GLOBAL JOURNAL
OF RESEARCHES IN ENGINEERING: J

General Engineering

Design of Piano-Playing

Development of Ground Nut Oil

Highlights

Job Shop Scheduling

Non-Nuclear Robotic War

Discovering Thoughts, Inventing Future

Global Journal of Researches in Engineering: J

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Design of Piano-Playing Robotic Hand

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Abstract- Unlike the market slowdown of industrial robots, service & entertainment robots have been highly regarded by most robotics reseach and market research agencies. In this study we developed a music playing robot (which can also work as a service robot) for public performance. The research is mainly focused on the mechanical and electrical control of piano-playing robot, the exploration of correlations among music theory, rhythm and piano keys, and eventually the research on playing skill of keyboard instrument. The pianoplaying robot is capable of control linear motor, servo-motor and pneumatic devices in accordance with the notes and rhythm in order to drive the mechanical structure to proper positions for pressing the keys and generating music. The devices used for this robot are mainly crucial components produced by HIWIN Technology Corp. The design of robotic hand is based on the direction of anthropomorphic hand such that five fingers will be used for playing piano. The finger actuations include actions of finger rotation, finger pressing, and finger lifting; time required for these 3 stages must meet the requirement of rhythm. The purpose of entertainment robot can be achieved by playing electric piano with robotic hand, and we hope this research can contribute to the development of domestic entertainment music playing robots.

Keywords: entertainment robot, robotic hand, fast fingers, robotic palm, piano-playing robot.

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Design of Piano-Playing Robotic Hand

Jen-Chang Lin α, Hsin-Cheng Li σ, Kuo-Cheng Huang ρ & Shu-Wei Lin ω

Abstract- Unlike the market slowdown of industrial robots, service & entertainment robots have been highly regarded by most robotics reseach and market research agencies. In this study we developed a music playing robot (which can also work as a service robot) for public performance. The research is mainly focused on the mechanical and electrical control of piano-playing robot, the exploration of correlations among music theory, rhythm and piano keys, and eventually the research on playing skill of keyboard instrument. The piano-playing robot is capable of control linear motor, servo-motor and pneumatic devices in accordance with the notes and rhythm in order to drive the mechanical structure to proper positions for pressing the keys and generating music. The devices used for this robot are mainly crucial components produced by HIWIN Technology Corp. The design of robotic hand is based on the direction of anthropomorphic hand such that five fingers will be used for playing piano. The finger actuations include actions of finger rotation, finger pressing, and finger lifting; time required for these 3 stages must meet the requirement of rhythm. The purpose of entertainment robot can be achieved by playing electric piano with robotic hand, and we hope this research can contribute to the development of domestic entertainment music playing robots.

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I. Introduction

The trends of robotics research has been getting more popular in recent years, while there have been continuous appearance of various types of robots in domestic and international media with applications ranging from education, entertainment, medical care, to home care service. This is an indication that the scope of robot application has already been extended beyond the factory and entering our daily lives and various other fields.

The gradually aging population distribution in this century and decreasing annual birth rates among developing countries have led to the aging society and dramatic change to the productivity-generating young/middle-aged/elderly population structures. Thus it can be predicted the imaginary era of robots in future world will soon be developed and realized in human technology world following this trend. Unlike the market slowdown of industrial robots, service & entertainment robots have been highly regarded by most robotics research and market research agencies. In response to the trend and pulse of this era and based on the considerations of manufacturing cost and market demand, education, leisure, and entertainment types of robots are going to be the top choices for future investments. In this study we plan to focus our research on entertainment type keyboard instrument playing robots.

Keyboard instrument includes harpsichord, organ, piano and electronic keyboard, while music tones of specific frequencies are generated by tapping keys by fingers. Keyboard instrument is suitable for solo or accompaniment with wide popularity among general public. Along with the enhanced living standards in our country, piano and electronic keyboard have become the important instruments for many families to encourage their children to learn how to play. In light of this popularity of keyboard instrument and the advancement of robotic technology, in this project we plan to develop a robot which is capable of playing keyboard instrument. There have been many music playing robots development in various countries. Toyota Motor Corporation (TMC) [1] in Japan developed Partner Robot in 2004 for the 2005 World Exposition in Aichi, Japan which was specialized in hand motions such as music playing. The first generation of this robot is capable of playing trumpet for the purpose of edutainment. The new model of Partner Robot [2] announced in December 2007 utilized technologies of precise control and coordination for enhancing the flexibities of palm and arm leading to additional violin-playing feature. The Waseda University in Japan announced WABOT-2 [3] in 1984 as a robot capable of playing organ in accordance with music standard. The next year WASUBOT [4] was announced with additional music score reading feature and capability of playing keyboard instruments with 16 kinds of tunes. Although all aforementioned music robots are capable of creating different music, they have been limited to mechanical finger motions or music playing within small acoustic range, and the instruments in use are limited to certain mechanism while the entire acoustic range has not been fully utilized. We hope the development of this keyboard instrument playing robot can be different from others as a music robot which plays music faster without being limited by certain mechanism. We would like to fully utilize the existing robotic design capability of our school in order to develop a product filled with market potential.

We would like to have the electronic keyboard playing robot developed by this project to play the electronic keyboard with anthropomorphic approach while utilizing linear motor, step motor and pneumatic cylinder to control the mechanism of music playing

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robot. The mechanical-electrical system we utilize is composed of computer based controllers, where two sets of linear motors sharing the same driver board are used for drive two palms. There are five fingers with each palm, and there are one joint mechanism and one finger mechanism in each finger controlled by step motor and pneumatic device. The step motor, pneumatic device and linear motor are controlled by the system through FPGA controllers. Every note is generated with the robot touching the key in four stages: palm movement (including finger rotation), finger pressing, finger holding, and finger releasing. Upon receiving information of music note and rhythm, the system will determine next targeted position for music playing based on music note information. Figure 1 is composed with anthropomorphic approach.

Figure 1 : Overall diagram of mechanical hands

II. Design of Horizontal Hand Movement

In automatic production process the linear movement mechanism is the kind of most frequently seen application carrier with degree of freedom of one to multiple dimensions. There is more than one kind of mechanism design for selection. The classification based on movement style will lead to the categories of indirect transmission and direct transmission. The indirect transmission is the most widely used form where rotating movement is converted into linear movement through mechanical mechanism. The common examples of indirect transmission are ball screw mechanism, rack and pinion mechanisms, and conveyor belt. The examples of direct transmission include pneumatic device, hydraulic device and linear motor. For pneumatic and hydraulic devices to achieve energy transmission, fluid must be used as the media. This will not only increase the system complexity, but also lead to various issues such as maintenance and regular service, media replacement, and increased cost. The linear motor with electromagnetic field as the media is capable of greatly reducing system complexity and issues of maintenance and service. The industry has always been pursuing higher precision, more rapid production, and less burden of maintenance, while linear motor can meet all these criteria. The contact

driving system of linear motor has introduced structural revolution for traditional tool machine, automation equipment and inspection instruments with no need for bearings and couplings.

a) Analysis of hand moving time

There are numerous factors affecting the moving speed of the mechanical hand. First we can exclude the weight factor and calculate the result of initial stage of hand speed. So far the hand promoter movements can follow several factors such as the interval containing seven keys (C,D,E,F,G,A,B) obtained from research on fundamental acoustic range, the time required for the hand to move from one interval to the next, the study on basic dimension of piano, the length of piano keys, and the hand moving speed from the left-most side to the right-most side. The study shows there are two stages of the sequence of hand movement as shown in Figure 2: the speed of movement from C5 to F5, and the speed of movement from F5 to C6 of the next interval.
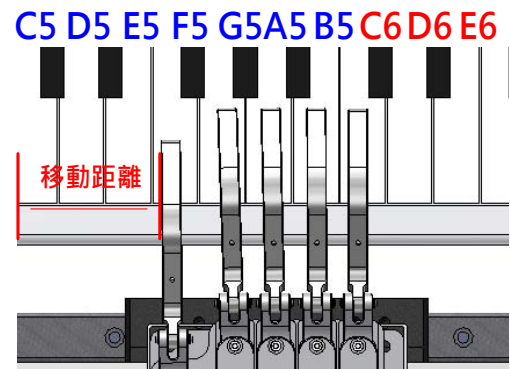
Figure 2 : Finger movement position

b) Analysis on the selection of linear motor

The movement of mechanical hand is driven by the linear motor. A certain distance of mechanical hand movement will be set for calculation of the speed, acceleration and time required for such movement. As one of the necessary factors for procurement of linear motor, this setting will lead to more accurate speed of linear motor during the movement.

