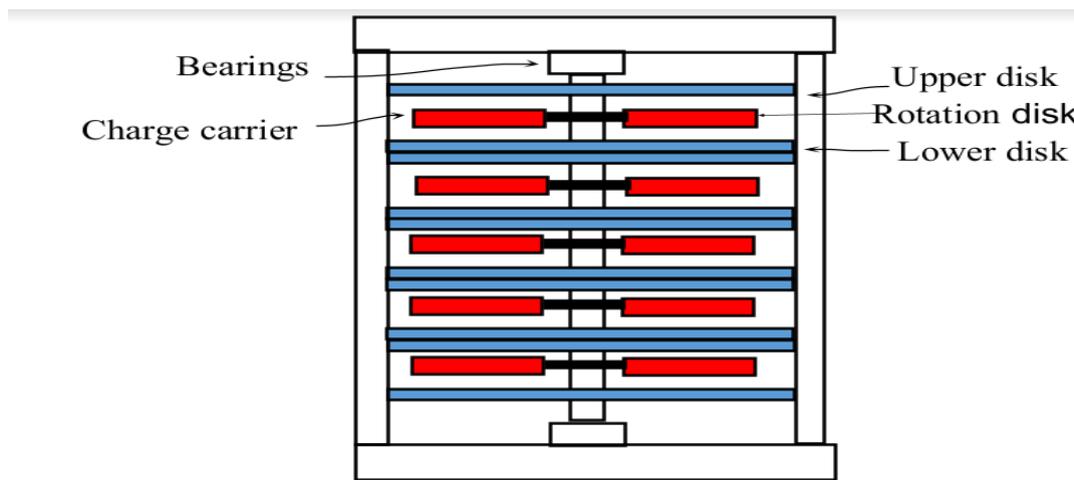
Fig. 12: An example of a commercial machine structure consists of five sets

The upper electrodes disk and the lower electrodes disk are fixed to main body.

The charge carrier disk is fixed to center pole shaft and rotates with it. Fig.12 shows five sets piling structure. However, many sets can be piled on one ball bearings, because the weight of the charge carrier is very light (10g).

The rotation speed of the charge carrier disk of the experimental machine is about 100 rpm.

However if air resistance that acts on the rotate charge carrier becomes zero by vacuum condition of the commercial machine, it will become several thousand rpm.

And if the ball bearings rotation is replaced of magnetic floating rotation, the rotation speed will become several ten thousand rpm. As a result, very big electric power will be realized.

The Increasing Method of the Electric Output of the Field Driven Generator

2-2 The methods that can increase the electrical output to one million times

2-2-1 High speed rotation of the charge carrier disk

The rotation speed of the charge carrier disk is about 100 rpm. The main resistance component is the air resistance. Therefore if the air in the equipment is drawn to the outside, the rotation speed become high.

The maximum rotation speed of the ADB ball bearings is 30,000 rpm. Therefore, when the rotation speed of the charge carrier disk become 10,000 rpm, the collected charge volume per seconds, namely a current becomes 100 times.

2-2-2 Increasing the charge density of the charge carrier

When the charge carrier enters between the upper and lower charge injection electret, two air capacitors are produced temporally between the injection electret and the side plane plate of the gutter shape charge carrier.

At this time, the charge carrier is earthed. As a result, some charge is injected into the charge carrier. The polarity of this charge is reversal to the polarity of the charge on the injection electret.

The injected charge density is in direct proportion to the charge density of the injection electret and inverse proportion to the distance between the injection electret and the side plane plate of the charge carrier.

Now this distance is 7.5mm, namely 7500 μm. Therefore, when this distance is reduced to 75 μm as shown in Fig.13 (2), the injected charge density increases to 100 times.
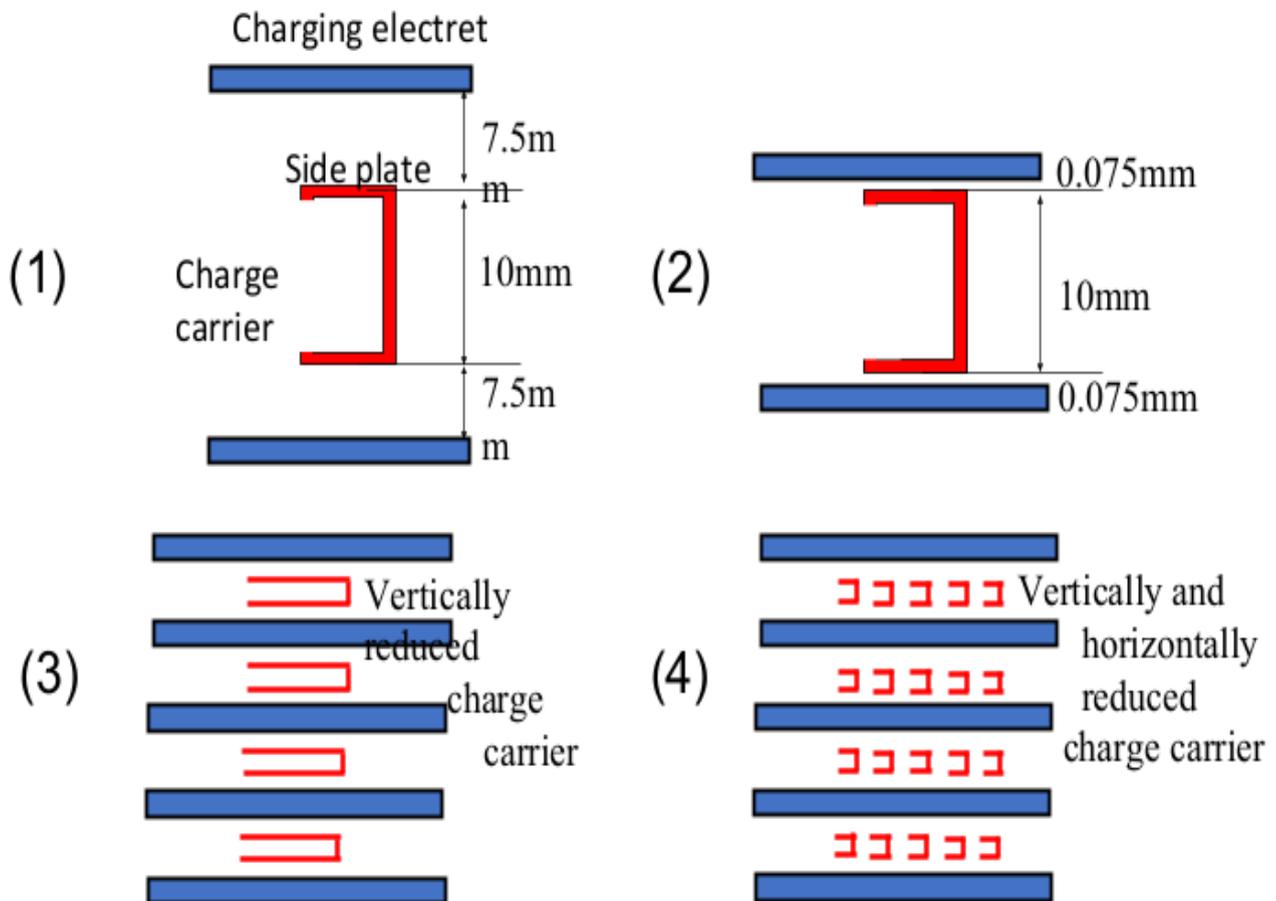
Fig.13: Charge carrier downsizing steps

As a result, the collected charge volume per second, namely a current becomes 100 times.

2-2-3 Method of increasing volume charge density

The height of the charge carrier was not related with the injection charge density. Therefore, the total volume charge of the all charge carriers become 100 times when the height is reduced from 10mm to 0.1mm as shown Fig.13 (3). However, width of the vertical reduced charge carrier becomes too long. Asymmetric electro-static force can not pull this charge carrier. Therefore, the width must be reduced to 1/100 as shown in Fig.13 (4). As a result, total charge volume of the all charge carrier in the equipment becomes 100 times. Namely, the volume charge density becomes 100 times.

If multiply by those three methods, the electric output becomes 100x100x100=1,000,000 times.

2-3 Simulation of the output increasing methods

Then the electric output of the field driven generator was simulated by finite difference method when the part size is reduced to 1/100. On the electrode disk, the size reduced injection electrets, the driving electrets and the collection electrodes are placed as shown in Fig.14.
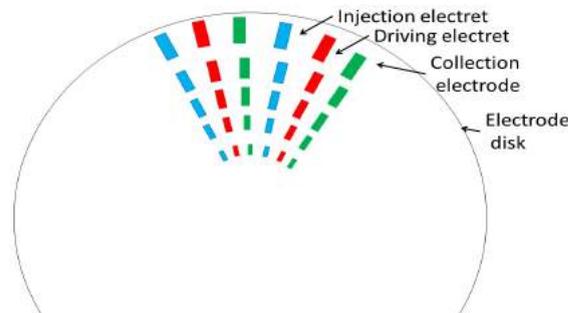
Fig. 14: Plane view of the electrode disk in that the three parts is reduced to 1/100

The radial direction is called as line and the circle direction is called as row in Fig.14. The width of the three parts are 0.160mm, 0.064mm and 0.192mm respectively. The distance between the injection electret and the driving electret is 0.330mm, and the distance between the driving electret and the collection electrode is 0.320mm. The distance between the collection electrode and the next injection electret is 0.140mm. As a result, the width of the one set become 1.200mm. The thickness of the two electret layer are 0.008mm, and the surface charge density of the two electret are 0.2 mC/m² And 1.0mC/m² respectively. The radius of the electrode disk is 50mm and thickness is 0.040mm. Therefore, 250 set are placed on the first row. The distance between the upper electrode disk and the lower electrode disk is 0.180mm.

On the charge carrier disk, the charge carriers are placed radially as shown in Fig.18.
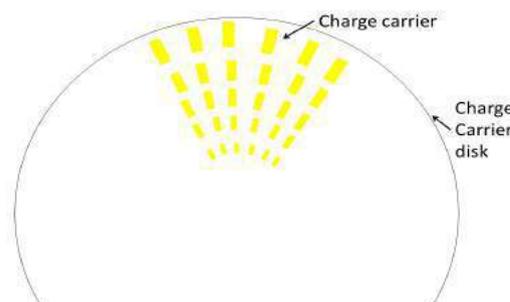
Fig. 15: Plane view of the charge carrier disk in that the charge carriers is reduced to 1/100

The width, the height and the length of the charge carrier are 0.102mm 0.104mm and 0.600mm respectively.

The distance between the horizontal plates of the charge carrier and the injection electrets is 0.010mm.

The distance between the charge carriers is 1.100mm. As a result, 250 charge carrier are placed on the first row. The length of the charge carrier is 0.600mm and the distance between charge carriers is 0.100mm on radial direction. As a result, 33 charge carrier are placed from 50mm to 25mm radial length.

The width of all parts and distance between parts on the 33 row becomes 50% of that of the first low. However, the heights and the length are the same as the first row.

At first, the electrostatic force that acts on the charge carrier on the first row was simulated. When the charge carrier placed just under the injection electret and earthed, the injected charge was simulated as -1.53 e-11 [C]. Then the electrostatic force that acts on this charged carrier was simulated while the charge carrier left from the injection electret and arrive at the collection electrode. The result is shown on Fig.16.
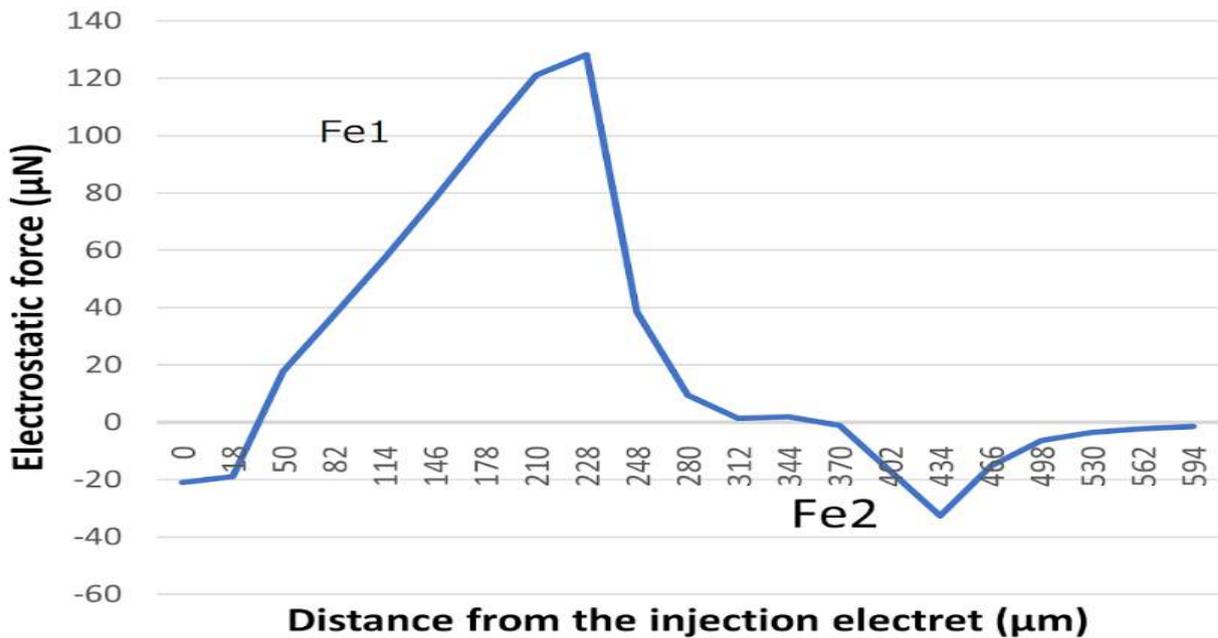
Fig. 16: Distance from the injection electret and electrostatic force that acts on the charge carrier on first row

It is apparent from this graph that the forward force is very strong and the backward force is very weak. As a result, the large extra energy remains when the charge carrier arrives at the collection electrode. It was 1.21e-8 [J]. The carried charge quantity was -1.53e-11[C], therefore, this charge can be lift up to -794[V] by this extra energy.

One charge carrier transports -1.53e-11[C] when it traverse in the one unit. There are 250 unit on the first row. Therefore, when the charge carrier disk rotates one time, -3.79e-9[C] is transported to the collection electrode. There are 250 charge carrier on the first row, therefore, when the charge carrier disk rotates one time, -9.49e-7[C] is transported to the collection electrode. The rotation speed of the charge carrier is expected 10 000 r m in the vacuum. Therefore it rotate 167 times in one second. As a result, -1.58e-4[C] is transported to the collection electrode in one second. Namely the current is -1.58e-4[A]. And the lifted voltage is -794[V]. Then the electric output of the first row becomes 1.26e-1[W].

The electrostatic force that acts on the charged charge carrier on the 33 row was simulated. It is shown in Fig.17.
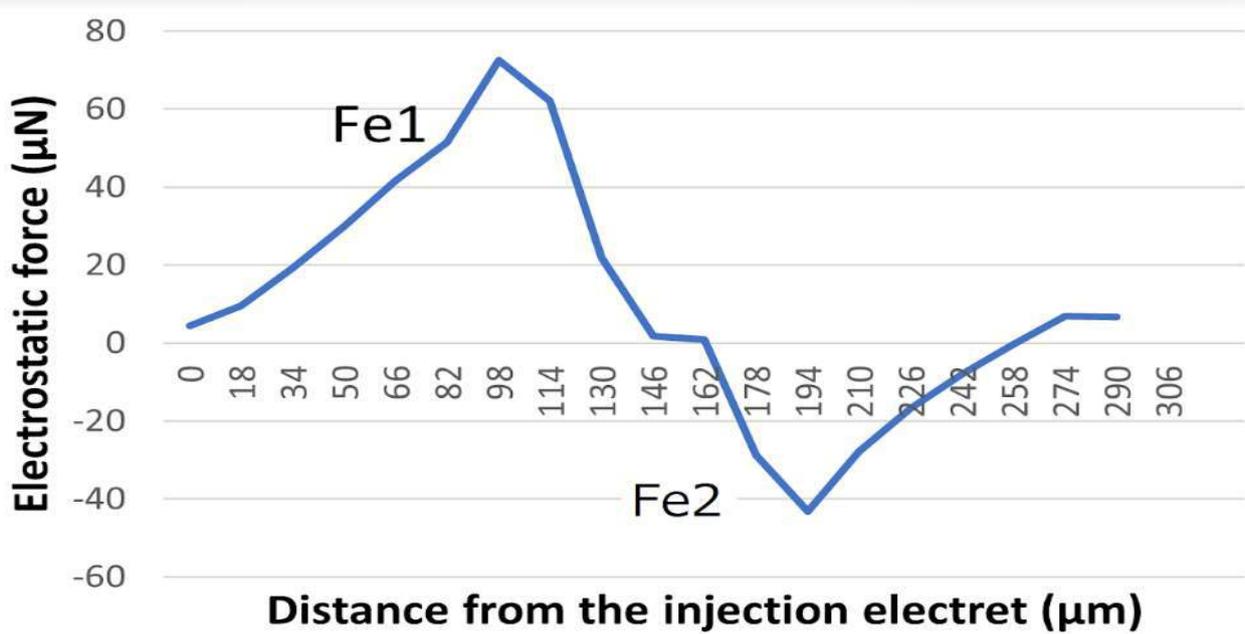
Fig. 17: Distance from the injection electret and electrostatic force that acts on the charge carrier on 33 row

The forward electrostatic force is not so strong and the backward electrostatic force is not so weak. As a result, the electric output of the 33 row was calculated as 3.40e-2[W]. The electric output of the second row to 32 row was estimated from that of first and 33 row. And the total electric output of the first row to 33 row became 2.63[W].

The thickness of the three disk is 0.180mm. Therefore 555 sets can be pilled in 100mm cubic box. As a result, the electric output of the 10cm cubic generator became 1.46[kW].

III.   CONSIDERATION

The horizontal distance between charge carriers was took 1.1mm in the simulation. However, it can be reduced to 0.3mm when the three charge carrier disks can be electrically separated. As a result, the electric output become three times. And the rotation speed of the charge carrier disk may be increased from 10,000rpm to 20,000rpm or 30,000rpm. As a result, the electric output become two or three times. And the surface charge density of the electret may be increased

more two times. As a result, the electric output become more two times.

The thickness of the charge carrier was 0.002mm in the simulation. However, this may be very difficult. Therefore, the thickness was increased from 0.002mm to 0.020mm. And The electrostatic force that acts on this charge carrier was simulated. Its result is shown in Fig.18.
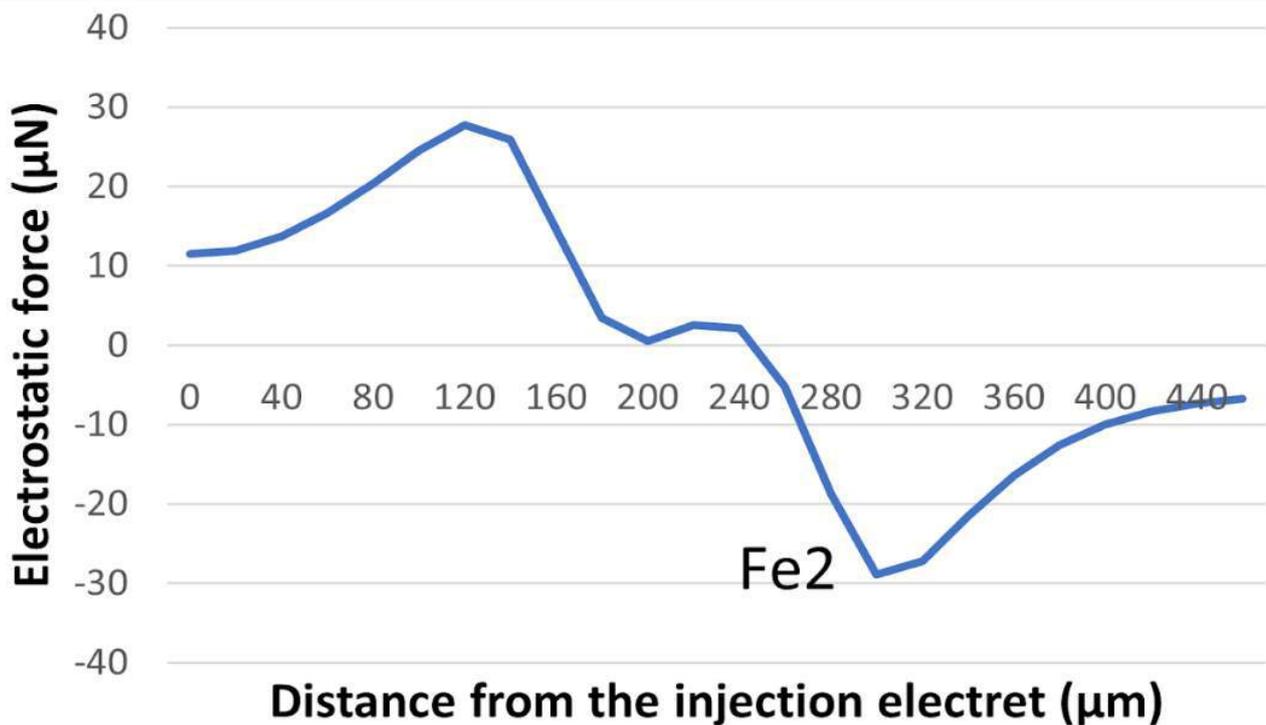
Fig. 18: Distance from the injection electret and electrostatic force that acts on the charge carrier that is consisted of 0.020mm thickness plate

It is apparent from this graph that the forward electrostatic force is about same as the backward electrostatic force. As a result, the extra energy became only 2.45e-10[J]. This means the electric output is almost zero. Therefore, the height of the charge carrier must be increased from 0.1mm to 1.0mm. However, the electric output becomes 1/10.

IV. CONCLUSION

The electric output of the 10cm cubic generator was estimated to be 1.46[kW] by the simulation when the parts size was reduced to 1/100. And there are another ideas that can increase the output more. However, the thickness of the charge carrier is 0.002mm. This may be difficult to produce with low cost. Therefore, mechanic engineer and physics researcher together must thought out the best solution.

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12. YouTubehttps://youtu.be/0eDCpg0CvIU

Note, the new electrostatic generator has the following features.

1. No maintenance or energy supply required (in the case of magnetic levitation rotation, lubrication is required for bearings).
2. Does not generate CO_2.
3. Miniaturization is possible.
4. The parts required for manufacturing are common and the product cost is low.
5. Long life (the life of the electret is 100 years).
6. The output is stable.
7. No danger (during manufacturing, use, disposal)
8. Lightweight.
9. Directly connected power supply for each electric product, eliminating the need for power transmission lines and capacitors.

As its application, for example

- Elimination of non-electric areas, temporary power supply in disaster areas, power supply in nuclear shelters.
- Use in space where sunlight does not reach (beyond Jupiter).
- Use inside the body where energy cannot be supplied from the outside, such as an artificial heart.
- Electronic devices that need to be charged frqeuently, such as smartphones and PCs.
- Power supply for radiotelephone relay stations. It can be installed on telephone poles without the need for solar cells or storage batteries.
- Power supply for equipment (traffic signals, emergency guidance) required even during a power outage.
- Power supply for meteorological observation equipment that is difficult to replace batteries in the sea, in tunnels, on mountain peaks, etc. And so on.

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Service Lifetime Loss Evaluation Method for Transformers Exclusively Serving Solar Power Plants

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ABSTRACT

In the last decade, South Africa has attracted and attained more investment by means of the Renewable Energy Independent Power Producer Procurement Programme (REI4P), which is a structured invitation to Independent Power Producers (IPPs) to submit a bid to generate and supply power to the electrical grid. In spite of REI4P's undeniable triumph, a much discussed drawback has been the related service lifetime cost of equipment that facilitate the renewable energy technologies. The description of the service lifetime loss method (SLLM) gets more complex in the new dawn of decarbonized electricity market. The SLLM must be modified for determining the total ownership cost of transformers facilitating Sustainable Energy Systems (SES's) in the decentralized energy market.

Index Term: renewable energy, transformers, service lifetime, total ownership cost.

Classification: DDC Code: 620.14, LCC Code: TP786

Language: English

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In the last decade, South Africa has attracted and attained more investment by means of the Renewable Energy Independent Power Producer Procurement Programme (REI4P), which is a structured invitation to Independent Power Producers (IPPs) to submit a bid to generate and supply power to the electrical grid. In spite of REI4P's undeniable triumph, a much discussed drawback has been the related service lifetime cost of equipment that facilitate the renewable energy technologies. The description of the service lifetime loss method (SLLM) gets more complex in the new dawn of decarbonized electricity market. The SLLM must be modified for determining the total ownership cost of transformers facilitating Sustainable Energy Systems (SES's) in the decentralized energy market.

The main focus of this work is to indicatively formulate a fundamental advancement upon the conventional service lifetime losses evaluation formula to contemplate the service lifetime loss evaluation method for transformers exclusively of service to solar power plants in South Africa. The distinct operational features of a solar plant have been embedded in the formulated service lifetime loss evaluation formula by way of the plants' Generation (GM) and Non-Generation Mode (NGM). Further, a levelized cost of energy supplied per unit of time by the solar plant is employed to determine the energy cost of the no-load and load losses that will be consumed by the studied transformers during their service life. Ultimately, the premier findings of this study indicate that the annual solar potential has an effect on the transformer service lifetime loss factors and the conventional method is not suitable there of for this application. This is a characteristic that should be precisely considered, as it may influence the tender adjudication process to purchase a transformer based on the total ownership cost offers of various transformer manufacturers.

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I. INTRODUCTION

THE rapidly escalating cost of energy from coal power generation in South Africa has aroused a substantial demand for feasible recourse energy sources. In spite of the fact that at present it contributes to only a small proportion of South Africa's power generation, deployment of solar power plants (SPPs) is rapidly increasing for both utility-scale and distribute generation power generation systems (DPGS). Reduction of the energy tariffs are impelled by the technological advances, proportionate saving in costs gained by an increased level of production in manufacturing, and novelties in finance has introduced solar power at arm's length of grid parity in an increasing renewable energy markets. Ongoing advances and additional cost savings will broaden these window of opportunities especially in South Africa where opportune solar conditions prevail. The energy tariffs for renewable energy technologies has been incessantly plummeting since the inception of the Integrated Resource Plan (IRP) [1] and [2]. Fig. 1 shows the annualized cost of energy

(ACOE) for wind and solar against coal energy tariff [3]. Wind and solar photovoltaic (PV) are observed to cost about 0.91 ZAR/kW and 0.755 ZAR/kW while coal based energy cost about 1.03 ZAR/kW [3].
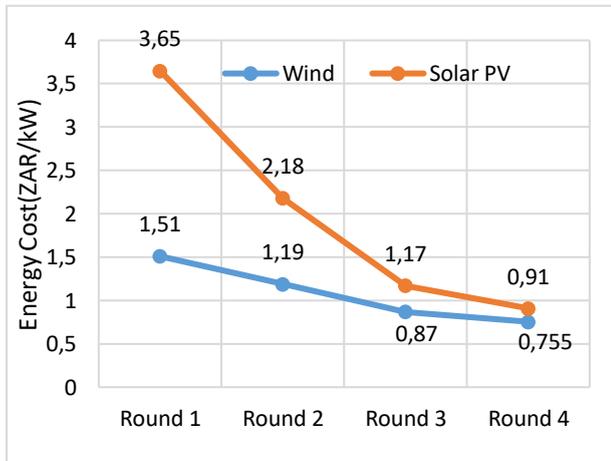
Meanwhile the rapid increase of the South African energy mix has been attended by an observed uneven proficiency revealed the new dawn of renewable energy market. For instance, the energy mix in South Africa by the vertically-integrated utility and Independent Power Producers (IPP's) exist together at the same time but have distinctive methodologies of evaluating their capital expenses, network expenditures and load curves. Therefore, the processes for the transformer loss capitalization must be distinctive. The methods available in the literature straggle the proficiency to appropriately unbundle the loading and energy components of the cost transformer losses in the concerned entities. This will significantly guarantee that each loss component is apportioned to suitable stakeholders in decentralized energy markets with regards to who is accountable to insure the losses of the transformer.

Transformers are often anticipated to be in service between 25-30 years [4]. The jurisdiction procedure by utility owners for purchasing a transformer should therefore not only be based on the initial purchase cost but also the operating and maintenance costs. The total

ownership cost (TOC) method [5] take into consideration the purchase cost, operational cost and maintenance costs over the transformer designed service lifetime. It has become possible for utility owners to compute the most technical and economic choice between competing transformer designs over its designed service lifetime through the TOC method. The TOC method also incorporates other cost related parameters such as annualized cost of electricity (ACOE), discount rates, tax rates et cetera. Considering that the TOC method comprises of the cost of service losses, in which will materialize in the future, there is a need to discount these losses to equalize them to current day South African rand (ZAR) value. The capitalization values CNLL and CLL in ZAR/kW studied by authors in [6], [7], [8], [9] and [10] derive the cost of service losses. Transformer manufacturers submit a technical and commercial offer in a competitive bid and if the capitalization values are provided, then the manufactures should be grounded on these values in all cases. The service no- load losses are reliant on the core steel grade and are unvarying for a transformer during service [11] and [12]. The service load losses on the other side are dependent on the loading profile of the transformer [13] and [14]. Significant service losses of a transformer during service can potentially culminate in excessive heating and consequently degradation of insulation of materials due to overloading and presence of harmonics especially in renewable energy technologies suchlike wind and solar [15], [16], [17], [18], [19] and [20]. As a result, a low-loss transformer would practically be in service for a longer duration with minimum potential for premature failure. Additionally, a low-loss transformer discount the amount of electrical energy necessitated to supply the service losses.

Firstly, this work presents classical SLLM for transformers that are intended to be in service for 8760 hours annually and from a single utility energy source. This method is based on transformer loss data supplied by the manufacturers and the utility characteristics.

Nevertheless, the understanding of the SLLM becomes knotty within the bounds of

for transformers intended to be in service for 8760 hours annually and from a single utility energy source. In the case of solar power plants, during the non-generating period, the solar plant will be feeding-off the electric grid with coal power generation.

II. TRANSFORMER COST ANALYSIS

In order to bestow the surged energy demand, the excessive loading of transformers during service and related remaining service lifetime on account of the hotspot temperature rise is structural components must be cautiously estimated in opposition to the replacement of transformers or supplementing existing unit with new transformer. IPP's generally ascertain definitely the size of suitable units for service based on current loading cycle, forecasted load growth and other sound engineering acumen. Additionally, IPP's determine the economic effect of service losses of the transformer over its planned service lifetime and the initial purchase price prior to procuring new transformers. The classical Total Ownership Cost (TOC) procedure provides a comprehensive analysis for the economic planning aspects of investing in purchasing and operating a transformer.

2.1 Service lifetime loss method: Classical Method

The purchasing of transformers by SLLM is predominantly employed based on the premise of a lowest TOC amongst competing offers of various transformer manufacturers. This method provide details on the cost of transformer service losses and the initial purchasing price of the unit. The service lifetime of the unit is presumed to be even irrespective of the MVA rating. Various transformer loading guides suggest a normal operating service lifetime of 30 years [4]. The aspect of investing in purchasing a transformer is determined to reflect an annual cost of the service no-load and load losses inclusive of the demand rate. The total revenue needed is treated by the ratio of the annual cost of these losses to the fixed charge rate (FCR). The FCR illustrates all the incurred charges in the utility independent of energy (kWh) traded, suchlike depreciation, tax, insurance and service maintenance.

For each unit of kilowatt (kW) of the service no-load and load losses, there is an inclusion of the demand cost (DC) portion derived from capital cost of the transformer. Consequently, there is an inclusion of the component for the energy cost (EC) in kilowatt-hour (kWh) by the utility. The cost of service losses (CSL) are hence computed as follows in eq. (1).

$$CSL(ZAR/kW) = DC + EC \qquad (1)$$

Here:

DC = System Investment(ZAR/kW)

EC = 8760×$ACOE$

FCR

System investment (SI) illustrates the acquisition in the bulk movement of electrical energy from a generating site to distribution facilities essential to deliver supplementary energy demand arising from transformer service losses at the system peak. There are essentially two approaches to assessing the SI rate in ZAR/kW. The first one is classical and is based on the established costs of constructing a generating site and related distribution facilities. The second approach is based on a scenario where the power utility does not self-generate power and instead purchase power. The SI rate can be ascertained by ratio of the DC (ZAR/kW-yr.) and the FCR.

Consequently, the ACOE is evaluated by forecasting and weighting the annual inflated cost of energy by means of capital recovery factor (CRF). Analytically, the latter can be expressed as shown in eq. (2).

$$ACOE = Current\ Energy\ Cost \times CFR \qquad (2)$$

Here,

$(1+i)\ n1-Xn$

$CFR = (i \times [(1+i)n-1]) (X \times [\ 1-X\ ])$

Where,

i – Discount rate

n - Designed transformer service lifetime

e – Energy escalation rate

$X = \frac{1+e}{1+i}$

It follows that the cost of losses can be expressed as follows in eq. (3). This equation is handily feasible for power utilities with their own electricity generation.

Additionally, eq. (3) segregate apiece class of service losses in ZAR/kW as shown in eq. (4), eq. (5) and eq. (6). The cost of no-load losses ($CNLL$) are expressed as shown in eq. (3).

$$CNLL(ZAR/kW) = CGTD + 8760 \times ACOE\ FCR \qquad (4)$$

Here, $CGTD$ is the utility costs for the generation, transmission and generation. The cost of load losses (CLL) are expressed as shown in eq. (4).

$$CLL = CGTD \times PRF2 \times EPR2 + 8760 \times ACOE \times TLF \times EPR2\ FCR \qquad (5)$$

Here, PRF and EPR is the peak responsibility factor and the equivalent peak ratio. The PRF is the ratio of the load's demand to peak power demand at the course of the system peak as expressed in eq. (7).

$$PRF = Transformer\ peak\ load \qquad (7)$$

The PRF can be implemented to unique customer classes. Needless to say that a loading with a PRF of one peaks concurrently with the overall system. The electrical loading of particular customer classes have a propensity to fluctuate at a similar fashion. For instance in South Africa, commercial electrical load are at peak from about 08:00 AM in the morning to about 18:00 PM in the evenings while residential electrical loads peak from around 18:00 PM in the evenings. Inevitably, the weather has a direct impact on the loading extent. In the winter for instance, electrical heaters increase the demand and lower the variety among loads. At the distribution transformer level, the loading factors are largely ranging from about 0.4 to 0.9 with 0.75 being common [6]-[8] and [10]. The standard values of PRF can vary from 1.0 to about 0.35. Given that PRF is a ratio based on the loading (kVA), the services losses are a function of $PRF2$. The most common values of the PRF for various transformers is tabulated in TABLE I.

Table 1: Prf Values for Various Transformer Classes

Power System Level	PRF
Generator Step-Up	1
Transmission Substation	0.9
Distribution Substation	0.8
Distribution	0.35

The interrelation between the service losses and the rated transformer loading is described by the peak ratio (PR). The latter can be expressed analytically as follows in eq. (8).

$$PR = Maximum\ rated\ transformer\ load \qquad (8)$$

Supposing the load increase by a specific percentage annually, then from eq. (5), the EPR may be employed as expressed as follows in e. (9).

$$EPR = PR \times \sqrt{\frac{(1+g)^{2t}-1}{In(1+g)^{2t}}} \qquad (9)$$

Where,

g – Rate of annual load growth

t – Time in years

Lastly from eq. (5), the annualized TLF can be described by the ratio of the average service load loss to the maximum load losses. The latter can be expressed as follows in eq. (10).

TLF = Average transformer load loss

Maximum transformer service load loss $\qquad (10)$

If the power utility provides the annual loading cycle data, then the services load losses can be evaluated from this data. Nevertheless, the utility owners endeavour to link up the transformer service loss factor with a more easily accessible information viz. the load factor (LF).