This calculation is based on the relationship between speed and acceleration. The movement of linear motor is different from the operating approach of circular rotary motor such that the calculation of rotation speed and acceleration/deceleration is based on the principle of linear movement. During linear movement, the time needed for a stationary object to be accelerated to the maximum speed is called acceleration time. While the object is moving at maximum speed, it is called the speed of constant speed movement. The time needed for an object to decelerate from this constant speed to the stationary state is called deceleration time. The linear structure of linear motor will lead to fixed motion stroke such that

there will be speed planning curves of acceleration, constant speed, and deceleration for the movement speed, and the acceleration, deceleration and time can be calculated by using the formula.

c) Calculation of specification selection

The following study is to derive required formula of acceleration a (2.1), formula of speed v (2.2), time t and speed curve formula (2.3) based on continuous thrust of linear motor, while the acceleration can be directly calculated from motor output and load. The motor output in this study is based on statistics of production specifications, while the load includes the custom-designed contained mass of mechanical hand, combination mass of motor promoter, and friction (which can be neglected in this study). The following analysis is focused on the time required for the LMC and LMS linear motors of HIWINMIKRO to move the mechanical by 16.5cm.

The LMC series of coreless motors are the first to be analyzed, where the calculation is based on the heaviest mass of contained mass of mechanical hand limited to 2kg. This numeric value is used as the calculation parameter.

d) Result of specification selection

From the Table 1 below we find that the numeric values of each series of linear motor calculated based on the distance of 16.5cm (60 per minute and quarter note speed 0.1333s) can all meet the standard. But the difference between sizes of promoter volume is rather large. The same P60 quarter notes all meet standard time, but the volume or promoter of LMC series is smaller than that of LMS series. Thus LMC series is the more suitable linear motor for the piano playing robot of this study due to the visual, aesthetic and performance factors.

Table 1 : Time of note

移動時間 T₁	P30	P60	P90	P120
四分音符(1 拍)	0.2666	0.1333	0.0888	0.0666
八分音符(.5 拍)	0.1333	0.0666	0.0444	0.0333
十六分音符(.25 拍)	0.0666	0.0333	0.0222	0.0166

In this plan we use LMX1E-C linear motor platform with coreless motor which is suitable for high speed and multi-axis simultaneous movement applications. The compact volume is the main feature, and the increment-type of analog or digital optical scale is used for the position feedback. LMX1E-C platform has superior dynamic features with length up to 4000 mm, maximum acceleration as high as 100m/s^2, and maximum speed as high as 5m/s. Therefore it is the linear motor meeting the requirement of this project as shown in Figure 3.

Figure 3 : LMX1E-C linear motor

III. System Structure of Mechanical Hand

The application of common mechanical hand is limited to grabbing object with anthropomorphic approach. With the space limit of hand design, many sensors and wirings have be installed in the hand such that the flexibility of fingers are limited leading to the lack of dexterity when flexible finger actions are needed. In this study the dexterity of finger has been demonstrated in the form of piano-playing. The piano-playing mechanical hand is based on anthropomorphic design. The hand is slightly wider than human hand at 120 mm, while the appearance of finger is imitating the bending of human finger during piano playing. On one hand it is an imitation of human playing piano, on the other hand it allows only the finger pulp to touch the surface of piano key. The opening and closing actions of hand during piano playing can demonstrate the technical aspect and anthropomorphic effect. As for the chromatic keys, they can be reached by all fingers expect for the thumb, and this is the design which has not been seen from previously announced piano-playing mechanical hands.

a) Mechanical hand system

The second generation mechanical hand system includes finger rotary actuator, finger-pressing pneumatic cylinder, finger flexible connection, linear guideway, swinging arm protection device, bottom plate structure, and sliding panel device. The structure of this mechanical hand is as shown in Figure 3.2 "The physical appearance of the second generation hand", and detailed statistics refer to Table 3.1 "Table of performance parameters of mechanical hand". The bottom plate of the mechanical hand is mainly 6061-T6 aluminum plate with 4 sets of pneumatic finger-pressing modules and an independent pneumatic thumb-pressing module installed on top of it. There are 4 SBR06 pneumatic cylinders beneath the hand bottom plate mainly for the extended actions of 4 sets of modules. Thus there are linear guideways installed at the bottom of the 4 sets of pneumatic finger-pressing modules mainly for allowing the 4 sets of pneumatic fingers to reach the chromatic keys.

The decomposition of finger pneumatic module of mechanical hand is based on single module, where the servo is used as an actuator at the rotary joint. The

actuator is installed in the rectangular groove on the sliding bottom plate with threaded holes on both sides for fixing. When the signal of rotating angle is received by the servo, it will drive the protection swinging arm on top of the servo. This protection swinging arm is installed at the bottom of special rotary joint, and there are threads on the rotary joint for integration with auxiliary clamp plate. There are bearing housings in the auxiliary clamp plate. This pressing plate will be placed on top of rotary joint during installation. The auxiliary clamp plate is installed on the sliding plate where there are holes for fixing and locking. Screws are utilized to penetrate through bearings until the rotary joint is screwed into the thread. This is mainly for reinforcement of the strength of rotary joint where the original structure of cantilever beam is converted to shear free beam for distributing the force on both ends such that the prolonged stress will not lead to the load of the servo motor.

There is the second degree of freedom on the rotary joint for the installation of finger rotation center. There are bearing housings in the fingers for installation of bearings. In the end the penetration of steel shaft is utilized and the E-type ring is used for buckling mainly for avoiding axial movement. Inside the finger there are grooves for integration with flexible device, where flexible devices are connected by using 1mm steel wire. The bouncing back action of finger is achieved by placing compress springs around steel wire. During compression of springs there must be guideways for guiding direction of spring compression such that the steel wire plays an important role in the center of spring. As for the selection of spring, if the wire diameter is too large, the rigidity can be too strong and causing fractures. If the spring is too soft, the finger bouncing-back will not be fast enough to keep up with the beat. The flexible device is connected to the combination of pneumatic cylinder and linear guideway. The pneumatic cylinder is mainly for generating tension with respect to flexible device with stroke around 10mm. The tension is controlled by flow adjustment by throttle valve on pneumatic cylinder. The direction of linear guideway should be kept consistent with the auxiliary force, such that attention must be paid to the interference issue during assembly of linear guideway and pneumatic cylinder, otherwise the response speed of fingers during piano playing can be affected.

As for the identification of corresponding same music alphabet, the number can be used to classify the interval level. The number "5" will be attached to the music alphabet of the key in the same set with central C. Numbers such as "6", "7" are attached to the notes higher than the set of central C, while numbers such as "4", "3" are attached to the notes lower than the set of central C as shown in Figure 4.