The determination of the TLF is dependable on some empirical data and can then be evaluated as expressed in eq. (11) [11].

$$TLF = a \times LF2 + b \times LF \qquad (11)$$

Here:

a – varies between 0.8-0.89
b – Varies between 0.2-0.11

In practice, the recommended a and b constants are 0.84 and 0.16 respectively. The total ownership cost is then expressed as shown in eq. (12).

$$TOC(ZAR) = TP + CNLL \times NLL + CLL \times LL + CAL \times AL \quad (12)$$

Here, TP is the transformer price offered by the most competitive transformer manufacturer. Prevalently, eq. (4) and eq. (5) are referred to as

(12). The CSL are them multiplied by the corresponding no-load (NLL) and load losses (LL) in kW.

the A and B factors. Subsequently, eq. (13) can be introduced as new factor C to the classical TOC method, in which ignores this factor.

$$TOC(ZAR) = PP + A \times NLL + B \times LL + C \times AL \quad (13)$$

2.2 Service lifetime loss method: Solar Power Plants

A majority of SPP's in South Africa are owned by the Independent Power Producers (IPP's). The plant consists of an array of solar photovoltaics modules connected in series and thereupon connected to an inverter that carries out the direct current (DC) to alternating current (AC) conversion. Furthermore, a step-up transformer is connected to the inverter output to increase the voltage to the desired transmission voltage level. Transformers in SPP's are connected on a permanent basis to the electric grid to guarantee the plant is fed with power to fulfil its auxiliary losses during non-generating mode (NGM). The energy cost of the coal power generation (*ECCPG*) will be effected in this regard. Conversely, during SPPs generation mode (GM) the solar irradiation is available and the solar modules can harvest power. Only, the energy cost of the solar PV (*ECPV*) in kWh will be effected.

Fig. 2 demonstrate a solar PV generation profile of a SPP as acquired by field measurements and the data is collected over the period of five months. It should be noted that the SPP profile is reliant on the effective average daily solar radiation profile on the surface area of the solar PV modules and corresponding solar PV technology. As demonstrated in Fig. 2, the GM of the SPP can be described by the affective area under the curve between the period 08:30AM to about 18:30PM.

Fig. 2. SPP generation profile in South Africa

The generation modes of the SPP generation profile is then tabulated as shown in TABLE II. A 24-hours generation state is considered in the analysis and about 14 hours the solar radiation will be available for the solar modules to harvest power (GM) while bout 10hours of that time the sun will be down (NGM). The ratios of GM and NGM against the 24-hours daily generation state result in the generating (FGM) and non-generation factors (FNGM)

Table 2: Generation Modes: Solar Power Plant

Generating State	24 hours
GM (Hours)	14
NGM (Hours)	10
FGM	0,583
FNGM	0,417

It is reaffirmed that the proposed SLLM proposed in this work is relevant to Independent Photovoltaic Power Producers (I3P) supplying electricity to the electric grid by means of step-up transformer. The critical element in capitalizing the service losses in these transformers is the correct definition of the

energy component of the cost of service no-load (*ZAR/kW*) and load losses (*ZAR/kW*). The energy component is the current energy tariff that will be utilised by a unit kilowatt (kW) of each service loss over the course of designed service lifetime of the SPP. In eq. (14), the proposed method to evaluate the *CNLL* for transformer intended to operate in SPP. Over the course of the day, the SPP has a greater likelihood to operate GM and NGM. Whenever, the SPP is operating in GM, then it is solely accountable to generate, solely supply of energy and service loss demands as well as transmission of energy to the electric grid. Conversely, during the course of NGM, the SPP purchase energy in a South African context from a coal power generation utility in order to supply its auxiliary requirements and losses.

The latter is expressed by eq. (14)

$$CNLL(ZAR/kW) = CGTD + 8760 \times NGM \times ECCPG\ FCR \tag{14}$$

In this case, the energy tariff of the coal power generation utility (*ECCPG*) applies. Moreover, the annual operating hours are weighted in accordance with the availability of the solar radiation. In eq. (15), the case of the evaluating for the cost of service load losses for transformers intended for SPP is also demonstrated by improving eq. (5) from the previous section. The energy tariff of the SPP (*ECPV*) and corresponding generating factor is considered when the plant is generating its power.

$$CLL(ZAR/kW) = CGTD \times PRF2 \times EPR2 + 8760 \times GM \times ECPV + 8760 \times NGM \times ECCPG \tag{15}$$

Additionally, NGM component is added into the formulation to take into account for the when the transformer is operated in reverse as a step-down transformer to supply the auxiliary and loss requirements of the SSP from the grid supply.

III.   CASE STUDY: 1500 KVA OIL-IMMERSED TRANSFORMER

In this section, the data in TABLE I is considered to conduct the service lifetime loss evaluation. The data is intended to make a substantiated decision to purchase a 1500kVA oil- immersed transformer with 65 ℃ mean winding temperature. Transformer designs from three distinct manufactures will be considered in this case study. Each design attempt to attain coveted specifications with cost-effective materials, minimum dimensions and lowest overall cost of transformer ownership. In South Africa, increasingly in South Africa, utility owners now purchasing transformers on the basis of the transformer TOC over its intended service lifetime, than just the purchasing price.

Table 3: Service Lifetime Parameters

Parameter	Value
Designed Service Lifetime	30 years
No. of service hours per year	8760
Annualized Energy Cost	0,61 ZAR/kW
Fixed Charge Rate (FCR)	0,192
System Investment (SI)	23000 ZAR/kW
Discount Rate (i)	10,00%
Energy Escalation rate (i)	2,00%
Load Factor (LF)	0,6
TLF	0,3984
EPR	0,97
Peak Responsibility Factor (PRF)	0,6
Peak Ratio (PR)	0,7
Load Growth Rate (LGR)	2,00%
Coal	1,03 ZAR/kW

In TABLE IV, a design comparison (A, B and C) of the service losses, selling prices and respective cost of service losses and TOC is presented for three different competing transformer manufacturers. This information is useful in the jurisdiction of the more technically and economically suitable transformer. Design A is the highest loss design of the three offers. Design

B and C are lower loss designs. Manufacturer B and C on that account have used better grades of core steel, optimized conductor dimensions and improved cooling medium and procedures.

Table 4: Service Lifetime Loss Analysis: Classical Method

Manufacturer	NLL	LL	SP	CLL	TOC
A	6	25	R460,839	R970 966	R1,431,806
B	5	20	R510,215	R789 677	R1,299,892
C	5	16	R559,591	R696 260	R1,255,851

In TABLE IV, the classical TOC method has been employed to evaluate the SLLM. This method makes the assumption that the transformer will be in service for 8760 days annually over its designed service lifetime. This premise does not however hold true for renewable energy applications considering the spasmodic nature of renewable energy sources. In TABLE V, the proposed solar power plant procedure for evaluating the SLLM is presented. This method takes into consideration the GM and NGM of the plant over the designed transformer service lifetime as described in the previous section. Design C is observed to have lower service losses in comparison to manufacturer B and C even though the selling price of the manufacturer is higher. It follows that the TOC of the unit is also lower over the normal operating service lifetime.

Table 5: Service Lifetime Loss Analysis Solar Power

Manufacturer	NLL	LL	SP	CLL	TOC
A	6	25	R460,839	R737,986	R1,198,825
B	5	20	R510,215	R597,308	R1,107,523
C	5	16	R559,591	R512,443	R1,072,033

The case studies in TABLE IV and TABLE V illustrate that cost of the transformer service losses over the transformer designed lifetime are critical to evaluate over just the purchase price.
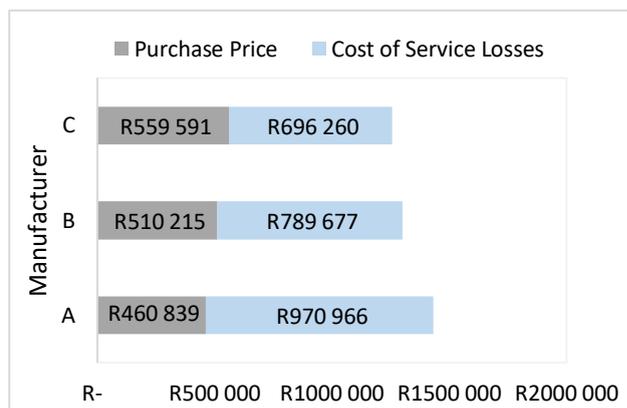
Fig. 3: TOC of the transformer manufacturers: Classical method

The results in Fig. 3 indicate that manufacturer C has the highest purchase price in comparison to manufacturer B and C by 9% and 18 % respectively. Additionally, the CSL for manufacturer C is lower by 13% and 39% respectively over the designed service lifetime. By employing the classical method, this results indicate that over the designed service lifetime of the transformer under study the IPP can purchase the most expensive transformer while keeping a relatively lower cost of service losses over the intended transformer lifetime. Alternatively, the IPP can choose the cheapest transformer offer with significantly higher service losses over the designed lifetime. However, from a maintenance perspective of the IPPP the later will not be economical.

Results of the proposed SLLM for the three transformer offers are presented in Fig. 4. As indicated earlier, throughout the day the SPP will undoubtedly operate in two modes. When the plant is operating in GM, the SSP is accountable to supply its own energy and losses in addition to supplying power to the electric grid. When the SSP is operating on the NGM, then auxiliary requirements of the SSP will be supplied by the electric grid, that is to say that the SPP will purchase power from the coal power generation utility and their energy tariffs will apply.
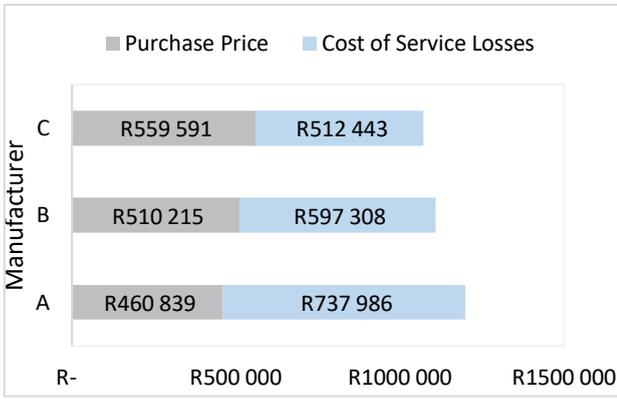
Fig. 4: TOC of the transformer manufacturers: Solar power plants

In Fig. 4, the results indicate that manufacturer A has the cheapest purchase price and highest CSL. Manufacturer B is the second cheapest offer while manufacturer C is more expensive. The CSL is cheaper by 44% and 17% in comparison to manufacturer A and B respectively. In this regard, the most techno-economical purchase decision for the IPP will be that of manufacturer C.

In order to demonstrate the differences between the classical and proposed SPP SLLMs, Fig. 5 is presented. It can be observed from Fig. 3 and Fig. 4 that the transformer offers from each respective method that manufacturer C has a significantly higher selling price but is more economical over the 30 years designed service lifetime.

Manufacturer B and C have managed to optimise their no - load losses by 17% in comparison to manufacturer A. in practice, this loss is minimised by four methods:

- Enhancement of the core steel construction
- Enhanced cutting of the core laminations and employing step-lapped joints as they interleave the core laminations that connect the joint gap.
- Enhancement of the core laminations stacking; and
- Computational modelling of the no-load losses.

The use of amorphous steel in the transformer design also plays a critical role and can minimise the no-load loss by 70 - 80% as opposed to silicon graded core steel.

Overall, manufacturer C has managed to optimise the service load losses by 56% and 25% in comparison to manufacturer A and B respectively. In practice, the service load losses is instrumental to the efficiency of the transformer during service. It therefore critical to reduce these losses for the purpose of enhancing and achieving the most optimal service performance. Reduction of the load loss is treated by the selection of large conductor dimensions in the interest of minimizing the resistance per unit length of winding conductors. A comparison of the CSL between manufacturer A and B is 12% while between manufacturer A and manufacturer C it is 19%.
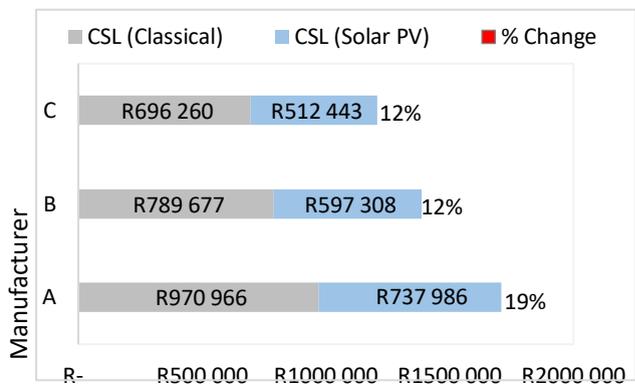
Fig. 5: TOC of the transformer manufacturers: Comparison

The results presented in Fig. 5, show some benefits of using the proposed method over the classical method. Taking into consideration the generation modes of the SPP and the ACOE has some techno-economic benefits for the IPP.

IV. CONCLUSION

This work proposes a holistic SLLM to compute the TOC of transformers designed to be of service to solar power plants. These transformers are predominantly owned by IPP's in South Africa. More notably, the proposed method acknowledge precisely how the cost of the service no-load and load losses should be calculated, taking into consideration the TOC of the transformer in relation to the operational requirements of solar power plants they operate in. The distinct operational features of a SPP have been incorporated in the classical SLLM by means of the two generating modes (GM and

NGM). Additionally, the proposed SLLM for the transformer under study is influenced by the reality that this transformer will exclusively facilitate the SSP, as distinguished from another generation utility. As a result the ACOE for SPP in South Africa is employed to evaluate the CSL that will be consumed by the transformer under study during service. At large, it is shown that the solar irradiation plays a pivotal role on the calculation of the CNLL and CLL. This is a property of the SPP that should be cautiously covered, as it may influence the tender jurisdiction criterion to choose the lowest TOC of a transformer over its designed service lifetime.

The insights gained in this work indicate that most economical transformer purchase choice for SPP owners is a high purchase price and low-cost transformer over low- purchase price and high-loss transformer.

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Determination of Manufacturing Parameters for Maintaining form Accuracy of Packaging Support Block Made with Polyurethane Foam

Jiwan Kang, Heeyoung Maeng & Suin Eun

ABSTRACT

A support block for packaging valuables usually uses a material with surface elasticity, such as polyurethane foam or polystyrene foam. This is to ensure that the surface can be well contacted and supported so that the contents of the package can be protected from vibration or shock when valuables are transported over long distances. In general, this polyurethane packaging support block is manufactured using an NC milling machine and a ball nosed end mill tool specially designed to cut the cushioned soft materials. However, because the elastic cushion of the material is very large, it is very difficult to implement the 3D form accuracy that can be in good contact with the surface of the packaged contents. This study tried to explore the manufacturing parameters that could maintain the good contact with the surface form of packaged valuables accurately and could support the contents stably, through the Taguchi technique, that minimizes the influence of uncontrollable factors through controllable factors.

Keywords: packaging support block; nc milling of polyurethane foam; manufacturing parameters; taguchi technique; form accuracy; vibration test.

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A support block for packaging valuables usually uses a material with surface elasticity, such as polyurethane foam or polystyrene foam. This is to ensure that the surface can be well contacted and supported so that the contents of the package can be protected from vibration or shock when valuables are transported over long distances. In general, this polyurethane packaging support block is manufactured using an NC milling machine and a ball nosed end mill tool specially designed to cut the cushioned soft materials. However, because the elastic cushion of the material is very large, it is very difficult to implement the 3D form accuracy that can be in good contact with the surface of the packaged contents. This study tried to explore the manufacturing parameters that could maintain the good contact with the surface form of packaged valuables accurately and could support the contents stably, through the Taguchi technique, that minimizes the influence of uncontrollable factors through controllable factors. Using the characteristics value by Taguchi technique based on the experimental accumulated machining data under similar environment, the optimal manufacturing parameters such as the spindle speed, feedrate, step over, and tool path pattern were determined. And the manufacturing parameters determined through these analysis techniques have been verified practically by testing experiment using a group of expert's machining data. Also, in order to examine the suitability of these parameters, the prediction accuracy was confirmed by comparing it with a large amount of experimental data accumulated by experts. In addition, in order to confirm the packaging performance of the support block manufactured under these parameters, the vibration test were performed on these samples to compare and analyze whether they satisfied the limits of the standard specification.

Keywords: packaging support block; nc milling of polyurethane foam; manufacturing parameters; taguchi technique; form accuracy; vibration test.

I. INTRODUCTION

With the recent development of the logistics industry and the exhibition fair event, it is increasingly necessary to safely transport valuables such as electronic products, expensive artworks, sculptures, jewelry, antiques, and cultural assets to long distances. When these valuables are safely transported, they usually go through a special packaging process, and most of them rely on the experience of experts. Companies specializing in this packaging industry use the cushioned and soft standardized packaging support block made of polyurethane or polystyrene block to effectively wrap the contents goods.

The support block used for this purpose should have adequate elasticity and protects the valuables from external impact as it is in contact with the content goods. To do this, the shape of the curved surface must have the consistent clearance so that the inner contact surface of the support block can smoothly contact the outer surface of the content goods [1]. The curved surface of support block is made into a suitable form by giving a uniformed margin considering the gap and pressing tolerance based on the contact region of the outer surface of the valuables, and then it is designed so that the surface of soft material foam is to be machined easy using NC (Numerical control) milling machine while satisfying the machining allowance [2].

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At this time, deformation occurs in areas subject to excessive pressure due to poor form accuracy. If there is a gap with insufficient contact, external vibration cannot be blocked and damage such as scratches or cracks may occur on the content surfaces. When it is machined at NC milling machine, unlike when machining metal or hard materials, it uses a specialized ball nosed end mill tool having a needle protrusion on the cutter blade. Therefore, cushioned deformation on the surface of support block is inevitable.

Regarding this special machining cases, Kim et al. [3], as part of an effort to increase the surface roughness of the workpiece when NC milling of relatively light epoxy foam, the cutting conditions such as appropriate spindle rotation speed, axial depth of cut, are experimentally determined. Also, Min [4] and Zhang [5] calculated the amount of tool offset by considering the deformation of the contact surface between a specially manufactured tool and a workpiece when NC milling a soft polyurethane foam material.

In addition, Shim et al. [6] have studied a method for estimating the shock absorption rate of polyurethane foam through the speed at which the steel balls were dropped. Furthermore, Kim et al. [7] have suggested the dropping simulation of the outdoor unit of an air conditioner in a state of being packaged with polyurethane foam, and through these simulation data, they found the weakened regions and reinforced areas of the packaging support block.

However, there have been no research so far in which the manufacturing parameters have been decided to maintain form accuracy when machining the polyurethane foams, and no research has been conducted on the effect of interference and clearance gaps of the support block.

This study investigated the method of determining the manufacturing parameters that can maintain the form accuracy of the contact surface so that the support block can stably support the content goods. A new method using Taguchi technique [8, 9] are proposed to find the optimal manufacturing parameters, which is not only feed speed and spindle speed, but also many factors such as machining direction, axial depth of cutting, and spacing between paths, act in a complex manner. And this method evaluated its applicability on the empirical data from a group of experts accumulated for a long time, and through a vibration test on the packaging support block in which manufacturing parameters were applied to the actual packaging process.

II. MANUFACTURING PROCEDURE OF PACKAGING SUPPORT BLOCK

The manufacturing process of packaging support block goes through the process as shown in Figure 1 generally. A 3D scanner is used to collect 3D scan data for the surface of the packaged object, and the shape of the support block form is designed based on the collected 3D data. At this time, after correcting the curved surface in consideration of gaps, elastic margins, and gouging, the tool path data for NC milling is generated for the curved surface of the contact part with the content goods.

Then, this NC data is input into the NC milling machine, and the milling work is performed on the table to complete the machining of the support block form. The next step is to assemble the various sub-elements that make up the packaging support block, and then place the contents inside the support block for packaging. This polyurethane foam has elasticity, but has stability in temperature change, chemical stability, shock and external vibration. Table 1 shows a comparison of three representative physical properties(i.e., conductivity, elastic modulus, and pH) for the two materials of foam, such as polyurethane material and EVA (ethylen-vinyl acetate) foam.

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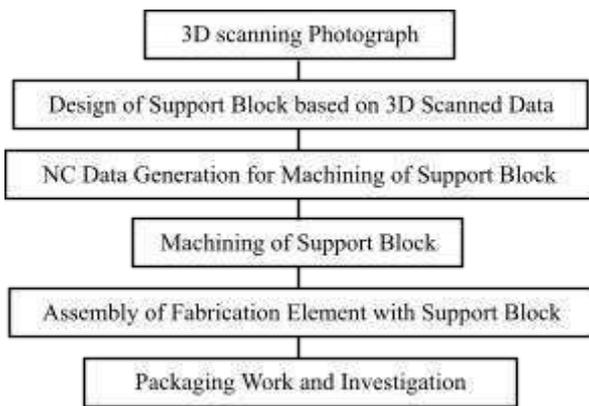
Figure 1: Process chart for manufacturing of packaging support block
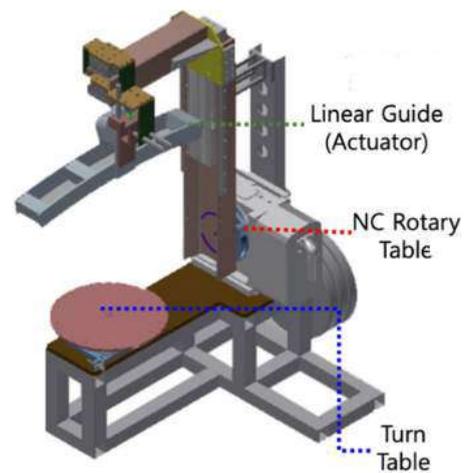
Table 1: Properties of packaging support block materials

Materials	Polyurethane foam	Eva foam
Conductivity ($W \cdot m^{-1} \cdot K^{-1}$)	0.024	0.038
Elastic Modulus (MPa)	0.34	0.49
pH	6.7	6.3

2.1 Collection of shape data using 3D scanning

Although there are various scanning methods depending on the complexity of the shape to scan the surface of the package content goods, a spherical coordinate system 3D scanner is widely used as equipment for easy automatic scanning on a desktop. This is because it is good to measure all surfaces at once in one place without moving valuables as much as possible by adjusting the longitude and latitude angles of the spherical coordinate system.

Figure 2 shows a typical spherical coordinate system 3D scanner. When data are collected using this spherical coordinate system, automatic scanning is performed using a macro after performing zero adjustment and calibration using a standard master ball. There is almost no loss time except for the time gap between scanner shooting and instrument setting, so high-speed scanning with high resolution is possible. After the scanning work is completed, the acquired data is automatically converted into the world coordinate system through the commercial application software.
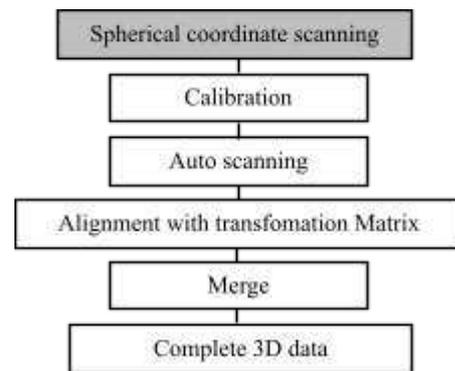
Figure 2: Spherical coordinate system device and 3D scanning process

2.2 Design of support block based on 3D scanned data

Figure 3 shows the scanned sample of a sculptured surface for content goods on a support block based on the scanned 3D data. At this time, the work of correcting the sculptured surface is performed in consideration of gaps, tolerances, and margins.

Figure 3: Scanned 3D data sample of packaging content goods

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As the first step, as shown in Figure 4(a), the scan data of the packaged content goods is merged and placed at the world coordinate origin, and the size of the packaging support block is laid out in a rectangular shape as shown in Figure 4(b).

And then, as shown in Figure 4(c), after placing them in a symmetrical structure at the center, it performed offsetting work considering gaps, tolerances, and margins to the normal direction of the curved surface. Finally, the cavity sculpture surface of the lower support block is completed by removing the protruded surface beyond the block boundary as shown in Figure 4(d).

Also, the design process of upper support block is applied as the same design steps of lower support block. Then the whole design process is completed.
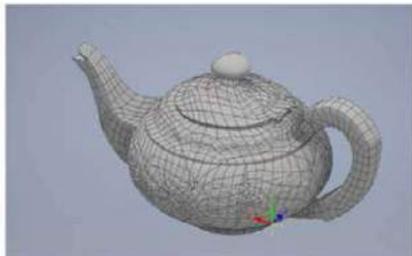
(a) Original scanned model
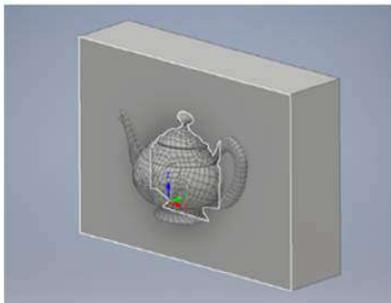
(b) Sizing of support frame block
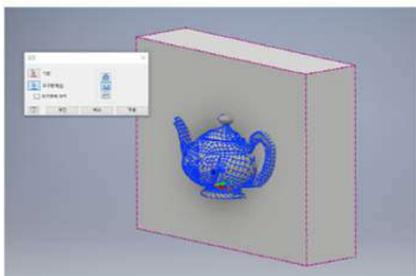
(c) Offsetting margin and clearance

(d) Completed lower support block

Figure 4: Design process of support block based on 3D scan data

2.3 Cutting path generation for sculpture surface

The inner sculptured surface of support block goes through the process of calculating the cutting path for NC milling as shown in Figure 5(a), and the cutting tool used here is a special tool in the form of a ball end mill on which has a needle-shaped protrusion as shown in Figure 5(b). This cutting path uses a lot of contour line cutting paths so that the slope condition varies smoothly and uniformly during the cutting process.
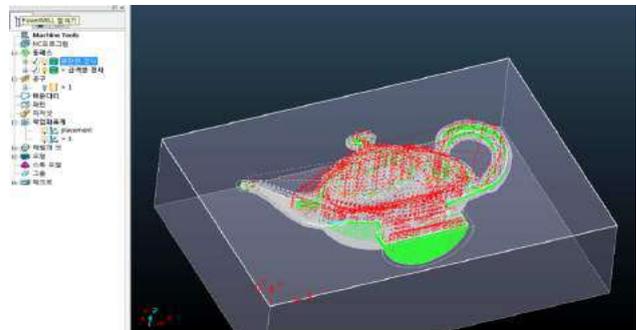
(a) Cutting path generation for inner surface
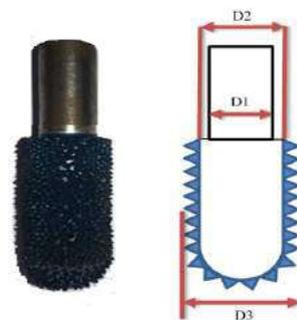
(b) Cutting tool shape

Figure 5: Cutting path generation for inner suface and cutting tool shape

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2.4 Determination of recommended cutting conditions

When polyurethane foam of support block is cutting along the cutter path generated in sculptured surface, poor form accuracy is easy to appear unless appropriate cutting conditions are applied because there is a large amount of deformation of the workpiece due to the elastic cushion. The determination of appropriate cutting conditions is a complex problem in that many factors such as feed speed and spindle speed, as well as machining direction, tool axial cutting depth, and spacing between paths, that must be simultaneously considered.

For this purpose, it tried to search the recommended cutting conditions by considering the characteristics that have a major influence on the form accuracy, that is based on the cutting conditions that have been accumulated empirically through the expert group. To solve this problem, the Taguchi technique [8, 9], which can easily evaluate the influence of each factor, was applied.

When the Taguchi technique is used, the influence of each factor of cutting conditions can be expressed in the form of a weight defined by the S/N ratio. This technique attempts to find the optimum levels for the controllable variables or design parameters. It applies a simple analysis of means to model the results, which gives quantitative information on the control factor effects. The smaller the error value of the form accuracy, the higher the machining quality expressed and the smaller the better characteristics.

So, it would possible to find out which condition is superior through the S/N ratio response table obtained by substituting the results of multiple experiments (N times) with form accuracy as a constraint as a local factor. In the S/N ratio response table, a small value corresponds to the best factor level, so if a cutting condition corresponding to a small value is found in the response table, this becomes the optimal condition in the corresponding environmental experiment area.

Here, the form accuracy is expressed by defining the distance difference between the original 3D model data and the 3D model target data of the finished workpiece. The 3D data of the finished workpiece were collected using commercial T-Scanner [10], and the comparison of surface data between the original and finished one was performed using the 3D shape analysis program named Geomagic Control X [11]. The average of the distance difference between the surfaces was converted in this program.

III. DETERMINATION OF OPTIMAL MANUFACTURING PARAMETERS

3.1 Experiment setup for searching optimal conditions

The initial cutting conditions to search for the optimal cutting conditions are to select the factor that has the greatest influence on the form accuracy, and apply experimentally for two factors: the tool path pattern in the inclined direction and the step over. The Tinyrobo's TinyCNC-6060 milling machine were used in this experiment, as shown in Figure 6, and a ball end mill for foam material manufactured by Taesan Solutions Co., Ltd. in Table 2 standard specification were used.

Table 2: Size specification of ball end mill used

Shank diameter D1	10 mm	Body diameter D2	15 mm
Blade Diameter D3	16 mm	Blade accuracy	50 μm
Blade length	80 mm	Sank length	50 mm
Particle height	0.5 mm	Particle width	1.4 mm
Size parameter	*Refer to Figure 5(b)		

The manufacturing model, as shown in Figure 7, was performed on three parts of the inclined model: a gentle slope(inclination angle of 12°), a sudden slope(inclination angle of 60°), and a corner. The initial cutting conditions were three conditions as shown in Table 3, which are already empirically applied in actual on-site machining. And, as a means to examine the stability of the cutting state, it confirmed the surface roughness measurement using the Mitsutoyo SJ-400

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instrument by selecting the same location for each of the gentle slope (inclination angle 12°), sudden slope (inclination angle 60°), and corner. Also, this measurement applied to 9 samples that have been machined and set the cutoff value to 8 mm.
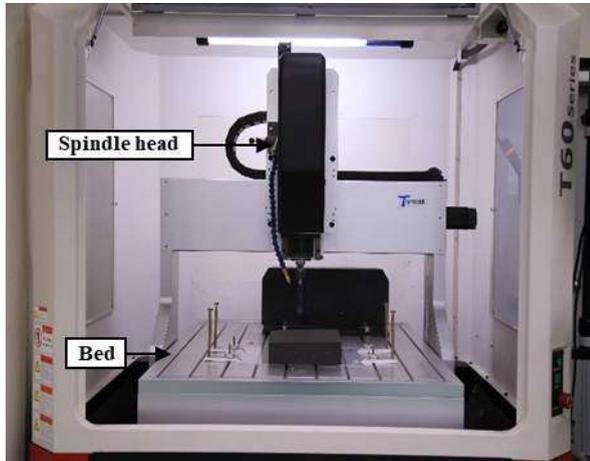
(a) NC milling machine
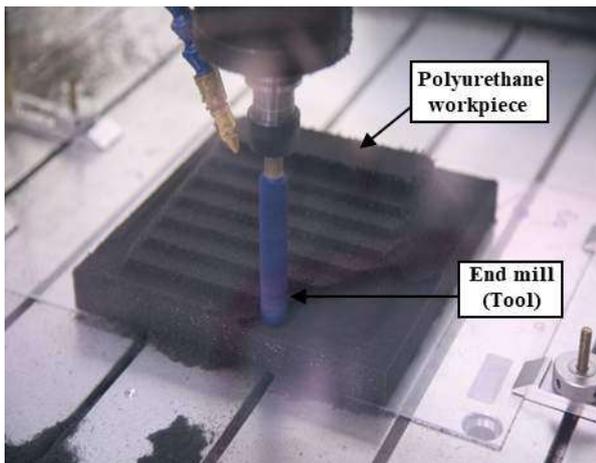
(b) Cutting process of polyurethane workpies

Figure 6: Configuration of NC milling machine and cutting process

(a) Perspective view   (b) Side view
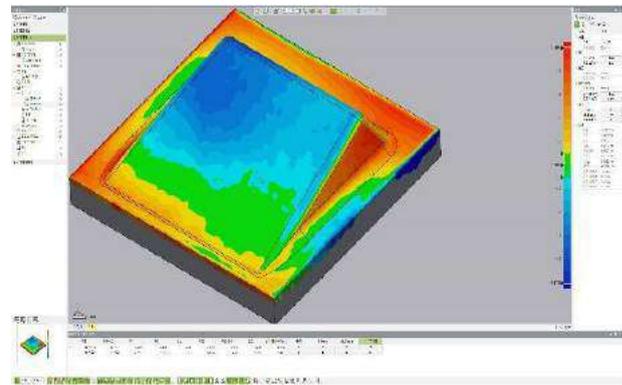
(c) Analysis of form accuracy

Figure 7: Surface model used for inclined machining

On the other hand, the measurement of 3D shape accuracy takes into account the concentricity evaluation of the finished product. As shown in Figure 8, two shapes, spherical and cylindrical, were selected as target models. The three machining conditions were set in Table 3 in consideration of the steep slope in the spherical shape, and then the change value of the form accuracy according to the machining pattern was calculated as the S/N ratio by the Taguchi technique.

The definition of S/N ratio is different according to an objective function, that is, the characteristic value [13]. There are three kinds of characteristic value : Normal is Best (NB), Lower is Better (LB) and Higher is Better (HB). Equation (1) shows the formula for calculating the S/N ratio for the LB characteristic. LB is preferred to determine the best control factor level in the S/N ratio response table.

The S/N ratio of LB can be calculated by

$$S/N = -10 \, log \left[\frac{1}{n} \sum_{i=0}^{n} y_i^2 \right] \qquad (1)$$

where n is the number of measurements, and y_i the measured characteristic value.

Meanwhile, in the case of the spherical shape model, two types of machining are applied: a linear reciprocating pattern through raster machining, and a pattern machining the spherical surface with the ball end mill descending along the spiral slope through spiral machining. For

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these models, both shape precision and concentricity were measured and compared.
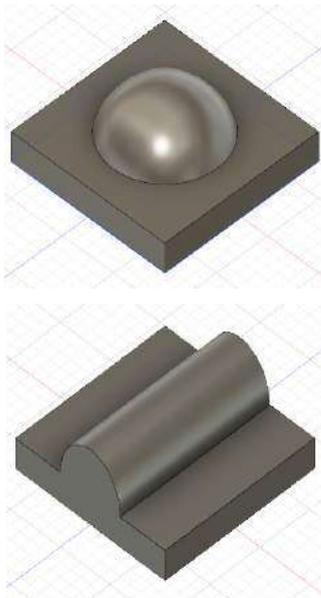
(a) Spherical surface model
(b) Cylindrical surface model

Figure 8: Two kinds of 3D model used for machining verification

Table 3: Three kinds of initial machining condition setting

Conditions factor	unit	Comparison conditions		
		I	II	III
Spindle speed	rpm	1,800	2,000	2,200
Feedrate	mm/min	1,000	1,250	1,500
Step over	mm	0.5	0.6	0.7
pattern	direction	X-axis	Y-axis	Diagonal

Table 4 shows the results of form accuracy measured for each experimental condition and Table 5 is the evaluated result of Taguchi characteristic coefficient (S/N value) obtained by applying the cutting conditions of Table 3 to the form accuracy distribution of Table 4. According to these results, the S/N ratio shows a large difference of up to 280%.

For the object to be machined in Figure 7, the trends of the S/N ratio obtained through Equation (1) are shown in Figure 9 to Figure 11.

As a result, from the point of view of form accuracy, the average value at experiment No. 9 was good at the gentle slope, the value of No. 3 was more good at the sudden slope, and the value of No. 4 was best at the corner.

Table 4: Results of form accuracy for each condition(absolute value, mm)

Sample number	gentle slope	sudden slope	corner
1	0.2645	0.0895	0.2989
2	0.1175	0.0660	0.2770
3	0.1002	0.0148	0.3047
4	0.0660	0.0390	0.1175
5	0.1651	0.1475	0.3039
6	0.0670	0.0347	0.2390
7	0.2074	0.1779	0.4977
8	0.2426	0.6510	0.4725
9	0.0420	0.1315	0.9999

Table 5: Evaluated result of Daguchi Coefficient(Calculated S/N ratio)

S/N Ratio	Spindle speed (Lv. 1/2/3)			Feedrate (Lv. 1/2/3)		
	Step Over (Lv. 1/2/3)			Pattern (Lv. 1/2/3)		
Gentle Slope	15.0	19.2	14.7	14.1	14.8	22.7
	13.5	21.8	15.7	14.8	16.9	16.1
Sudden slope	23.8	22.1	8.0	18.6	8.2	22.0
	8.4	21.1	17.5	18.0	19.1	8.5
Corner	10.6	12.6	3.1	9.3	8.8	4.1
	9.1	4.4	8.4	4.4	9.0	9.6

3.2 Estimated result of optimal cutting conditions

When examining the optimal cutting conditions based on the case where the mesh characteristic value is small in the results of Table 5, first, for the case of the gentle slope machining, the spindle speed which is the condition III (2,200 rpm) in Table 3, is suitable. It can be seen that condition I (0.5mm) is most suitable for the amount of stepover, condition I (1,000mm/min) for the feed speed, and condition I (X-axis direction) for the pattern.