線性滑軌 輔助壓板 擬人手指

節流閥

旋轉關節

雙動氣壓缸 伺服機 保護擺臂
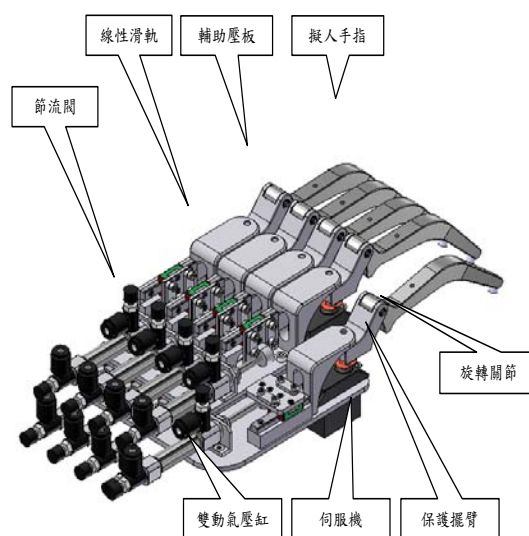
Figure 4 : Illustration of the second generation mechanical hand

b) *Device design of mechanical hand-rotary actuator*

For the finger rotation of piano-playing mechanical hand, features such as fast rotation, precise position, and compact motor size are required, so is a certain level or torque. Although the required torque force is not too large, certain level of support from rated torque is required. Nonetheless, the most important factor is the size of motor. If the size of motor plus reducer box is too large, the designed mechanical hand will be too large. On the contrary, a smaller motor will lead to a smaller mechanical hand which is more like a human hand. As for the reducer box, the finger motor does not need a very large reduction ratio.

The design of second generation mechanical hand is different from the first generation where the torque transmission by actuator is conducted by direction transmission approach instead of the connecting rod approach. This is mainly due to the additional third degree of freedom installed on the movement joint within the mechanical hand leading to the modified design of the second generation mechanical hand. The protection swinging arm is installed on the servo axis such that there will not be any position sliding during finger rotation with gears of swinging arm and servo axis meshing with each other. The screw fixation approach between protection swinging arm and rotary joint is mainly for facilitating the replacement during maintenance. The principle of protection swinging arm is when the finger is hit by external force, the mandatory rotation under the excitation state of protection servo motor will lead to skipping of internal gear. The appearance dimensions of the actuator installation are as shown in Figure 5.
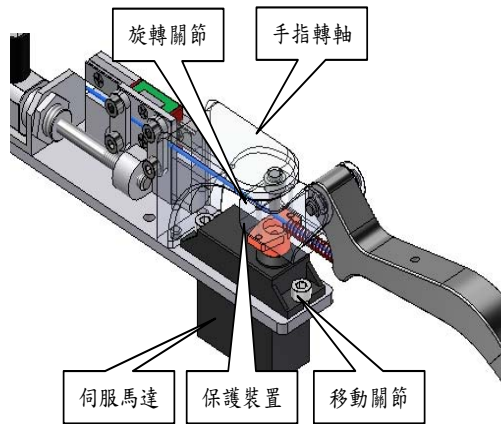
Figure 5 : Actuation installation location

The finger rotation is transmitted to the rotary joint through protection device. Since the protection device is a flexible connection part, reaction will be generated during finger pressing process affecting the rotary joint. The protection device cannot withstand such force, thus the auxiliary clamp plate is designed in response to this issue. The auxiliary clamp plate is installed on top of the rotary joint. The reaction will cause the rotary joint to be lifted, and this is when the auxiliary clamp plate can balance the force.

c) *Device design of mechanical hand-pressing actuator*

For the finger pressing actions of piano-playing mechanical hand, features such as speed, stability, and compact device size are required. By studying the action of finger pressing the piano key, we find that currently there is no control over force for finger action such that the control device is only handling constant speed movement with fixed stroke. In terms of the volume requirement, there must be 5 actuators placed on the hand for pulling steel wires, thus lie-flat installation is required for the devices to be used in order to prevent the hand from being too thick. In terms of the pressing speed, there must be very fast reciprocating motion in a rather short stroke such that there will not be very high demand on precision. In terms of output force, this finger mechanism will require at least force of 1kgf and above. Summarizing features of all aforementioned device requirements, we conclude that pneumatic cylinder is the best choice. It is equipped with aforementioned features of compact size, short stroke, large force, and high speed. Pneumatic cylinder is a kind of pneumatic driver generating linear movement which has been widely adopted in the industry. Because pneumatic cylinder is capable of generation simple mechanical actions, there are various kinds of pneumatic cylinders with numerous methods of use.

In the design of finger pressing mechanism of mechanical hand, the pneumatic cylinder is used as the actuator in coordination with other auxiliary devices. The

reciprocating actions are generated by the pneumatic cylinder to pull finger by pulling connection steel wires. With one end of the finger fixed on a rotation axis, the finger motion of up and down swinging is centering on the rotation axis. When the steel wire is pulling the finger based on the principle of leverage, it is a fixed ratio between the distance from the joint of steel wire and finger to the rotation center, and the distance from finger tip to the rotation center. This is mainly the increase of pressing speed which reduces the movement of pneumatic cylinder. Due to this ratio, the increased speed will lead to reduced action force. When there is larger resistance at the finger tip, larger force is required at the stressing end for achieving balance due to the principle of force arm. For the overall beauty of fingers, this design also prevents the exposed mechanism from being seen during actuation of mechanism such that the overall appearance is a better fit for anthropomorphic design. This is going to contribute greatly to music playing where more lively music can be played as the demonstration of finger dexterity while meeting the feature of anthropomorphic fingers.

The difference between the design of the second generation mechanical finger and the first generation design is at the position of bending joint. Based on the joint of human hand, the bending position of mechanical hand is at the junction between carpal bone and mid bone. The distance from the finger bending joint to the finger tip is 100mm, while the distance from the junction of steel wire and finger to the bending joint is 17mm. This will lead to a larger ratio such that the pneumatic cylinder only needs to move by 5 mm for the pressing distance to reach 25 mm. This way the speed of finger pressing on the piano key will be greatly enhanced to twice the speed of the first generation. However, in terms of the pressing force, the adoption of old pneumatic cylinder will lead to slightly insufficient force output. The reaction force is increased due to the enlarged force arm of the principle of leverage such that greater force is required at the stressing end in order to achieve the balance. Therefore, in the second generation design we replace the old pneumatic cylinder with the one with outer cylinder diameter of 10mm in order to achieve ideal output force. Figure 6 is about the description of all parts of the second generation finger, and the simulation of pressing action.
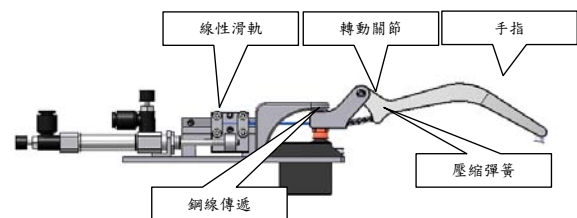
Figure 6 : Detailed functions of the second generation hand

d) Device design of mechanical hand-pressing simulation

New design approach has been used with respect to the speed of piano key pressing by the second generation fingers. The distance from the finger bending joint to the finger tip is 100mm, while the distance from the junction of steel wire and finger to the bending joint is 17mm. The speed of finger pressing the piano key can be more obvious through the principle of leverage, while the design of finger appearance has been also imitating the bending of human fingers while playing piano. Through the computer-assisted mechanical drawing, 3D drawing has been utilized for the simulation of finger pressing as shown in Figure 7 and Figure 8.