On the other hand, looking at the relative influence of each machining condition here, in the case of spindle speed and pattern, there is not much difference between each condition, but the difference between the maximum and minimum values in the feed rate and stepover is large.

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In the case of sudden inclined part machining, the difference between the maximum and minimum values appears large in most cases. Condition III (2,200rpm) is suitable for spindle speed, but condition I (0.5mm) is the most suitable for the amount of stepover, and feed speed. Therefore, when viewed as a whole, the condition II (1,250mm/min) and the condition III (diagonal direction) are appropriate conditions.
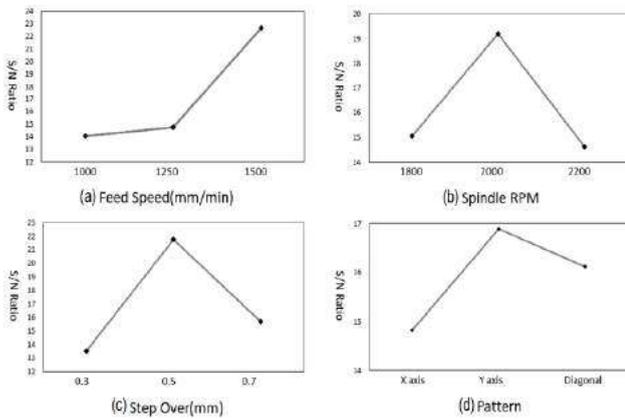
Figure 9: Main effects S/N ratio of a gentle slope
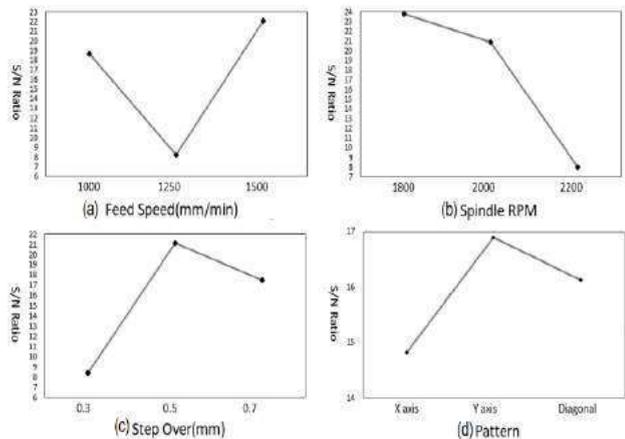
Figure 10: Main effects S/N ratio of a sudden slope
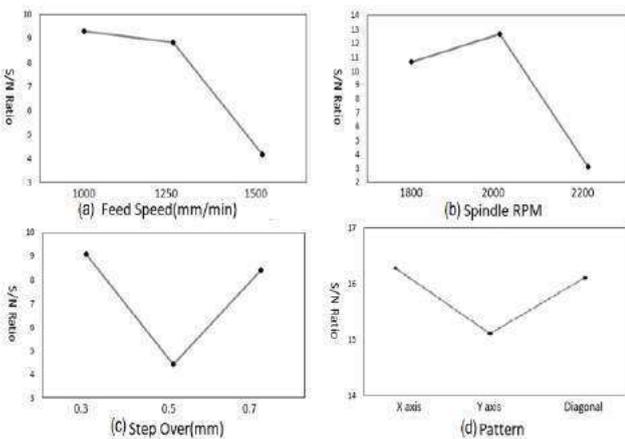
Figure 11: Main effects S/N ratio of a corner

In addition, the difference between the maximum and minimum values is generally large in the case of corner machining. Condition III (2,200 rpm) is suitable for the spindle speed, but condition II (0.6mm) is the most suitable for the stepover. Also, it can be seen that condition III (1,500 mm/min) for the feed speed and condition I (X-axis direction) for the pattern are appropriate.

In view of these results, when cutting regardless of the type of sculptured surface, that is considered as a case of cutting a sculptured surface including all shape elements such as a gentle slope, a sudden slope, and a corner, it is recommended to set the cutting conditions by considering the overall distribution of S/N values.

Table 6: The resulted optimal cutting condition

	gentle slope	sharp slope	corner
Spindle(RPM)	2000	1800	2000
Feed speed (mm/min)	1500	1250	1000
Step over(mm)	0.5	0.5	0.3
Pattern	Y axis	Y axis	Diagonal

Hence, in the environmental conditions targeted in this experiment, the spindle speed is set to No. III (2,200 rpm), the feed speed is set to No. II (1,250 mm/min), and the step-over is set to No. I (0.5 mm). And it can be determined that the pattern III condition (diagonal direction) is an appropriate condition.

3.3 Measurement results of form accuracy

In order to verify the cutting characteristics of the cutting pattern according to the shape of the workpiece against the previously recommended cutting conditions, the form accuracy was examined for two models having spherical and cylindrical surfaces as shown in Figure 8.

For the cylindrical surface model, the X-direction cutting pattern and the Y-direction cutting pattern were applied, and for the spherical model, the cutting patterns in the linear cutting direction and the spiral-linear direction were applied. At this time, the form accuracy of the machined product was measured with a 3D scanner and compared with the CAD prototype model of Figure 8.

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(a) Form accuracy for X-directiont path
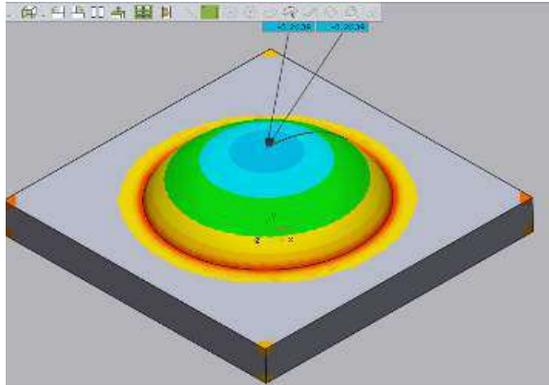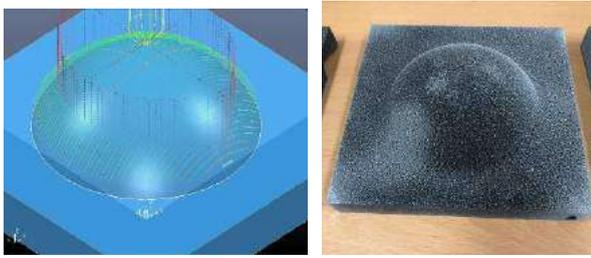
(a) Form accuracy for straight path

(b) Form accuracy for Y-direction path

Figure 13: Form accuracy for X and Y-direction path applied to cylindrical model

Table 7: Comparison of concentricity error for each model

Spherical	Concentricity Error (mm)	Cylindrical Model	Concentricity error (mm)
Straight direction	0.2639	X axis direction	0.5039
Spiral direction	0.1749	Y axis direction	0.3925

The error distribution diagram is shown in Figure 12 to Figure 13, in the form of a distribution map according to the chromaticity applied to the surface.

As a result, it can be seen that the shape error (the amount of deformation of the workpiece) is largely generated in a portion or a corner portion having a sudden inclination. Also, by inputting these scanned data into the Geomagic Control X

(b) Form accuracy for spiral path

Figure 12: Form accuracy for straight and spiral path applied to spherical model

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program [11, 12], the center coordinate eccentricity of the regression analysis surface between the original CAD model and the measured cloud data was obtained, and this was calculated as the concentricity of the spherical surface and the cylinder. The results are shown in Table 7.

Here, the concentricity can be viewed as a scattering of the shape accuracy error for the processed sculptured surface. When evaluating the form accuracy according to the cutting pattern, the error is the largest at 0.5039 mm when the cylindrical surface is processed in the X direction.

When the spherical surface was processed in the vortex-linear direction, it was found to be the smallest as 0.1749 mm, indicating that the shape accuracy when machining the spherical surface in the vortex-linear direction was the best.

In addition, when comparing only the machining of the spherical and cylindrical surfaces regardless of the cutting pattern, it shows that the form accuracy when machining the spherical surface is superior to that of machining the cylindrical surface, which is the slope of the cutting path or the amount of step-over due to the nature of the workpiece. It can be said that the smaller the change in, the better the form accuracy is.

3.4 Review of packaging performance by vibration test

In order to examine the packaging performance according to the clearance of the packaging surface, an experiment was conducted on packaged products and boxes. This experiment was conducted for four packaging methods: PU(polyurethane) packaging with small gap which is machined by recommended machining conditions in this study, PU foam packaging with large gap which is machined by conventional cutting conditions, cotton felt packaging using a goft cotten fiber cloth, and bubble wrap packaging using vinyl with bubble for general shock mitigation.

The process of machining of support block and packaging for this experiment is as shown in Figures 14 (a) to (d). Figure 14(a) is the process of cutting the PU material on the NC milling machine, and Figure 14(b) is the process of inserting the content goods into the support block. The Figure 14(c) is the process of putting the support block into the packaging box, and Figure 14(d) shows the process of mounting it on the vibrator for the vibration test.

The vibration test standards related to the frequency band affecting the packaging should follow the vibration test method of KS A ISO 1017. The frequency was linearly increased from 10 Hz to 40 Hz for 15 minutes.

(a) Machine the sculpture surface on the PU support blcok

(b) Placement of the contents on the support block

(c) Inserting inside the box

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(d) Mount the packaging box on the vibration tester

Figure 14: Arrangement for the vibration shock experiment

In order to know the vibration displacement input from the excitation tester according to each packaging method, an accelerometer is attached to the side of the packaging box to achieve 10Hz and 20Hz. The input amplitude was measured at 30 Hz and 40 Hz and compared with the amplitude of the package contents.

In this vibration test, vibration is given under the same conditions for each packaging method, and the RMS(root mean square) acceleration value as for each 1 Hz section is obtained through the response acceleration according to the time as shown in Equation (2), and the vibration level $dB(V)$ is calculated using Equation (3).

$$a_{rms} = \sqrt{\frac{1}{T}\int_{t_i}^{t_{i+1}} (t)^2 \, dt} \quad (2)$$

$$dB(V) = 20 \log \log \frac{a_{rms}}{10^{-6}} \quad (3)$$

Where a is the acceleration response, T is time taken to increase by 1 Hz, and T= $t_{i+1} - t_i$.

The estimated RMS acceleration value and vibration level was compared for each method. At this time, the acceleration sensor was attached so that the X-axis direction was the direction of gravity.

Table 8 is the data comparing the amplitude of the input from the vibration tester for each frequency and the amplitude of the package contents. In Figure 15, the ratio of the amplitude of the packaged contents to the amplitude input from the vibration tester is compared and graphed for comparison. The smaller the value, the greater the decrease in the input amplitude.

Table 8: Amplitude of frequency interval by packaging method (Unit : mm)

		10 Hz	20 Hz	30 Hz	40 Hz
PU package with small gap	content	1.171	0.179	0.171	0.196
	box	1.348	1.134	1.141	1.205
PU package with large gap	content	2.102	1.287	0.63	0.678
	box	1.348	1.134	1.142	1.205
Cotton felt	content	0.975	1.275	2.125	1.697
	box	1.355	1.142	1.149	1.207
Bubble wrap	content	2.359	1.232	0.678	0.272
	box	1.131	1.135	1.147	1.206

The PU packaging support block with small gap, which is machined by recommended manu-facturing conditions of this study, shows very stable support performance in all frequency ranges compared to other packaging methods.

Figure 15 shows the acceleration response according to each packaging method, and Figure 16 shows the vibration level for each packaging method in a table for comparison.

In the case of PU packaging with large gap and the cotton felt packaging, it was confirmed that the packaged product was not properly supported over the entire frequency range and showed a large range of vibration levels.

(a) PU packing with small gap

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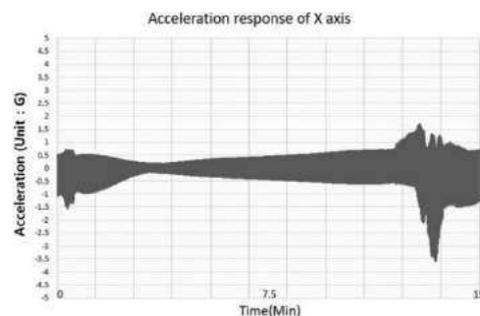
(b) PU packing with large gap
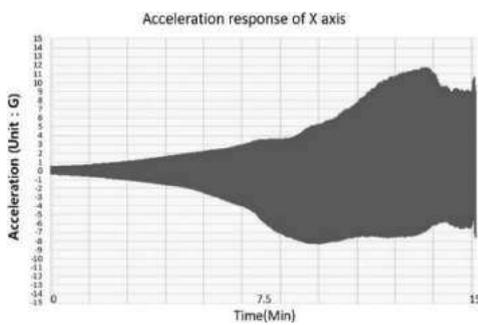
(c) Cotton felt
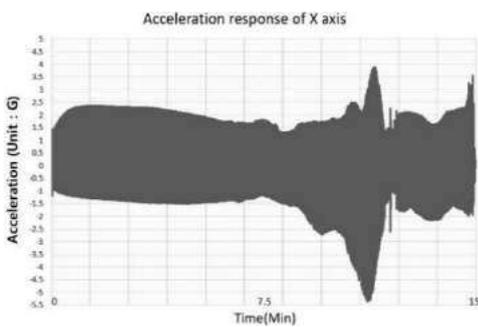
(d) Bubble wrap

Figure 15: Acceleration response of each packing method
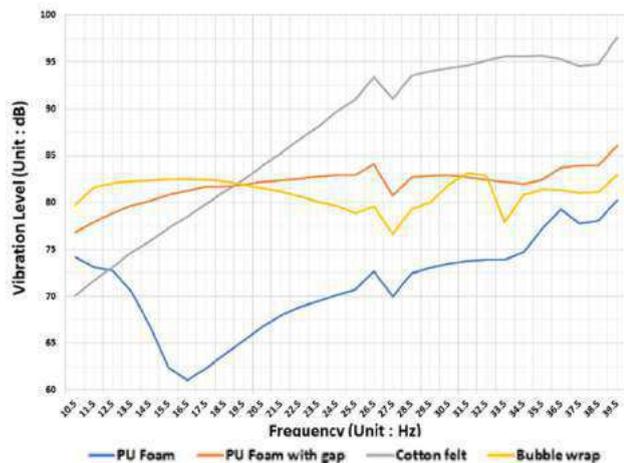
Figure 16: Vibration level of each packing supports method

In the case of packaging using bubble wrap, it has a large amplitude range in the range of 10 Hz to 20 Hz. Also, the vibration is stabilized thereafter, so it can be confirmed that the vibration level temporarily rises around the 30 Hz section.

Therefore, it was found that the PU pavement with small gap showed a better amplitude reduction rate than other packaging methods after 20Hz.

IV. CONCLUSION

Because the polyurethane materials used for packaging support block of valuables have high cushion and elasticity, it is not easy to manufacture them while maintaining form accuracy, which is an important factor that allows the contents to be well protected from shock or vibration during the transfer process. For this reason, it is also very important to well determine various manufacturing parameters in the machining of packaging support block.

This study explored the manufacturing conditions that can maintain the form accuracy of the contact surface so that the support block can stably support the contents. As these parameters, not only feed speed and spindle speed, but also many factors such as machining direction, tool axial cutting depth, and spacing between paths, are considered in a complex manner.

Based on the manufacturing data accumulated by a group of field experts for a long time, the search process of the optimal condition using the Taguchi's method was applied. The optimal conditions were searched through these analysis results, considering the characteristics value that affect the form accuracy as the initial conditions, and considering the mesh characteristic values of the Taguchi technique derived from main effect S/N ratio for a gentle slope, sudden slope, and a corner.

As a result, it was found to be optimal that the appropriate feed rate is 1,250 mm/min, the spindle speed is 2,200 rpm, and the stepover is 0.5 mm in the case of cutting a sculptured surface that includes all of a gentle slope, a sudden slope, and a corner. Also, it could be revealed that it is excellent to select the diagonal direction for the

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cutting patterns, and the PU packing with small gap, which is machined by recommended manufacturing conditions of this study, showed very stable support performance in all frequency ranges compared to other packaging methods in the experiment of vibrational shock test.

However, since these optimal conditions were limited to the environment and to the machinability of the ball end mill used in this study, these conditions may change a lot if the machinability of these tools is different. For this case, if this algorithm is supplemented with the wide range of experience data when a ball end mill of a different shape is applied, it could be used as it is expected that the conditions in the corresponding environment can be expanded to general manufacturing purpose.

For the follow-up study, it is suggested that a lot of empirical data on a wider range of conditions and environments should be accumulated and applied. If a lot of comprehensive cutting data is accumulated for various support block materials with different hardness and elastic modulus, it is thought that it will be possible to derive optimized conditions in the applicable environment by applying the methodology in this study. In addition to the Taguchi method in which such a large amount of data is secured, it is considered possible to use big data-based self-learning artificial intelligence techniques.

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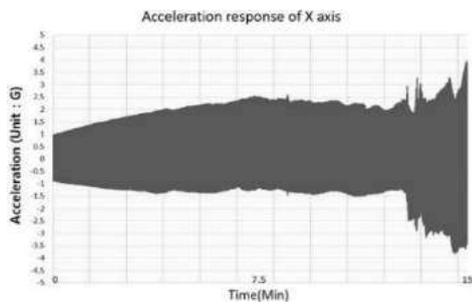3. Nam-Hun, Kim., (2012), Selection of the Optimal Machining Condition for a High-hardness Resin using the 5-axis Machine, Journal of the Korean Society of Manufacturing Process Engineers, 11(5), 29-34.
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Integration of University Projects to Local Development. Case of Study of Camajuaní Municipality

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ABSTRACT

Purpose of investigation work that is presented was to study, with focus of Study of Knowledge Networks, integration among a group of projects of Central University Marta Abreu of Las Villas (UCLV) and Municipal University Center (MUC) of Camajuaní, to actions of local development in municipality. Methods and technical of theoretical and empiric levels were applied. Plan of actions was elaborated starting from theoretical references and results obtained in investigations and field work by students of MUC and UCLV and knowledge of university projects. With this research a work way is contributed that contributes to local development in economic and socio-cultural, heading to endogenous develop- ment of Camajuaní municipality. It was determined evolution, map and channels of interactions, actors and their benefits in local knowledge and innovation network arisen around university projects in Camajuaní municipality.