線性滑軌　轉動關節　手指
壓縮彈簧
鋼線傳遞
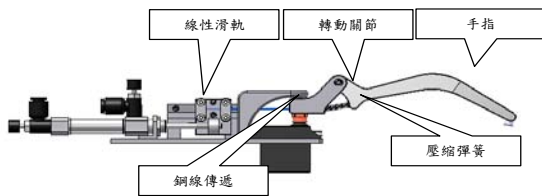
Figure 7 : Simulation of finger pressing (front)

滑塊移動 5mm
25mm
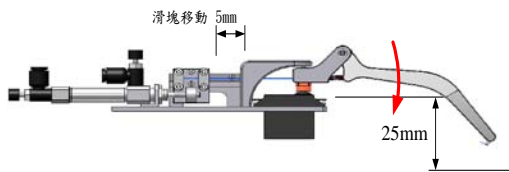
Figure 8 : Simulation of finger pressing (rear)

e) Device design of mechanical hand pressing assistance guideway

Linear guideway has been utilized, while the coordination of mechanism is based on the connection between pneumatic cylinder and linear guideway through steel wire clamp plate. The steel wire is fixed between the pneumatic cylinder and the linear guideway such that when the force is transmitted from the pneumatic cylinder to the steel wire, it is not easy for the torque generated during pulling of steel wire to lead to increased friction of the linear guideway. Based on this design, there is one module per finger installed in the hand. Due to the size factor, the linear guideway must be fixed on the hanger in side-lying fashion. There are 2 M2 threads on the slider for fixing the steel wire clamp plate on the slider and for fixing the axis of pneumatic cylinder beneath the slider. There are two aluminum plates on the steel wire clamp plate for clamping the steel wire. The double clamping approach can ensure the steel wire not to be loosened while being pulled. The Figure 9 below is the description of pressing design of the second generation mechanical hand.

SBR10×15氣壓缸　線性滑軌　鋼線雙壓板
線滑吊架　1mm鋼線
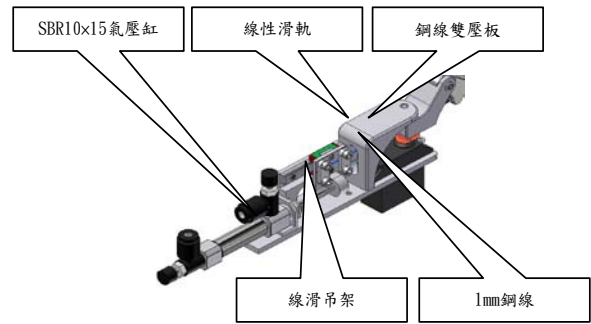
Figure 9 : The second generation pressing design

f) Device design of mechanical hand –pressing assistance guideway

In the system design of the second generation mechanical hand, the opening angle is required by the fingers. Based on the design principle of the first generation mechanical hand, the finger itself must be equipped with two degrees of freedom. However, in the finger design of the second generation mechanical hand, a third degree of freedom must be added, which is the position required for the fingers to hit the chromatic keys during piano playing, while the appearance must be even more anthropomorphic. Based on these two criteria, the finger design of the second generation mechanical hand must have 3 degrees of freedom, where the third degree of freedom is for the finger to be extended to the position of chromatic key. The basic actuation principle is similar to the first generation mechanical hand. The difference is the pneumatic cylinder is installed in the hand on a sliding module such that the finger module can be moved as an entity. Therefore the pressing module itself must have two degrees of freedom. In terms of the module, the action force generated by the pneumatic cylinder is transmitted through the flexible device. The pneumatic cylinder is installed in the rear of the finger mainly for avoiding the friction loss during force transmission. The flexible device we use is 1mm steel wire. The path of steel wire is almost a straight line during transmission for generating enough force for finger pressing. When the finger is opened by a certain angle, the steel wire will be bent with an angle. This angle is not very large, and the steel wire is introduced into the rotary joint with the tangent approach, such that the transmission of steel wire is based on an arc angle rather than a right-angle bending. This bending is within the bending range of 1mm steel wire. The appearance of the second generation mechanical hand is as shown in Figure 10.
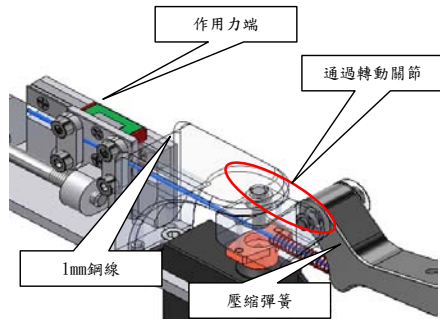
Figure 10 : Mechanical finger flexible transmission design

During normal piano-playing process the fingers of mechanical hand are placed on the white keys. Whenever the chromatic keys need to be pressed during piano-playing, the mechanical hand will be moved to the proper position, while the finger for pressing the chromatic key will be stretched to the position and the finger will be pressing down. After the pressing action is completed, the hand will return to the normal state. The finger pressing process is simulated by computer software as shown in the following Figure 11 and Figure 12.

g) *Device design of mechanical hand –gliding joint*
First of all the relationship between the chromatic keys and the mechanical hand is analyzed.
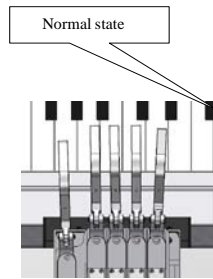
Figure 11 : Mechanical fingers (normal position)
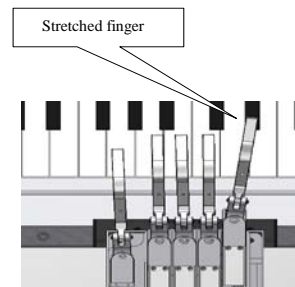
Figure 12 : Mechanical fingers (stretched)

The distance from the finger position on the white key to the finger position on the chromatic key is 30 mm, the width of chromatic key is around 8 mm, and the width of buffer silicone at finger tip is 6 mm. Therefore, there is only 1 mm tolerance of left/right deviation during finger pressing process, which is very important to the stability after stretched mechanism. There is a drop height between the white key and the

black key, which means the black key is 15 mm above the white key. Therefore, for fingers to reach for the chromatic keys while playing on white keys, they must be lifted. However, the actuation of mechanism must be in a stable state such that the heights of fingers and keys will be raised by a certain distance during piano-playing on the white keys. The dimensions of the design appearance are as shown in Figure 13 and Figure 14.
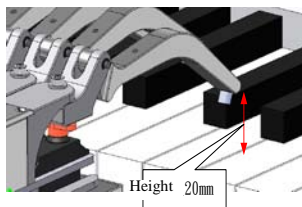
Figure 13 : Heights of fingers and white keys
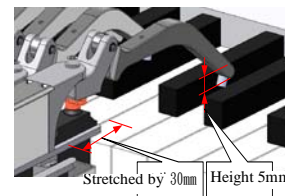
Figure 14 : Heights of fingers and black keys

h) *Device design of mechanical hand – gliding joint module*
In the mechanical hand design, fingers are designed with modularization approach. A finger is designed to be a module capable of pressing the piano key and rotating by a certain angle, such that a mechanical hand is composed of four identification finger modules and one thumb module. As mentioned in

previous chapters, the finger module includes servo motor, pneumatic cylinder, linear guideway and flexible transmission device. All devices will be integrated on one mobile joint mechanism to form a mobile joint module with the feature of the second generation mechanical hand as the third degree of freedom for playing the chromatic key. The appearance dimension of this module is as shown in Figure 15.
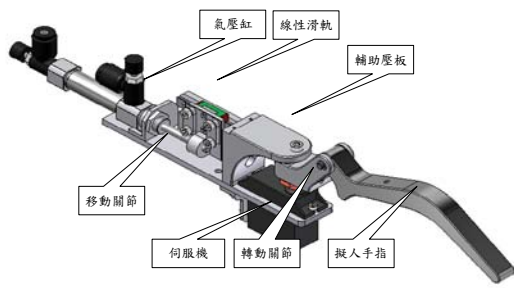
Figure 15 : Mobile joint module

The bottom plate of mechanical hand is integrated with the mobile joint module in order to facilitate the action of forward stretching of mobile joint. Therefore there must be guideway at the bottom plate as the junction between the bottom plate and the mobile joint. Here we use the MGN5C guideway of HIWINMIKRO with 70 mm length. The action force is generated by the pneumatic cylinder during the movement. The pneumatic cylinder is designed to be installed at the bottom of mechanical hand where the mobile joint and the axis of pneumatic cylinder are integrated. The moving speed of this mobile joint is controlled by the exhaust throttle valve. The higher speed will lead to larger impact on the mechanical hand, thus this statistic must be adjusted in accordance with the requirement of piano-playing. The dimensions of the design appearance are as shown in Figure 16.
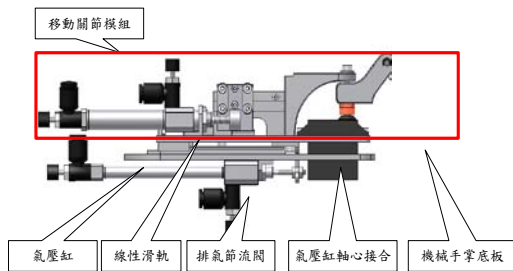
Figure 16 : Pressing module

IV. Analysis on the Fingers of Mechanical Hand

The R&D of the fingers of mechanical hand has gone through three generations of designs such that the analysis on the fingers are focused on the comparisons among the structural strengths and stresses of these three generations, and the formula calculated from these stress related statistics. The analysis on the fingers through software approach and the results are as shown below.

a) Static analysis of the fingers

According to the data of output file of ABAQUS/CAE, the maximum stress of mechanical finger takes place at the element near the fixed end. Since in this study we focus all the loads of mechanical

hand on one side, there is going to be a rather significant phenomenon of stress concentration. The yield strength of aluminum alloy material (6061-T6) is at 270MPa with must larger estimated safety factor mainly because of the better processing properties of aluminum and easier access to such material. Thus there is less concern of the stress damage to the mechanical fingers. With the smaller stress on the mechanical fingers, other materials (such as PE material with rapid prototyping approach) with less strength can be used for saving the cost. However, there is another consideration of using aluminum as the material of mechanical hand. During the stage of program testing of mechanical fingers, if the fingers are not completely raised after pressing on the piano keys and the linear motor has started to drive the lateral movement of mechanical hand, the mechanical hand may suffer from lateral impact due to large force generated by the linear motor. This is why we need a high safety factor for the mechanical fingers.

The results of analysis on mechanical fingers are described in Table 2 and Table 3. The features of maximum stress and maximum deformation among three generations of mechanical fingers have led to different statistics of increased finger load.

Table 2 : Structural stress of the third generation mechanical finger (MPa)

Load (kgf) Model	0.2	0.4	0.6	0.8	1
First generation finger	1.215	2.43	3.645	4.861	6.076
Second generation finger	2.068	4.136	6.204	8.273	10.34
Third generation finger	2.122	4.244	6.367	8.489	10.61
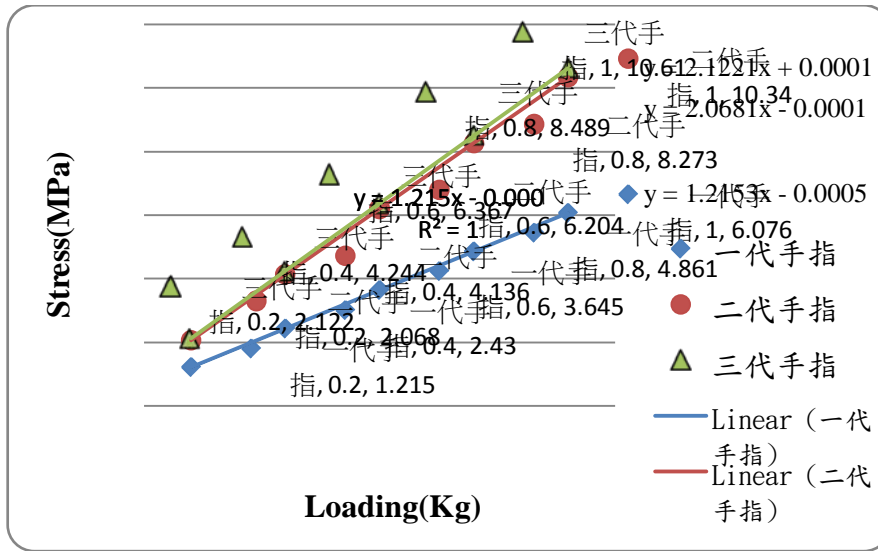
Figure 17 : The curves of structure-stress of the first generation, second generation, and third generation fingers

Table 3 : The structural deformation of the third generation mechanical fingers (mm)

Load (kgf) / Model	0.2	0.4	0.6	0.8	1
First generation finger	0.0048	0.0097	0.0146	0.0194	0.02433
Second generation finger	0.0015	0.0308	0.0464	0.0617	0.0778
Third generation finger	0.0015	0.0315	0.0473	0.0631	0.0788
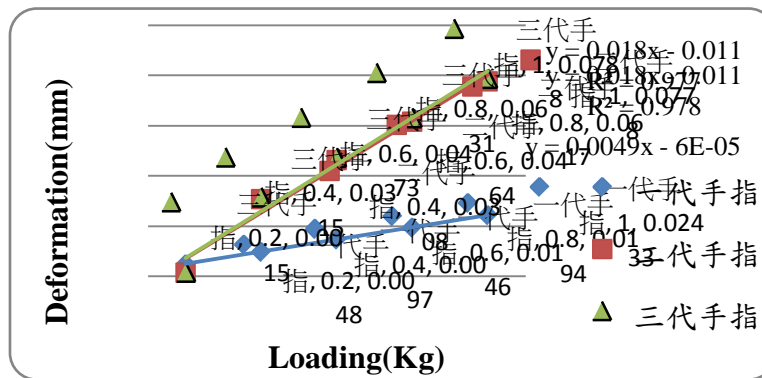
Figure 18 : The curves of structure-deformation of the first generation, second generation, and third generation fingers

As for the stress curves and deformations of the second generation and third generation mechanical fingers, there is not much difference between them. However, there is obvious difference between their inner structures. There are weight reduction holes within the third generation fingers to greatly reduce the mass for finger pressing action without losing any strength.

Based on the experimental statistics of structures, stress of each load, and deformations of the first generation, second generation, and third generation mechanical fingers, curves are drawn from all points for solving the trend lines. Six linear straight lines can be obtained from Figure 17 and Figure 18 in order to obtain the estimated structures, stresses corresponding to all

loads, and deformation formula corresponding to all loads of mechanical fingers.

Equations 5.1 to 5.3 are the formulas of load and stress of mechanical hand structure, where y is the stress value based on structural analysis, and x is the load (from 0.2kgf to 1kgf). This formula can be used for estimating the stress values of mechanical fingers

corresponding to all loads. Equations 5.4 and 5.6 are the formulas of load and deformation of mechanical finger structure, where y is the deformation values based on structure analysis, and x is the load from 0.2kgf to 1kgf. This formula can be used for estimating the value of deformation of mechanical finger structure corresponding to all loads.
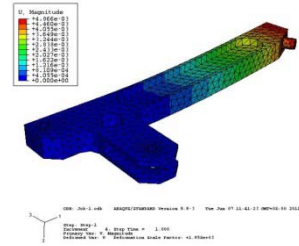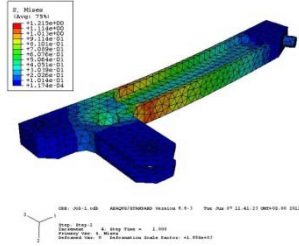
Figure 19 : First generation finger-stress diagram

Figure 20 : First generation finger-deformation diagram
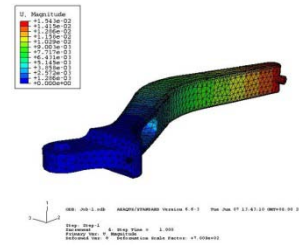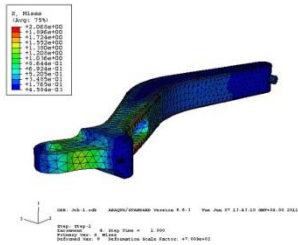
Figure 21 : Second generation finger-stress diagram

Figure 22 : Second generation finger-deformation diagram
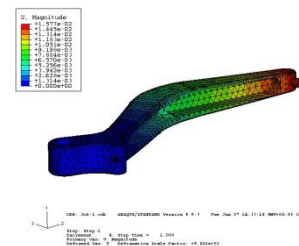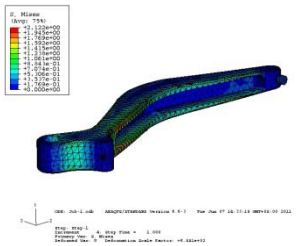
Figure 23 : Third generation finger-stress diagram