Keywords: integration, university projects, local development, municipality, university centre, innovation network, evolution, map of interactions, interaction channels, actors, benefits, impacts.

Classification: DDC Code: 320.850971, LCC Code: JV7295.T6

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I. INTRODUCTION

Through their core mandates of education and research, universities contribute prominently to processes of knowledge creation, dissemination and use; they provide society with highly qualified human resources, specific skills as well as new knowledge and ideas;(Nelson, 1993; Pavitt, 1998). Asizable body of literature documents the factors that determine the functioning and efficiency of education and research systems (Lundvall et al., 2002). Universities confront a third core mandate, one that increasingly invites reflection about their roles in economic expansion, social development, political organization and governance (Göransson et al., 2009). Universities are expected to provide complementary assets that support science, technology and innovation activities carried out elsewhere within an innovation system, notably by firms.

Largely inspired by the work of authors such as (Klevorick et al., 1995), (Narin et al., 1997), (Faulkner et al., 1995) or (Cohen et al., 2002), the study of university-firms interactions is perceived as starting point for a dynamic interpretation of the importance, role, and nature of science and technology (Kruss et al., 2015:1). A rapidly growing strand of research seeksto understand the different forms, mechanisms, benefits, motivations and obstacles to interactions between universities and firms (Fontana et al., 2006; Laursen and Salter, 2004; Monjon and Waelbroeck, 2003; Sampat and Mowery, 2004; Santiago and Dutrenit, 2012; Welsh et al., 2008). In the case of developing countries, research on

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university-firms interactions is at an early stage, (Albuquerque et al., 2015) set 2005 as the start date of systematic, comparative work across developing regions. The authors highlight a series of special issues that bring together the results from research projects conducted in Africa, Asia and Latin America (Dutrénit, 2010; Eom and Lee, 2009; Kruss et al., 2012).

Notwithstanding the relative novelty of research on university-firm interactions, work carried out in both developed and developing country contexts has rapidly uncovered the richness and complexity of interactions in which universities participate. Those interactions sustain innovation but also a larger number of problem solving, training and other activities that underpin an economy built on the capacity to generate and exploit knowledge(Göransson and Brundenius, 2011). From a broad perspective of institutional interactions within systems of innovation, the range of stakeholders and potential partners has increased exponentially; universities confront increased demands and expectations about their capacity to contribute to societal change, sustainable development and processes of social and economic inclusion (Arocena and Sutz, 2005; Bortagaray, 2009; Göransson et al., 2009; Göransson and Brundenius, 2011; Kruss, 2012; Pienaar-Steyn, 2012; Vera-Cruz, 2014). The literature documents the heterogeneous interpretations and approaches to this third mandate or mission for universities. (Akpan et al., 2012)and (Göransson et al., 2009)assert that concepts such as 'community engagement', 'community service', 'university–community partnership', 'social responsiveness', 'academic citizenship', 'service learning", 'entrepreneurial university' or 'specialized university" or 'development aluniversity" are used to characterize the ways in which universities seek to respond to pressures compelling them to engage in activities that reach beyond their traditional teaching and research functions. A common conclusion so far is that the capacity of universities to respond to many of these challenges is insufficient, while further research is needed to build appropriate analytical frameworks that help clarify the meaning, contexts of application and ways to properly capture many of the concepts indicated above(Douglas, 2012; Göransson et al., 2009; Kruss and Gastrow, 2013; Pienaar-Steyn, 2012). In other words, the challenge is to make meaningful progress from the theoretical, the ideal, almost aspirational representation of the university, to the transformation of the university into an agent fully identified with and engaged in development (Akpan et al., 2012; Arocena and Sutz, 2005). This paper is a contribution to this debate.

1.1 In search of a developmental university

A lively debate exists on the ever changing relationship between universities and society; increasing interest exist on the interactions that lead to development outcomes and that involve universities engaged with a heterogeneous set of partners defined in the broadest sense possible, as civil society, government officials, and entrepreneurs(Bortagaray, 2009; Göransson and Brundenius, 2011; Kruss, 2012; Vera-Cruz, 2014). Many of these interactions are driven mostly by self-interested, socially committedre searchers; frequently, they occur informally, under the radar of performance evaluation systems and linkage structures at universities (Kruss and Gastrow, 2013). Concrete experiences reflect the agendas and funding streams from international donors (Kruss and Gastrow, 2013; Santiago, 2014). The evidence suggests thatinteractions between universities and a broader set of partners are contextual, embedded in local history and tradition; at the same time, the analysis needs to capture how local interactions connect to global trends concerning the role of knowledge and academic changes(Arocena and Sutz, 2005; Göransson and Brundenius, 2011).In effect, the ideal is universities functioning 'as a bridge between global flows and science and technology on the one hand, and local conditions for economic development on the other' (Göransson and Brundenius, 2011, p. 5)

A developmental university recognizes its critical role in conducting problem-oriented research and in upgrading the productive sector through the formation of skills and the generation of knowledge adapted to local needs. Moreover, it acknowledges that in developing countries, the productive sector is not dominated either by firms

or by industry, but there is a significant participation of other forms of productive organisation in different economic sectors with very low basic scientific and productive capabilities.For this reason, the analysis should capture interactions with different, frequently informally organized, forms adopted by the productive sector (Santiago, 2014; Vera-Cruz, 2014). In these context, the use of traditional notions of innovation is problematic, rather, the concept often needs to be stretched to encompass social innovations, read large,that impact on the quality of life of marginalized communities (Kruss and Gastrow, 2013); in effect, those organizations perform based on problem-solving rather than profit-seeking behaviors where the agents engaged do so from the perspective of doing-using and interacting modes (Jensen et al., 2007; Letty et al., 2012). Research is needed to better understand the forms, mechanisms, benefits, motivations and obstacles to interactions between universities and these alternative forms of productive organizations.

Based on their exploratory study based on South African universities, (Kruss and Gastrow, 2013) suggest that interactions between universities and social actors vary by type of university, the more traditional, research oriented universities focused on traditional knowledge relations and a slow movement towards bidirectional, mutually beneficial partnership. By contrast, universities of technology,characterized by more explicit mandates and commitment to work-integrated and service learning, the interactions more likely imply some forms of technology transfer to small, medium and micro enterprise (SME) partners with students as the main channel of interaction. This observation resonates with the interest of the South African government to make students the champions of social responsibility and social and economic development through community service programmes(Akpan et al., 2012); similar aspirations exist in developed country contexts (Douglas, 2012).

(Pienaar-Steyn, 2012:41) asserts that to better understand the nature and possible development outcomes resulting from interactions between universities and a broader set of social partners requires research into 'articulated standards or objectives with clear indicators against which to monitor progress, measure impact and evaluate effectiveness'. This research would help to appreciate the contribution of universities to development, and to inform strategies in support of such interactions by governments, higher education institutions themselves and even international development agencies. Diverse approaches have been proposed, including for example, linking innovations to economic indicators such as productivity or efficiency, but also more broadly defined notions of sustainable livelihoods or the achievement of Millenium Development Goals (MDG's) (Kruss and Gastrow, 2013; Letty et al., 2012; Pienaar-Steyn, 2012; Santiago, 2014).

1.2 The case of Cuba

Cuba offers a pertinent case to study the interactions between universities and social partners. (Pérez Ones and NúñezJover, 2009)and (Jover et al., 2014) posit that from the late 1980s and early 1990s, teaching and scientific research at Cuban universities have increasingly become more directly and intensely involved with the economic and social development of the country; a process that has not been free of difficulties and challenges and controversies, particularly because of the bottlenecks resulting from existing dynamics, governance practices and incentive structures at universities (Jover et al., 2014; Núñez Jover et al., 2011). This is a process that has taken place in the context of an intense knowledge-driven development strategy and great expectations for the transformation of universities after the University Reform undertaken in 1962. According to (Pérez Ones and NúñezJover, 2009:97), 'The 1962 University Reform underscored the role of scientific research and high-level training, emphasizing sciences and engineering, as well as linking theory and practice in the training of students.' The reform that took place against the dramatic changes in the institutional background linked to the economic, political, ideological and cultural transformation resulting from the Cuban Revolution.'Social relevance and commitment to society were taken upas key values of the new university and scientific institutionalization.' (p.98). The strategic transformation of Cuban universities has

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gradually taken shape including through the creation of production capabilities and the establishment of close relationships with productive agents in key technological sectors –for example, biotechnology and medical-pharmaceutical-, and the creation of specialised offices to facilitate technology transfer from universities to firms (NúñezJover et al., 2011). Cuban universities operate based on an "interactive model" under the assumption that society is much more than market; thus knowledge and science can meet commercial demands, but mainly socialnecessities, demands for equity and social justice (Jover et al., 2014; Núñez Jover et al., 2011).

(Pérez Ones and NúñezJover, 2009) recognize that this positive dynamic of interaction between universities and the productive sector has not necessarily followed pace in other areas of social and economic relevance. However, explicit efforts are underway, including efforts for the decentralisation of policy decision-making, the recognition of non-state owned productive organisations, notably private and cooperative forms, and the creation of municipal university campuses with a mandate to contribute and promote local development based on knowledge and innovation (Jover et al., 2014; Núñez Jover et al., 2011). Research that looks into the nature and results of interactions between Cuban universities and social agents is still limited.

Different interaction forms according to motivations and address of knowledge flows in both addresses or unilateral provision of intellectual resources of innovation producers organizations toward companies and society are: traditional form of interaction where knowledge flows from innovation producers organizations toward companies. Their content is defined by its conventional roles (teaching and investigation); Of services: reason is to provide scientific and technological services that get paid, knowledge flows from innovation producers organizations to companies; Commercial: motivated by an intent of marketing scientific products generated in innovation producers organizations, knowledge flows from innovation producers organizations to companies and Bi-directional: motivated by long term objective of creating knowledge in

innovation producers organizations and to innovate in company, knowledge flows in both directions and both agents provide resources of knowledge. (Dutrenit, 2015).

Construction of interactive processes, conformation of alliances between actors and daily learning in networks formation are characteristic of science, technology and innovation at moment. These processes have been identified in literature for a lot of low time linking concept, being emphasized mainly linking university / company. However, like it has been documented in numerous studies processes of knowledge and innovations generation they imply participation of a wider group of actors. (Casas, 2015)

One of analytic bases that sustains idea of knowledge networks is the position of Sábato and Botana about necessity of integrating 3 vertexes of triangle that it would allow local development: investigation, production and government support institutions. Of there part focus of innovation systems and especially, of regional innovation systems.

Triple Helix focus tries on innovation systems based on relationships among university, industry and government. It is broadly grateful for their importance like base institutional dynamics for creation of goodness in sense of well-being and sustainable development through knowledge generation and their effective application.

While focus of Innovation Systems puts accent in economic logic, networks focus makes it in social logic, Innovation Systems put accent in companies and Triple Helix in universities. When focus of Innovation Systems and Triple Helix has made emphasis in innovation, networks focus has made emphasis in knowledge, from perspective of its generation, distribution and use. (Dutrenit, 2015).

For knowledge networks studies in Latin American context universities and investigation centers have had a central importance because they have given rule to analyze "third mission of universities", in measure that in last decades many universities incorporated in their mission, besides teaching and research, their contribution

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to socioeconomic development, and they implemented a wide repertoire of linking mechanisms with companies (Casas and Luna, 1997 and Casas, 2001) and they have shown importance of knowledge generated in universities for society.

It is appreciated in Cuba a tendency to a theoretical production without bond with practice and a practice without due academic foundation. This prevents to systematize and to disclose good practices that are taken to end in some places of country and that can serve as reference in other territories. (Núñez et al. 2006)

The linking of university and territory projects makes that generalizes good practices and those be used for benefit of municipality. "Dissemination of Participative Phyto improvement in Cuba" a precedent went to Project "Program of Local Agricultural Innovation" (PIAL). It had as starting point a conventional agricultural innovation from academy, where extensionists disseminates results so that farmers adopts techniques and practices according to their necessities.

In Camajuaní municipality exists integration among key areas for territorial development and several university projects. This article is related with work carried out in the municipality with projects PIAL, Coinnovación and Agrocadenas. Their general objective was: To contribute to study of interactions of academic institutions with social and productive sectors so that good practices contributed by University Projects are implemented in Municipal Strategy of Local Development and Local Innovation Groups consolidate as participation spaces in Innovation Platform for Local Development.

II.   MATERIALS AND METHODS

2.1 Case study: Participation of University Projects in local innovation

As previous action, they were carried out, for students of municipality, belonging to several careers of Marta Abreu Central University of Las Villas and guide professors of Camajuaní Municipal University Center, a diagnosis from their labor practice, coexistences with actors in cooperatives and Theses of studies culmination.

Case study went toward work that carry out productive units that are sample of trust of Projects: PIAL, Coinnovation and Agrocchains for development of territory. Students of Agricultural, Sociology, Social Communication and Sociocultural Studies careers participated.

By means of documents study, regularities were determined on Initiatives of Local Development (IMDL) manifested in investigations of theses of Sociology and Sociocultural Studies careers students' of MUC.

In whole process of work organization we kept in mind methodology for knowledge management of Lage (2005) that outlines that knowledge management supposes: a) actors' identification; b) construction of networks; c) build conectivity; d) stimulate and organize interactions; and) create in companies capacity of assimilating knowledge and technologies; f) arm "closed cycles" across direction by projects; g) implement training for a lifetime; h) select, qualify and evaluate directives; i) build infrastructure (informatization among other demands) and j) build and evaluate indicators.

We kept in mind three focuses of networks that have influenced in study of knowledge networks that it can work as complementary and starting from them analytic marks can be built: 1. Analysis of Social Networks (ASN) or formal analysis of networks that is in charge fundamentally of networks morphology and it allows to deepen in study of social structures that underlie to knowledge and information flows. Its application to study of collaboration in I+D is novel. 2.. Focuses based on "Theory of Actor Net" (TAN), where net notion has a bigger theoretical statute because it tries to decipher complexity from bound phenomena of innovation, and in particular to diffusion of innovations, with base in recognition of importance of learning. It is in charge of processes, dynamics and evolution of networks and of building analytic models to describe their trajectories and 3. Focus of network like integration mechanism, inscribed in theories of social coordination, of half range. (Casas, 2015) Methodological approach that we have built starting from mentioned influences, has considered following dimensions: 1: morphology: actors that participate, their interests and

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motivations; when they enter or they leave scene. 2: genesis and dynamics: forms like are coordinated and interacte participant actors; which their integration forms and form in that approach conflicts, they solve problems and they make decisions. 3: nature of knowledge flows that take place in context of network: what actors exchange, which channels are for exchange (mobility), what effects they have in improvement of new products and/or processes, nature of knowledge that is exchanged (coded, tacit), if impact is direct and immediate, what kind of information it exchanges: market, technique, scientific; what type of knowledge: devise, abilities, experience, methods and 4: impact of knowledge network in: formation of human resources; processes/products improvement; New processes/products; solution of an economic or social problem and opening of new investigation and of basic investigation lines.

This way, we socialized with communities antecedents of work and basic principles of PIAL, Coinnovación and Agrochains projects in territory and contributions that make for local development. Then were taken to end coordination actions and elaboration of annual operative plan (AOP 2014 or 2015) for Municipal Platform of Local Agricultural Innovation.

Specific objectives of University Projects with Platform of Local Innovation were: To contribute to invigoration of municipal capacities for local development starting from good practices contributed by University projects and to create capacities in government and local actors to formulate and implement strategies, programs

and municipal projects with agricultural, of gender, concerted and sustainable focus. Four trasversal axes were seen: genetic and technological diversity, gender transversalización, adaptation and mitigation to climatic change and work with women and youth.

III. RESULTS AND DISCUSSION

3.1 Clasification of interaction channels

Interaction channels among University, represented in territory by MUC and productive sectors, services and local authorities are represented in the Table 1. By means of them, University comes closer to problems of the Municipality in periodic diagnoses and obtains pertinent investigation topics. Meanwhile society receives scientific results obtained in academy that can be introduced to social practice with growing increment of quality of population's life, principal objective of our economic-social formation.

Contrary to most of consulted studies that concentrates on university-company relationships, our case study includes relationships of university with social, productive and of services actors, and mainly with Government and local authorities. This result is based in that Cuban university fulfills social objective of advising to Government, Companies and Organisms in its Development Strategies and training of its directives. Ministry of Higher Education advises, at central level, to Government in Strategy of National Development and it directs National Schools of DirectivesTraining.

Table 1: Interaction channels in Local Network of Knowledge and Innovation Management

CHANNELS	WAYS OF INTERACTION
Traditional	Conferences and Meetings, Publications, pamphlets and folding Work of students in their communities
Services	Actors' training in situ and in MUC, Informal consults Professionals give classes in MUC and professors go to companies Consultancy and technical attendance and Technical Advisory Council of Government
Commercial	Patent and registrations of varieties, computer and of intellectual property Creation of educational Units in Companies and Organisms (spin-off) Sale of seed of new varieties, sementals and strains of microorganisms
Bidirectional	Institutional and Managerial projects, Combined projects of Innovation - Development Office CIH in University contract investigations and introduction of results

Benefits obtained by investigators, government, companies and organisms product of relationship

among university, represented in territory by MUC, productive and services sectors, and local

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authorities are represented in Table 2. These resemble each other reported by Dutrenit (2015) for Latin America although order of priority changed. In our study have priority search of benefits of social recognition for investigators and work group to improve quality of local life in productive and service sectors, and government. It responds to priorities of Socialist Social System that reigns in Cuba.

Table 2: Analysis of benefits in Local Network of Knowledge and Innovation Management Researchers

CHANNELS	FORMS OF INTERACCIÓN
ECONOMIC	Financial and material resources to research
	Pay of publications and participation in Scientific Events
	Access to use of technologies, reactives, seed and equipment
INTELLECTUAL	Social Recognisement
	Appropriation of organizational and technical know how
	Possibility of diagnose to obtain pertinent investigation themes
	Empowerment in gobernment decision centre for consulting position

Companies of productive services sector and government

WAYS OF INTERACTION	BENEFITS
Technological surveillance of tendencies in field and obtain training at measure of necessities. To be able to hire services of environmental and social diagnostic and t obtain support in knowledge and innovation management	Related with long term innovation estrategies
To request manpower to form in Academy with prospective and to use it while they study. To obtain consultancy to solve problems of productive process ex ante y ex post. Use of tests and quality laboratories and prove products and services at pilot scale.	Related with short term production activities

3.2 Relation between channels and benefits

We coincide with Dutrenit (2015) in that agents have different motivations, value different types of knowledge and obtain benefits of different nature. Also, they generate different benefits for each agent. Investigators and companies prefer channels of services and traditional and informal interaction forms and those wrap human resources. Equally, commercial channel, with obtaining of patents, incubators, spin off, etc., is less important for both agents.

In study we have discovered that, like it is a regularity in Latin America (Casas, 2015), effect that have innovation and investigation projects is very positive about benefits obtained as so much for companies and organisms of municipality like for professors and investigators of MUC and University.

We also find that while nearer is collaboration among actors, combined university projects have more positive effects on quantity and quality of academic publications presented in Congresses and published by academics, mainly if it was carried out together with their partners in society. Example of it is that most of directives of companies, organisms and government in our municipality possess scientific categories of Master or, at least, have some Graduate study in their specialties.

3.3 Paper of students in the municipality

Recently graduate students have become an exchange agent to foment innovation in companies, organisms and Municipal Government. We are able to prepare them to play that paper of interface among results of their professors that are investigating in University and companies, organisms and municipal authorities of their town, during their entire career.

In their curriculum, although they are studying outside of municipality, it is hired with University that formed them that all productive practices, course works and their investigation of Diploma Work are carried out in the municipality, solving a problem whose solution contributes to Local Development.

We have experience in achieving that graduates of municipality don't emigrate with otorgation, since they were students, of a job in the municipality that guarantees him an interesting work, implementing in local socioeconomic life results of investigations that as student they carried out.

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This leaves clear that is necessary to formulate new politicians that promote a bigger impact on graduate students to stimulate interactions and, by this way, local innovation.

Table 3: Actors and interactions of Local Network of Knowledge and Innovation Management

No.	Actor	Institutions	Interactions
1.	CLIA Camajuaní	MUC, Municipal Delegation of Agriculture, Municipal Bureau of ANAP, Agropecuaria Compant Luis Arcos, ACTAF, ACPA, Local Gobernrnent, MUC of Health, Municipal secretariat of FMC, Municipal Committee of UJC, CDR, CITMA, Movement of Science and Technique Forum, CCS, CPA, UBPC.	Position of demands and ideas of projects. Reception, Discussion and decision of local priorities. Discussion/decition of Annual Operative Plan (AOP) Administration of coordinated actions. Knowledge and Innovation management. Evaluation and monitoring of Network. Documentation and systematizing of results and impacts. Combined preparation of Projects, Programs, Lines and Strategy of Local Development.
2.	Municipal Group of Local Development Projects	MUC Camajuaní, Municipal Delegation of Agriculture, Municipal Bureau of ANAP, Agropecuaria Compant Luis Arcos, ACTAF, ACPA, Local Gobernrnent, MUC of Health, CITMA, Movement of Science and Technique Forum.	Position of demands and ideas of projects. Reception, Discussion and decision of local priorities.. Administration of coordinated actions. Knowledge and Innovation management. Evaluation and monitoring of Network. Documentation and systematizing of results and impacts. Combined preparation of Projects, Programs, Lines and Strategy of Local Development.
3.	Polítical, gobernment and of masses Authorities	AMPP, PCC, ANAP, CDR, FMC, ACRC, UJC.	Position of demands and ideas of projects. Recepción of demands and ideas of projects. Discussion and decision of local priorities. Administration of coordinated actions.
4.	Municipal and province´s organisms	MINAGRI, MEP, MES, CITMA, MINED, MINSAP, MTSS, ONE.	Position and Recepción of demands and ideas of projects. Discussion and decision of local priorities. Administration of coordinated actions.
5.	Universities, Centers of Investigation, Media.	UCLV, UNICA, CENSA, INCA, ICA, CIAP, CEDEM, Radio CMHW, Caibarién Radio, Tele Cubanacán, Rev. Agricultura Orgánica.	Position and Recepción of demands and ideas of projects. Discussion and decision of local priorities. Administration of coordinated actions. Knowledge and Innovation management.
6.	ONG and other movements.	ANAP, Movement of Science and Technique Forum, ANIR, ACTAF, ACPA, ANEC, APC, COSUDE, HIVOS.	Position and Recepción of demands and ideas of projects. Discussion and decision of local priorities. Administration of coordinated actions.

3.4 Regularities about situation of IMDL in thesis of Sociology and Sociocultural Studies of MUC

Municipal Directives has training lack on knowledge management, requires abilitie in Local Development.

- Limited activities, of Council of Municipal Administration, directed to impel Local Development
- Little interrelation with local actors that can contribute to development.
- Limited exploitation of local resources and not recognizing necessity to combinate endoge-

nous and exogenous factors that can lead to local development.
- Lacks in government of a defined Strategy of Local Development.
- Insufficient orientation actions and local agents' preparation.

Main characteristics of municipal productive distribution obtained in diagnosis carried out by means of participative observation in productive spaces and directives of Cooperatives and Management Systems of ANAP were:

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Table 4: Fundamental products that were cultivated in the municipality in the period

Products	Volume of annual production	Varieties
Beans	84.1 t.	3
Corn	198.8 t.	2
Banana	272.2 t.	4
Yucca	152.0 t.	1
Sweet potato	51.0 t.	2
Malanga	130.0 t.	1
Rice	850.0 t.	3
Tomato	250.0 t.	2
Yam	83.0 t.	2
Mango	156.5 t.	5
Peanut	134.8 t.	2
Other fruits	150.0 t.	-

Table 5: Productions in cattle segment

Product	Volume of annual production
Cow milk	965 000 l.
Pig meat	260.0 t.
Ram meat	16.0 t.
Rabbit meat	6.0 t.

3.5 Impacts of Innovation made by Universitary Projects in the municipality

Seed productions are carried out in own productive units except for seeds of tobacco. Means of work of animal traction are already used, fundamentally American plow, Creole plow, tier of prickles and farmer, thrown by oxen.

Integration of animals to agriculture-ecosystem arrives in properties to a range from 1 to 1,5 mature animals for hectare although properties are possessed with a range from 0,3 to 0,5 mature animals for hectare and properties with a range of 0'5 to 1'0 mature animals for hectare·

Level of recicling of system is given in use of organic residuals without breaking down for slowness of process, insolent organic residuals on surface of soil and use of some techniques of recicling of residuals of property. There is 10 biodigestors mounted in properties with big swinish breedings and in 45% of properties compost crop remains for organic fertilization and to eliminate pathogens and pests.

Conservation of vital functions of agriculture-ecosystem is manifested in a general way in practices of sowing alive fences, breaking new ground against the slope, rotation of cultivations, use of biological means in handling of pests, policultives, natural patches of vegetation, use of repellent plants for pests and conservation of good quality of landscape.

As for handling of pests and diseases fundamental actions go directed to alternative use of chemical products with antagonistic bacterias and fungi, efficient microorganisms, biological control, predators and cultivation rotations for handling of pests and diseases and majority use of MIPE with products of properties.

The resources of energy of used agroecosistem are combination of external inputs with animal traction, human energy and other inputs of property like seeds. Wind mills are generalized in properties for extraction of water of wells, mainly for attention of livestock.

Project Coinnovación closed its cycle leaving formed to multipliers of its experiences, 3 Centers of Production of Efficient Microorganisms, a Shop of Production of Silos to conserve seeds, inputs to work Agroecology and to modernize center for reproduction of Entomofags and Entomo-pathogens (CREE) and 3 reference Properties in municipality. In their shops they spread agroecologic technical that producers considered more useful under local conditions.

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PIAL Project begins its third phase and with her it seeks to contribute to decentralization of taking of strategic and financial decisions from program to municipal level. In initiatives that start it prevails chain focus or work in net. Synergy is propitiated among actions of program with other local initiatives, structures and municipal organizations. Institucionalization of good practices of program in strategies provides to give priorities to society, institutions and municipal organizations.

Training in Sustainable Development and Strategic Address for 65 directives facilitated taking of decisions for: President, vice-presidents and officials of AMPP, Presidents of Popular Council, Directors of Companies of Local Subordination, Specialists of Science and Innovation in Companies and Professors of 4 MUC. Training of a critical mass of specialists, leaders, peasants and residents are vital for invigoration of local innovation as alternative of agricultural development.

Actors of agricultural sector were qualified in 97 training actions with 4.261 actors' participation. MUC, involved with local actors, strengthens local systems of seeds and innovation in Agriculture. 7 Centers of Biological and Agricultural Diversity and Local Agricultural 7 Groups of Innovation were constituted, Local Agricultural Platform of Innovation (PIAL) with their Annual Operative Plan (POA).

Local biological and technological diversity was increased, having bigger number of technologies, varieties and clones, races of vegetable species and animals with an increment of yields of viandas cultivations in 12% and grains in 8%. it was achieved in two properties productions of ecological bean with yields of 1,8 t./ ha.

Network utilities were increased by concept of increments in diversification of production, revenues for sales of seeds and products of added value and decrease of production costs and actors' of municipality sensitization, toward employment of agroecologic practical in foods production.

Empowerment was achieved from woman when assuming producer role, what confers them identity and strengthens taking of decisions.

Knowledge flows toward territory favor introduction of new technologies that impact favorably in agricultural production in municipality. Increment of relationships with educational, scientific and investigation institutions in productive base of territory, increased municipal alimentary sovereignty.

Generation of new employment sources for women, bigger adults and youths in territory facilitated a sustained increment of participation of women, bigger adults, children, adolescents and youths in training spaces and innovation. This has also strengthened interdisciplinary focus in solution of municipality problems with sinergic appropriation of scientific methods, technical of investigation and technical language.

We had great improvement of curricula of Municipal University Center with 27 agricultural professionals' formation, 5 Master in Agricultural Sciences, a Master in Sustainable Agriculture and 2 Doctors in formation.

We leans on taking of local actors' decisions on which technologies to adopt and to introduce for what integration between University and society facilitates access to genetic and technological diversity to local actors. Also training to Directive Meetings of rural cooperatives, starting from a command of ANAP Congress, gave an overturn to performance of ANAP in the municipality.

3.6 Principal strategies that support the universitary projects

Free access to the genetic and technological diversity and stimulation of experimentation "in situ" and exchange and local dissemination of genotypes and knowledge to consolidate innovation groups or primary centers of genetic and technological diversity, with support of local institutions.

Develop and implementation of learning processes in an action that supplement the curriculum of degree and pre-degree students, technological transfer and creation of capacities and abilities in producers and decisors.

Development of concrete initiatives that contribute to diminish the vulnerability in front of

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the climatic change and to mitigate the emission of gases of hothouse effect

Develop of positive actions to contribute to the gender justness

Decentralization of planning, implementation and evaluation of actions and strategies of Projects at the hands of local institutions that coordinate the work of Local Centers of Agricultural Innovation and groups of local innovation.

The work with focus of agricultural chain, where all the links should be developed in function of adding value to the agricultural productions.

3.7 Functions of Municipal Universitary Center to the linking with local development

- It is not limited to the formation of professionals; their capacity to produce, to diffuse and to apply knowledge is increased to the functions of Investigation and Technological Innovation, Superation of Graduate degree, Training of Directives and University Extension, among others.
- It takes to the Territory a Local System of Knowledge and Innovation Management to participate actively in the development, interacting with all the actors of the Municipality.
- It facilitates the knowledge of people and institutions that nuclete to their surroundings to the service of the solution of the problems of the Territory, arising a new collective actor able to favor the creation of competitions for the management, assimilation and creation of knowledge of social significance, always linked with the remaining political, administrative and educational actors of the territory.
- It participates to establish connections that allow the local flows of knowledge.
- Their mission is to act as outstanding local agent, dinamizer, able to identify the local problems and to collaborate in social construction of knowledge that facilitates its solution.

3.8 Procedures acepted and assumed by the Local Innovation Platform

1. Exchange among actors. (Productive units, Properties, Cooperative, Government, CITMA, ANAP, MINAGRI, PCC, FMC, UJC, UCLV and CUM, among other)
2. Use of spaces with the mission of advising the actors on the good practices of the University Projects PIAL, Coinnovación and Agro-cadenas.
3. Training to actors in charge of the processes.
4. Socialization shops between producers and social actors in the community.
5. To support Strategies of the municipality in the Government, Companies and Organisms.
6. To create municipal platform for the reflection on the results of the diagnosis and the elaboration of actions of the Platform of Local Agricultural Innovation.
7. Concretion of the agreements in the Strategy of Local Development of the municipality.
8. To disseminate good practices from the Platform to producers and communities.
9. Evaluation and annual upgrade of the results and diagnostic.
10. To create Indicative r of acting to measure r impacts of the work.
11. Systematizing of the obtained results.
12. The Plan of actions agreed in the Shop of Annual Operative Plan 2015 (POA 2015) carried out in the Theater of ANAP with Government's participation, ANAP, CUM, UCLV, Cooperative, Delegation of Agriculture, Physical Planning and all Organisms and implied Companies are exposed in the Chart 1.

3.9 Procedure adopted in the POA 2015

1. Exchange among subject of the Local Development. (Party, Government, University, MUC, organizations of the civil society, ONG and other actors.)
2. Creation of an instance, office or another denomination, with the mission of auxiliary to the government in the whole work related with the local development
3. Training process to subject of the Local Development.
4. Elaboration of the characterization of the municipality for the advisory Technical

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Council (CTA) and the government's auxiliary instance for the development.

5. Space reflection group on the results of the characterization.

6. Upgrade of the proposal of Prospective, Strategy of Community Local Development, Program and Projects of the municipality previous analysis of the prospective and base strategies.

7. Analysis and approval for AMPP of Local and prospective Strategy of Development.

8. Concretion of agreements in Plan of the Economy to add them to the Budget.

9. Evaluation.

10. Systematizing.

Table 7: Plan of actions agreed in the Shop of Annual Operative Plan 2015

Objective	Acción	Participan	Responsable	Fecha
1. To strengthen munici-pal capacity for local development starting from good practices contribu-ted by PIAL, Coinno-vación, Agrocadenas	1. Linking of topics of studies culmination to problems of the territory. 2. Carry out coexistences in CPA Rubén Martínez. 3. Students' linking of UCLV to Labor Practice to the territory and PIAL. 4. to carry out the diagnosis.	Professors, students local actors	Professors Professors and decisors. Professors Professors and decisors.	First stage
2. To create capacity to formulate and implement strategies, programs and municipal projects with agro-pecuarian focus, of gender, concerted and of sustainable development in government and local actors.	1. To create the platform. 2. Realization of participative workshop to elaborate POA. 3. Creation of exchange space. 4. Carry out Shops of seeding of varieties of seed of corn with women's participation and young. 5. Training in investment projects and microindustries for the professors of PIAL and MUC Camajuaní for Economy Faculty. 6. Training and exchange of grasses and forages, to elaborate local cattle foods and reproduction of bovine livestock. Visit UBPC Landing of the Granma. Exchange experiences of Leadership with youths. 7. Commercialization Fair with innovative women in greeting at March 8 8. Training on investment project and Microindustry. Exchange among producing with results. 1. Realization of 2 shops of training of coffee and fruit-bearing. 2. Training in gender, rural development, innovation and analysis of social networks. 3. Training swinish rabbits and birds in Placetas. Exchange of products and among producers. 4. Shop training in agroecológical practices: conservation of soils, compost elaboration and biodigestores. 5. Fair of corn 6. Shop and seeding of varieties of bean seed, with participation of women and young.	University Professors Local decisors Young producers Members of platform, producers, mplicated actors Women and youngs govermetn, MUC, ANAP Young producers.	University Professors Local decisors University Professors Local decisors University Professors Local decisors Specialists Specialists Members of platform Specialists Specialists Specialists, producers Specialists, producers Members of platform Members of platform	Second stage
2. To implement strategy, programs and projects in Platform	1. Shop of Evaluation POA-2015. 2. Gender shop.	Platform Women and youths.	Proffesors, producers and decisors	Third stage

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VI. CONCLUSIONS

1. The alliance of the MUC with the University Projects Program of Local Agricultural Innovation, Coinnovación and Agrocadenas has had an essential role in the bond university territory for the Projection of the Local Development in the Municipality Camajuaní.

2. For the local governments it is necessary the bond with the University Projects by means of the MUC so that the realization of synergies is propitiated among projects that provide the development of the territories

3. The participation of the MUC and other local actors, under the direction of the Government, in the dissemination of the good practices contributed by the University Projects Program of Local Agricultural Innovation, Coinnovación and Agrocadenas generated processes of local innovation based on strategic processes and participative dynamics.

4. Importance of fomenting several interaction forms and of the students for the companies and organisms

5. Politics's formulators should put emphasis in promoting those characteristics of the investigators and companies that are more tuned to generate practics of linking.

6. For Investigators all the channels except the commercial one generate intellectual benefits. The channel of services is the most effective to generate economic benefits but in the companies the bidirectional and traditional channels are the most effective to generate both types of benefits.

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Design and Implementation of Amba based Ahb2apb Bridge

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ABSTRACT

The Advanced Microcontroller Bus architecture is an open system-on-chip (SoC) protocol used by high-end devices to communicate with low- power devices. AMBA uses an advanced high- performance bus (AHB) to connect high performance processors, DSPs, and memory controllers, and an advanced peripheral bus (APB) to connect low-bandwidth peripherals such as UARTs. There is also a bridge connecting the AHB and APB buses. A bridge is a standard interface that allows IP addresses connected to different buses to communicate with each other in a standard way. This paper represents the design and implementation of a Bridge that connects AHB and APB known as AHB2APB BRIDGE. The bridge is designed using Verilog HDL and implemented using XILINX ISE tool.

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The Advanced Microcontroller Bus architecture is an open system-on-chip (SoC) protocol used by high-end devices to communicate with low-power devices. AMBA uses an advanced high-performance bus (AHB) to connect high-performance processors, DSPs, and memory controllers, and an advanced peripheral bus (APB) to connect low-bandwidth peripherals such as UARTs. There is also a bridge connecting the AHB and APB buses. A bridge is a standard interface that allows IP addresses connected to different buses to communicate with each other in a standard way. This paper represents the design and implementation of a Bridge that connects AHB and APB known as AHB2APB BRIDGE. The bridge is designed using Verilog HDL and implemented using XILINX ISE tool.

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I. INTRODUCTION

AMBA is an interconnection standard for SoC that supports high bandwidth, speed and pipelined data transfer using various bus signals In some cases, if the device on the AHB side needs to communicate with the device on the APB side, a bridge is needed for proper communication. Jehun Song et al. Proposed an effectively tested on-chip / off-chip bus bridge SOC design for advanced high-performance on-chip buses and off-chip peripheral interconnect buses. This was exploited by maximally reusing the Bridge function to get efficient functional and structural testing [1].