Figure 24 : Third generation finger-deformation diagram

V. Acknowledgement

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2. TOYOTAViolin-playingRobothttp://www.toyota.co.jp/en/news/07/1206_2.html
3. Autonomic Limb Control of the Information Processing Robot- Movement control system of robot musician 'WABOT-2'- The International Exposition, Tsukuba, Japan, 1985 JRSJ Vol.3, No.4, pp.81-95.
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Non-Nuclear Robotic War and Frequent Entry of Blood Feeding Animals to Foot Hill Townships, Made Possible by Rising Environmental Estrogen, Alpha Feto Protein, Human Chorionic Gonadotropin, as Evidence for Environmental Contraceptive Menstrual Blood Pollution, Aborted Blood Pollution; Emergency Baby Boom, Mandatory Reversal of Contraception, Eradication of Global Contraception, Abortion - - - Ultimate Solution to Global Threats

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Abstract- Non-nuclear Robotic war of spewing fire into the houses, following global positioning system [GPS] as cautioned by Joel 2nd chapter of the Word of God and frequent entry of blood feeding animals like tigers to the human habitat of Foot hill townships is made possible, by the environmental aborted blood pollution and contraceptive menstrual blood pollution, documented by rising environmental estrogen, alpha feto protein, human chorionic gonadotropin, in rivers, oceans and air, and associated rapidly declining human race, whose presence would have been a strength for security.

Keywords: urgent baby boom, patriotic Godsintel robot, devastator robot, aborted blood pollution, contraceptive menstrual blood pollution, declining human race/density.

GJRE-J Classification : FOR Code: 091007

Strictly as per the compliance and regulations of :

Non-Nuclear Robotic War and Frequent Entry of Blood Feeding Animals to Foot Hill Townships, Made Possible by Rising Environmental Estrogen, Alpha Feto Protein, Human Chorionic Gonadotropin, as Evidence for Environmental Contraceptive Menstrual Blood Pollution, Aborted Blood Pollution; Emergency Baby Boom, Mandatory Reversal of Contraception, Eradication of Global Contraception, Abortion--- Ultimate Solution to Global Threats

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Abstract- Non-nuclear Robotic war of spewing fire into the houses, following global positioning system [GPS] as cautioned by Joel 2nd chapter of the Word of God and frequent entry of blood feeding animals like tigers to the human habitat of Foot hill townships is made possible, by the environmental aborted blood pollution and contraceptive menstrual blood pollution, documented by rising environmental estrogen, alpha feto protein, human chorionic gonadotropin, in rivers, oceans and air, and associated rapidly declining human race, whose presence would have been a strength for security.

Live humans including the millions who have gone down the drain, by contraception and abortion, with their sound waves, radio waves, micro waves could have interfered [as telephone calls interfere with flying of Aero plane, equipment's functioning in intensive care unit, operation theatre] with the remote controlled, global position system based, non-nuclear, fire spewing, horse likened robots, probably 1-2 feet height, directed to climb walls, enter the houses through windows, to produce devastation; but agonizingly the humans with their sound waves, telephonic waves are non-existing by globally achieved contraception, abortion with their blood residue, seen as rising environmental estrogen, α feto protein, β human chorionic gonadotropins.

Aborted blood pollution, contraceptive menstrual blood contamination of the Environment namely oceans, rivers, air, attracts blood feeding animals like Tigers to frequently enter the human habitat at Foot hills, far away from the virgin forest with no aborted blood pollution, to the score of 20 fold over the past 15 years [p <0.0005]; with associated reducing human density, the animals prey upon easily, due to reduced strength of security.

Urgent escape to the mountains in the [s/o fore seen] event of this non-nuclear robotic war, wherein global positioning system does not exist, can be an emergency solution.

Concept is Patriotic `Godsintel` robots able to produce million micro waves equal to e.g. a million or lakh or thousand phone calls, should be planned to reach the devastator robots; million micro waves or telephonic waves of patriotic `Godsintel` robot will interfere with devastator robot`s command and inactivate it, simultaneously another incorporated command, with alternative global positioning system of rerouting former devastators to the right hand sea, rear end devastator robots to the left hand sea, wherein the devastator robots can be drowned and quenched, should be activated.

Ultimate solution for global threats is to eradicate global contraception, with urgent contraception reversal, including Fallopian tubal re-canalization, to achieve robust, uncurbed Baby boom with dire emergency.

Keywords: urgent baby boom, patriotic Godsintel robot, devastator robot, aborted blood pollution, contraceptive menstrual blood pollution, declining human race/density.

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I. Introduction

Blood feeding animals like Tigers, Cheetahs` entry to the human habitat at foothills is steadily increasing over the past few decades, as more and more of the roads, buses, shops appear empty with few people, secondary to the rapidly declining fertility rates and associated   aborted blood pollution, contraceptive menstrual blood pollution evidenced by rising environmental estrogen, α feto protein, ß human chorionic gonadotropins, achieved by global contraception, abortion, implemented successfully without therapeutic indication.

Drastically declining human density of the foothill townships, with reduced sound waves, increasing silence, aborted blood pollution making the river waters, tastier by aborted blood to the blood feeding animals, than that of the virgin forest without abortion, contraception, invites the daring animals; this event, reminded about a similar dangerous, non nuclear robotic war, descending like the dew, cautioned in the word of God in the book of Joel following abortions, contraception.

Even as I am writing this, in the wake of past two weeks, a few cheetah`s have entered the heart of, two different metropolitan cities, [not only foothill townships,] with aborted blood polluted, contraceptive menstrual blood contaminated rivers flowing in the midst.

II. Methods and Strategies

Hence an observational analysis was planned to assess the apparent increase in frequency of the blood feeding animals` entry, endangering human habitat at foothills, as observed by the corresponding author over the past 15 years; the regions included for the analysis of animal entry are, foothills, forest outskirts, townships, and busy roads 20 years back, but deserted now, of different geographical locations separated by ~1000 Km.

The book of Joel mentions of a probable non nuclear robotic war, depicted as remote controlled, devastator robots of probably 1-3 feet height, let down on the streets as dew, probably let down in thousands by air carrier for different, specific areas, guided by Global positioning systems, directed to climb walls, enter houses through windows, spew fire, and burn every thing, so that smoke rises to heights; it also suggests the former robot to be rerouted to right hand sea, the rear end robot to be directed to the left hand sea, by some means to be drowned and quenched as remedy.

Author of the Universe, technologies, Life, provides a clue to reroute; *the concept is telephonic waves, micro waves, sound waves of millions of people [early demise of young parents], babes who would have existed on earth but for global contraception, abortion, could have interfered, nullified remote controlled devastator robots; Figure 1 density of the people has decreased drastically, promoting success to the devastator operation Figure 3.*

Mobile phone calls are prohibited inside flight, outside intensive care unit, outside operation theatres to avoid interference with the systems involved in flying, intensive care and surgeries.

To plan a rescue, patriotic `Godsintel` robot to do two components 1] to produce 1001, or lakh, or million phone calls akin waves, to achieve interference and nullify the devastator robot`s operation, 2] simultaneously activate alternate Global positioning system to reroute the former devastator robot to the right hand sea, rear end robot to the left hand sea, where it can be drowned and quenched; because going forward, backward is an ordinary, dominant command; let engineering technologies use this concept to devise patriotic Godsintel robot.

a) Results

Remote controlled Devastator Robot by GPS

Spews Fire, Climb walls enter houses

Interferes, inactivates

Sound Waves
Radio Waves
Telephonic Waves
Micro Waves
of uncurbed
population growth
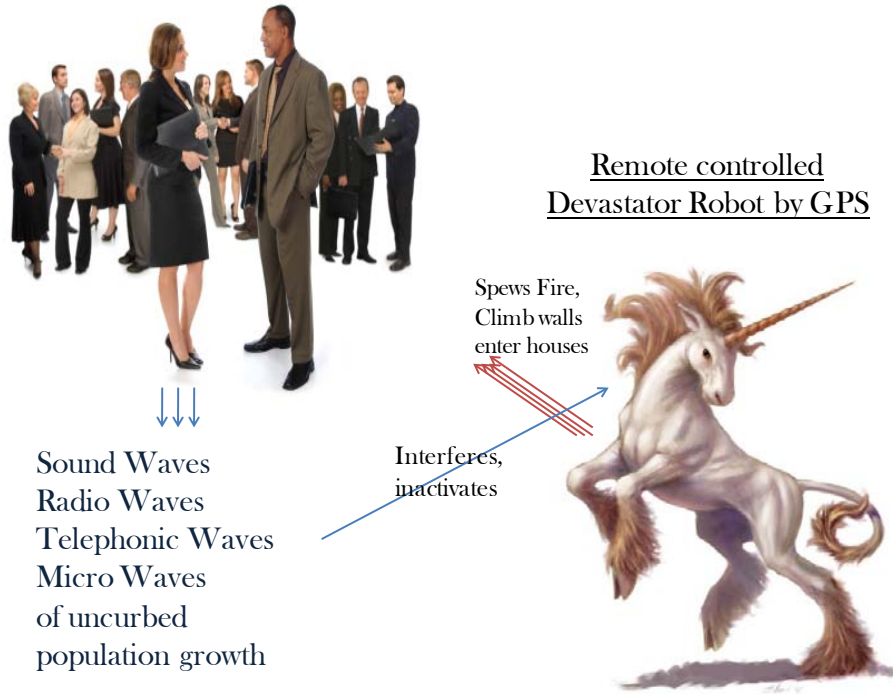
Figure 1

Human resources/ Density -- blessing

- Many people-sound waves, radio waves, telephonic waves, microwaves***will nullify or interfere-×××××-remote controlled devastator robot 1-2 feet height

- Many people××× Devouring blood feeding animals*** will flee

Figure 2

Urgent escape by the people to nearby mountains with no existing Global positioning system, is an immediate solution Figure 4.

Baby boom, with urgent contraception reversal, and eradication of global contraception, abortion are the ultimate solutions, strategies to prevent entry of blood feeding animals, and devastator robots.

There was 20 fold increase in entry of prowling Tigers to Foot hill townships over the past 15 years [p<0.0005] Figure 5;

Aborted blood contraceptive menstrual blood pollution

Frequent tiger's entry to towns

Devastator Robot progresses uninterfered by human sound waves

Devastator operation succeeds

Sparce people
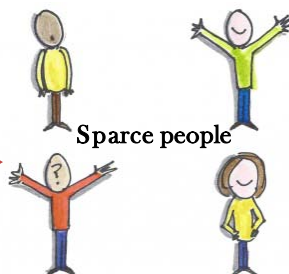
Reduced sound & radio waves

Figure 3

Urgent Solution

People flee to mountains **without GPS**

Devastator robot spewing fire by **GPS**

Patriotic gods intel robot nullifies devastator operation by emitting million micro waves & reroutes to seas

Patriotic robot alternate GPS to reroute

Figure 4
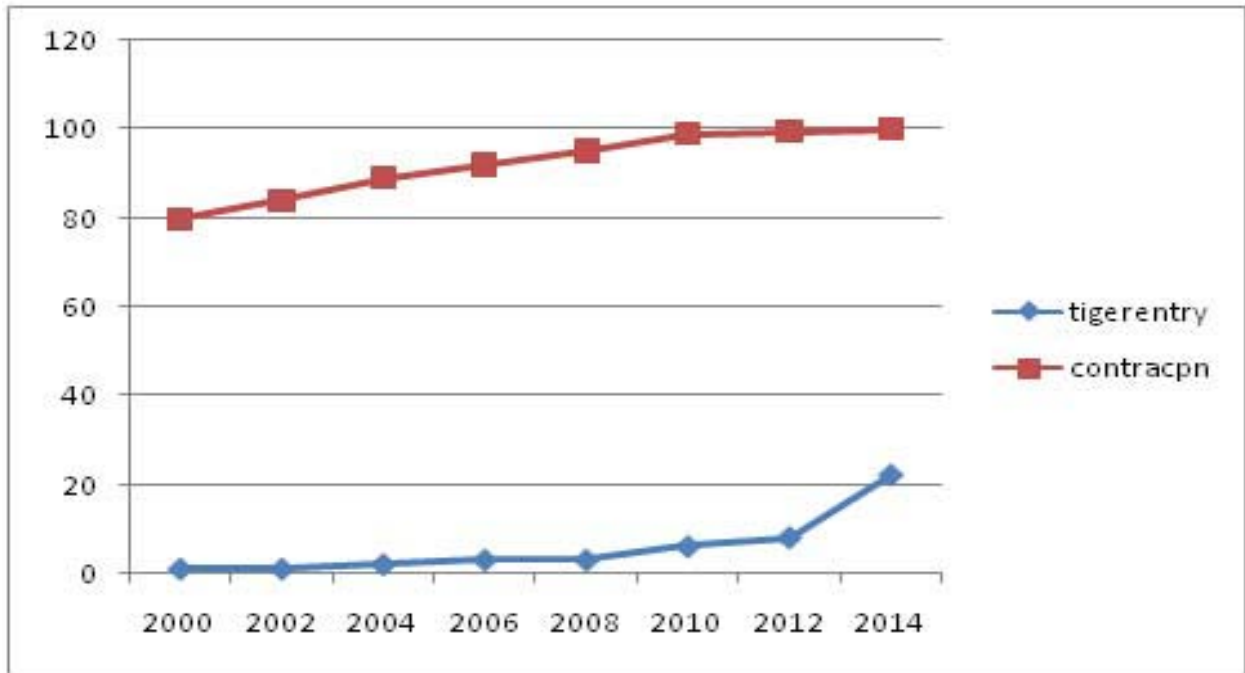
Blood feeding animal's entry to human habitat and rising environmental estrogen

Figure 5

Godsintel patrotic robot nullifies, reroutes to seas

Devastator Operation ww spew fire

Patriotic robot – ww emit million telephonic waves nullify devastator

Ww Former devastator to right hand sea rear devastator to left hand sea by alternate GPS

Figure 6

Godsintel patriotic robot incorporates two components: one component has to generate million or lakh micro waves, or sound waves, or telephonic waves to interfere, inactivate and nullify the remote controlled devastator operation, the devastator being guided by global positioning system to climb walls, enter houses through windows, spew fire; Godsintel patriotic robot`s second component is to simultaneously activate alternate Global positioning system to reroute the former devastator robots to the right hand sea, rear end robots to the left hand sea wherein, they`ll be drowned and quenched Figure 6.

III. Discussion

Distributions of populations have changed radically due to long term decline in fertility rates and improvements in mortality rates; increase in life expectancy was crowning achievement for the past century [era before contraception]. This demographic transition is accompanied by epidemiological transition in which non communicable chronic diseases are becoming the major causes of death; population aging is transforming the world in dramatic and fundamental ways, global aging is affecting the economic growth, migration, health systems, trade, and relative standing of nations. Around the middle of 20th century, under 5 years [1] age constituted 15% of total population and >65 years of age 5%; its predicted it`ll take about 30 years for 65 and older age groups to equal about 15% and *the*

younger <5years age group 5% [alas! disappearing global human race].

Global contraception, abortion has resulted in smashed fragmentation[2] of germ cells as ring chromosomes, a centric fragments, chromatid breaks, associated reduction of endogenous estrogen, androgen leading to deranged cell metabolism, defaulted genomic repertoire[3] resulting in 275% increased incidence of degenerative, neoplastic, autoimmune diseases[4] and increased mortality, [early demise of young parents] further adding on to global decline of human race.