Protocols are the back bones of the SoC designs as their failure may result in malfunctioning chips. Open Core Protocol (OCP) and AMBA-AHB are the most commonly used and standard protocols. A bridge was designed and reported to interface these protocols as they play important role in an SOC application where it may lead to failure if it does not work properly. Initially these protocols were modelled using Verilog and simulated [2]. Advanced Microcontroller Bus Architecture (AMBA) is an embedded bus architecture used to improve IP core reuse and is a widely used system-on-chip (SOC) interconnect standard. Here, Synthesized Net list of Bridge module is generated [3].

Enhanced Extensible Interface (AXI 4.0) and Enhanced Peripheral Bus (APB4.0) are commonly used in microprocessor bus architectures. Bus bridges are designed to interact with these protocols. These protocols play an important role in SoC applications because they can crash the application if they do not work properly. The simulation results show that the communication between AXI4.0 and APB4.0 over the bridge is correct. All commands and data are properly connected from the AXI4.0 protocol to the APB4.0 protocol. There is no loss of data or control information [4]. The author, Krishna Sekar, proposed Flex Bus, a new architecture capable of efficiently adapting the communication architecture and the logical connections of the components connected to it. The Flex bus achieves this by dynamically managing both the communication architecture topology and the mapping of SoC components to the communication architecture. This is achieved by using new methods of dynamic bridge crossing and component remapping [5].

The proposed paper is organized into different sections. Section II gives information about the AHB2APB bridge implemented whereas Section III describes the implementation procedure of the bridge. Results are reported in Section IV. Conclusion and future scope are discussed in Section V.

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II. AHB2APB BRIDGE

2.1 AMBA System

Soc Generally defined as an integrated circuit that contains all the necessary elements that make up a computer. The component textures on the chip quickly made the connection and management of the six subsystems a disaster.
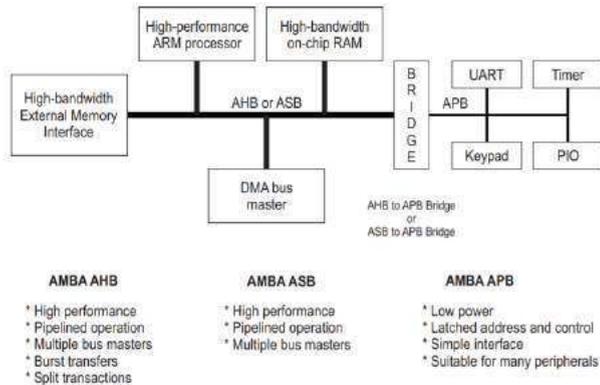

Fig. 1: Typical AMBA System

AMBA is one attempt to solve this problem. A typical AMBA system is shown in Figure 1. AMBA is an open standard that outlines how to connect and manage various components or blocks within a SOC. AMBA-based microcontrollers typically consist of a high-performance system backbone bus (AMBAAHB or AMBAASB) that can maintain external memory bandwidth. The high performance bus also has a bridge to the low bandwidth APB where most of the peripherals in the system are located

2.2 AMBA AHB

AHB is AMBA's next generation tire to meet the demands of a high performance design. AMBA AHB is a new layer bus that sits on top of the APB and implements features required for high performance, high frame rate systems such as:

1. Explosive material
2. Separate Transfer
3. Delivery of the bus master in one cycle
4. Tri-state implementation
5. Larger data bus configuration (64/128 bit)

2.3 AMBA APB

The Advanced Peripheral Bus is part of the Advanced Microcontroller Bus Architecture bus hierarchy and is optimized to minimize power

consumption and simplify interfaces. AMBA APB should be used for interfaces on all low bandwidth devices that do not require a high performance pipeline bus interface.

2.4 AHB2APB BRIDGE

AMBA connects support for high throughput, width and data pipeline with an elaborate set of bus signals. In some cases, if the device pointer communicates with the APB device, a proper communication bridge is required.

The bridge can be designed for both asynchronous FIFO and handshaking. This bridge was designed using manual signal wash to reduce damage. The AHB2APB Bridge provides the high speed AHB and the low power APB acts as a interface. The read and write translations in point B are converted to equivalent translations in the APB. For example, APB does not wait for a pepper image to be inserted in translations to and from APB when APB is waiting for point B, which ensures no data loss.

AHB2APB connects the AHB interface to the APB interface. Stores peripheral device addresses, controls, and data signals, address buffers, controls, and data from the AHB, and manages peripheral device and APB data with response signals to the AHB.

III. IMPLEMENTATION PROCEDURE

The Architecture of AHB2APB Bridge is shown in below figure 2. It has 3 modules to be designed are listed below-

1. Bridge Top
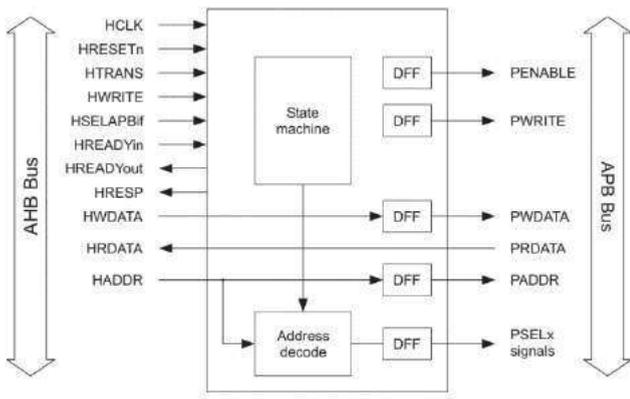2. AHB Slave
3. APB Controller

Fig. 2: Architechture of AHB2APB Bridge

2.1 Bridge Top

This has 2 basic modules namely AHB Slave and APB controller which are designed individually and instantiated in the top module.

Verilog Code Implementation steps are explained below:

a) Define ahb_apb top bridge consisting 9 input signals namely Hclk, Hresetn, Hwrite, Hreadyin, Hwdata, Haddr, Prdata, Htrans, Hsize and 8 output Signals namely Hresp, Hrdata, Hreadyout, Penable, Pwrite, Paddr, Pwdata, Pseln.

b) Instantiate APB Controller module consisting of FSM.

c) Instantiate AHB Slave Interface.

2.2 AHB SLAVE

This module has logic for implementing Pseln, Valid and Pipelined data. It also has input and output signals that are required for further implementation.

Verilog Code Implementation steps are explained below:

a) Define AHB SLAVE interface consisting 9 input signals namely Hclk, Hresetn, Hwrite, Hreadyin, Hwdata, Haddr, Prdata, Htrans, Hsize, and 10 output signals Hresp, Hrdata, Valid, addr_reg1, addr_reg2, addr_reg3, data1, data2, Hwrite_reg, Pselx.

b) Always use multiple conditional clauses to implement Pseln proposals: valid methods and pipelines for data and addresses.

Depending on the state of the Pselx signal controllers, operate the bridge in a specific region

that you want to use. The email setting is shown in the map below.

Table 1: The Status of Pselx Signal [2:0]

The Range of Address	Pselx Status
32'h800_0000 to 32'h83FF_FFFF	001
32'h840_0000 to 32'h87FF_FFFF	010
32'h880_0000 to 32'h8BFF_FFFF	011
Default	00

Valid Signal has used to indicate valid data have been coming from master to slave. If it goes low, it indicates that no valid transfer is remaining. Status of Valid signal is shown in below table.2

Table 2: Status of Valid Signal

Condition	Status of Valid
Hreadyin=Low OR Haddr>8C000000 OR ! (Htrans==2'b10 || Htrans==2'b11)	Low
Hreadyin=high && Haddr>=32'h8000_0000&& Haddr<=32'h8C00_0000 && (Htrans==2'b10 || Htrans==2'b11)	High
Hresten= Low	Low

Signal data channels, address words, and control signals are passed to the APB interface and delayed by two clock cycles, always using blocking and non-blocking procedural assignments (<=).

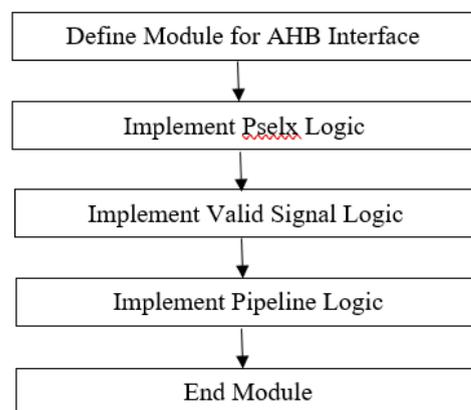The flow chart for implementing AHB SLAVE is shown below fig.3

Fig. 3: Flow chart of AHB Slave Interface

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This is an essential part of design that helps you make the decisions needed to make your design behave correctly, based on the current state that the coding is in, the next state, and the output logic.

Verilog code implementation steps are explained below:

1. Define APB Controller consisting 11 input signals namely Hclk, Hresetn, Hwrite, Valid, Hwrite_reg, addr_reg1, addr_reg2, addr_reg3, data1, data2, Pselx and 6 output Signals namely Penable, Pwrite, Pwdata, Paddr, Pseln, Hreadyout.

2. Use the built-in Verilog PARAMETER keyword to set the FSM state as a parameter versus. Use various procedural blocks to describe the current, next state, and output logic according to the phase diagram.

WSF design

According to the AMBA protocol specification, the phase diagram is shown in Figure 1. 4 and the status table are shown in table. 3.
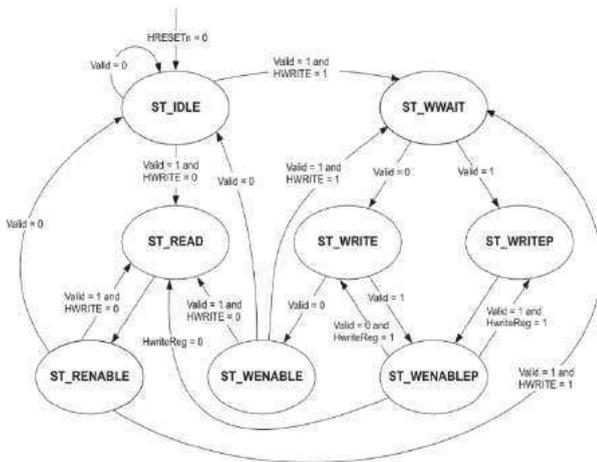

Fig. 4: Controller FSM state Diagram

Table 3: Controller FSM State Table

Present state	Input	Next state
ST_IDLE	Valid && Hwrite	ST_WWAIT
	Valid &&~Hwrite	ST_READ
	~Valid	ST_IDLE
ST_WWAIT	Valid	ST_WRITEP
	~Valid	ST_WRITE
ST_WRITEP	Unconditional	ST_WENABLEP
ST_WENABLEP	~HwriteReg	ST_READ
	~Valid&&HwriteReg	ST_WRITE
ST_WENABLE	~Valid	ST_IDLE
	Valid && Hwrite	ST_WWAIT
	Valid && ~Hwrite	ST_READ
ST_RENABLE	~Valid	ST_IDLE
	Valid&&~Hwrite	ST_READ
	Valid&&Hwrite	ST_WWAIT
ST_READ	Unconditional	ST_READ
ST_WRITE	Valid	ST_WENABLEP
	~Valid	ST_WENABLE

Driving different Hbursts and Hsizes, the results obtained show that the AHB master's Hwdata reaches the APB slave's Pwdata and the APB slave's Prdata reaches the AHB master's Hrdata, so no data is lost rise field. The INCR8 read and write transactions are shown in Figures 8 and 9. WRAP8-explode read and write transactions are shown in Figures 10 and 11.

Figure 7 shows a gate level schematic diagram of the AHB2 APB bridge showing a detailed view of the AHB slave interface and APB controller components. Composed of flip-flops, base gates, decoder, etc.

IV. RESULTS

The design is done using Verilog HDL and implemented in XILINX ISE tool. The results of the project are explained below.

The RTL schematic of AHB2APB Bridge with all the input and output signals is shown in below Fig. 5.
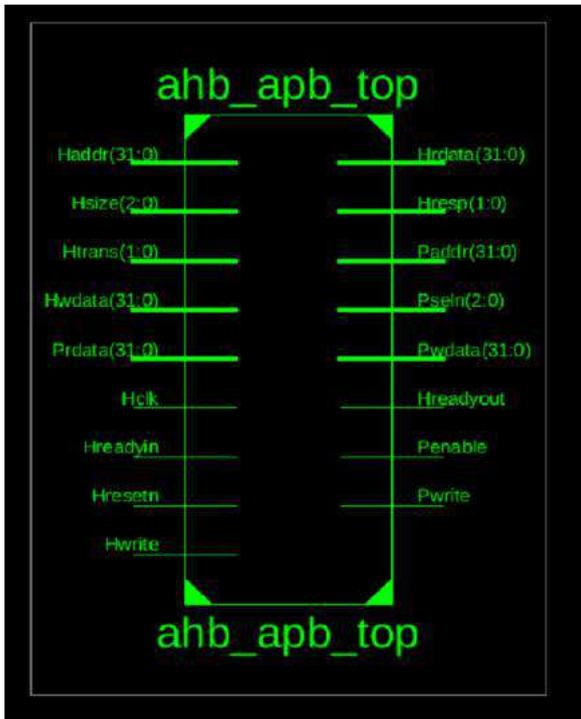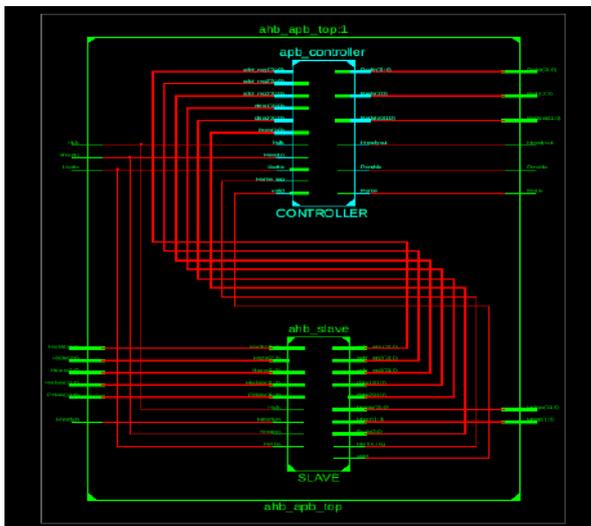
Fig. 5: RTL Schematic of AHB2APB Bridge

Ehnanced RTL schematics of Bridge module are shown in below Fig. 6

The figure shows the gate level diagram of the AHB2 APB bridge, which shows a detailed diagram of the interface components of the AHB slave and APB controller. 7. Consists of basic flip-flops, gates, decoders and more.
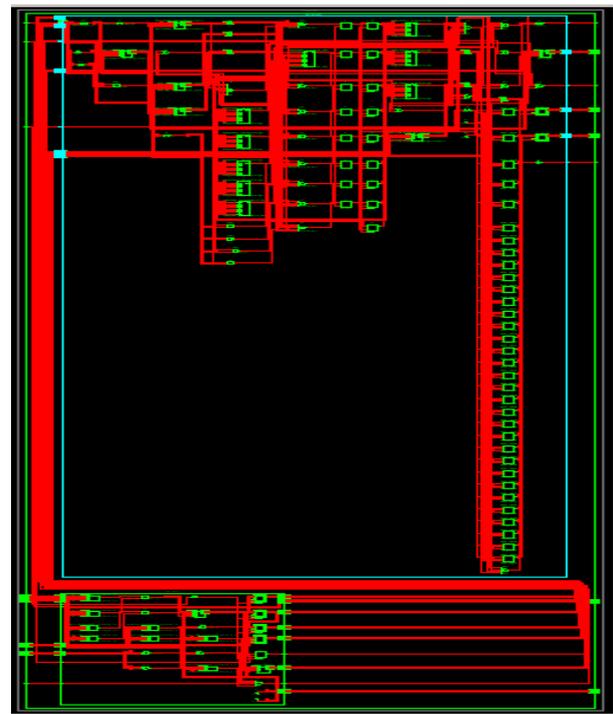
Fig. 7: Enhanced RTL Schematic of Bridge Module

With different Hburst and Hsize driving, the result is the AHB master Hwdata reaches the APB slave Pwdata and the APB slave Prdata reaches the AHB master Hrdata, so no data is lost. Shown. The Figures 1 and 2. 8 and 9 below are shown the INCR 8 read and write transactions. The Figures 1 and 2. 10 and 11 are shown the WRAP8 burst read and write transactions

Fig. 8: INCR4 Write Transfer

Fig. 9: INCR4 Read Transfer

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Fig. 10: WRAP8 Write Transfer

Fig. 11: WRAP8 Read Transfer

Back-to-Back read and write transfers are shown in below fig. 12.

Fig. 12: Back-to-Back Transactions

V. CONCLUSION AND FUTURE SCOPE

I successfully implemented the AHB2APB bridge using Verilog and simulated the project implemented using the XILINXISE environment. AHB2APB bridge implementation for multi-master and multi-slave is an area of the future.

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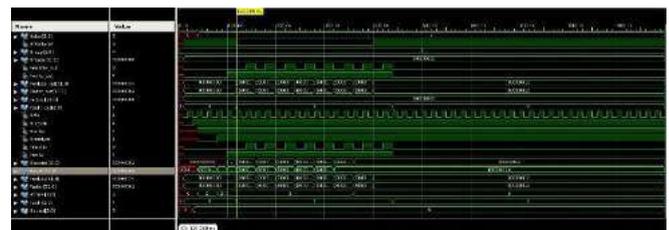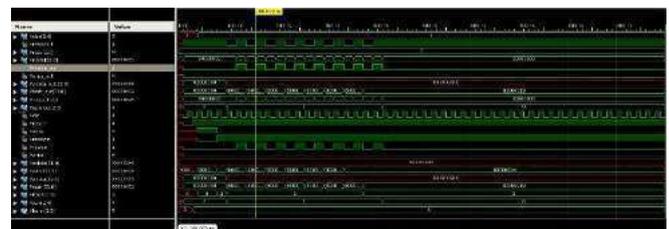1. Jaehoon Song, Student member, IEEE et al.," An Efficient SOC Test Technique by Reusing On/OffChip Bus Bridge". IEEE Transactions on Circuits and Systems-I: Regular Papers, Vol. 56, No.3, March 2009.

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