In 1994 Dr. Susan Jobling of Brunel University[5] of United Kingdom, observed that estrogenic compounds are the pollutant in river waters, when they attempted to find the pollutant responsible for the disappearance of fish. In 1998 Professor Paul Devroey, identified` estrogen like particles are in the rise in the[6] air` as pollutant, when they attempted to analyze the cause for increase in infertility. Global abortion summary mentioned 863,000,000 reported[7] surgical abortions till 2010; 498 abortions per minute in the globe; United nations mentioned 3,750,000 reported surgical abortions /year; estrogen is a steroid hormone derived from[8] cholesterol[hence it gets the name-cholesterol-steroid], secreted directly into the blood, circulates in the blood, bathes , nurtures each cell; its surveillance is essential for cell differentiation, controlled multiplication, cell[9] metabolism, cell cycle, essential for genomic repertoire.
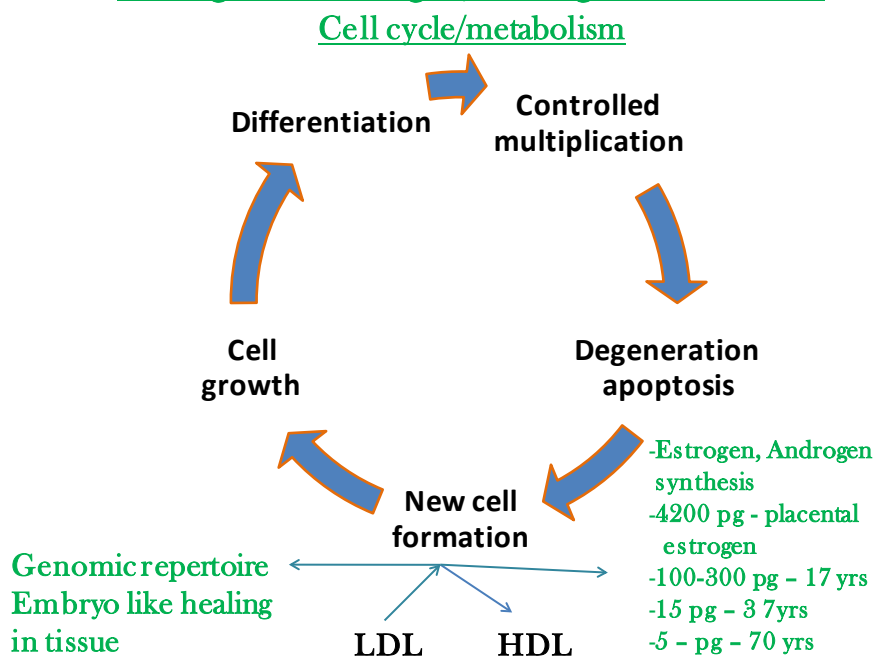
Reference-9

Reduced Endogenous estrogen, androgen

Contraception, Abortion - Deranged Cell cycle/metabolism

Reference 9
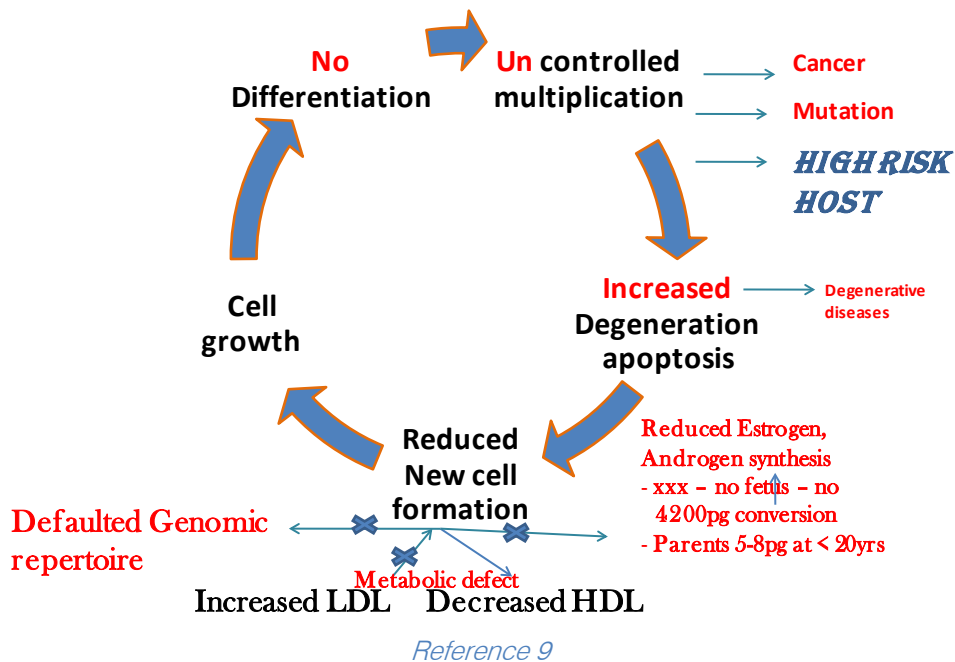
Unless blood is shed estrogen cannot reach the environment; during teen age estrogen levels will be 100pg-300pg [trillionth-a very small amount]; >37 years-the estrogen levels decrease to 15 pg; ~80 years, estrogen levels will be 5pg; during pregnancy placenta has to secrete 4200pg of estrogen, otherwise the fetus will be spontaneously aborted around 3rd month, called as placental switch over insufficiency.

If a person >50years` blood is spilt by murder, 150 ml of blood loss×15pg=2250pg estrogen contaminant to the environment;

if a teenager`s blood is spilt by accident then 150 ml of blood loss ×300pg=45000pg estrogen[10] contaminant to the environment;

when a pregnancy is aborted eg.498 abortions /minute×60 minutes×24 hours×365 days×60-80years×4200pg of estrogen×350ml.blood loss=estrogen pollutant of the air, water;

if a mother is blessed with 10 children she will not menstruate for minimum 200 months or 20 years, of the ~25 years menstrual span; whereas with contraception, small family norms, a lady menstruates 200 months more; so 1989,375,754 women of reproductive age group [15-45 years]×350ml blood loss/menstruation×300pgm estrogen×200 months/ woman=environmental estrogen pollutant.

Global innocent aborted blood, contraceptive menstrual blood polluted air, water inhalation, ingestion respectively; rising environmental estrogen equates with innocent aborted blood, contraceptive menstrual blood pollution of air, water. Innocent aborted blood, contraceptive menstrual blood with its hemoglobin, binds avidly to oxygen of the environment, and cannot be replaced by plants, unlike emissions; since live humans , with their emissions are made extinct, which is food, manure for plants, disabling replenishment of oxygen, resulting in ozone layer- atmospheric, environmental oxygen depletion, global hypoxia, global warming, disappearance of fish, islands, birds, grapes, solar keratoses, and soaring infectious diseases; hot air currents resulting in inevitable tsunamis, tornadoes, hurricanes, cyclones, floods, earthquakes.

Innocent aborted blood, contraceptive menstrual blood pollutant of the environment is further confirmed by detected α feto protein [fetal source], ß Human[11] chorionic gonadotropins [placental source] in river waters and water of the oceans.

Attempt to identify fetal hemoglobin in sea waters by hemoglobin electrophoresis, could not detect visible bands, because the instrument can measure hemoglobin in grams only, whereas estrogen can be detected in pictograms in sea, river waters; if nano science can detect fetal, adult hemoglobin in nanograms in waters, air, this concept of aborted blood pollution can still be confirmed.

This aborted blood pollution, contraceptive menstrual blood contamination of the rivers, attracts the prowling Tigers; contraception over decades has

achieved significant reduction in human density, with reduced strength of security, inviting the daring blood feeding animals. In this analysis the entry of Tigers, Cheetah`s into the foothill townships has increased by 20 fold with an alarming increase over the past 1 year, even as the birth control policies got progressively implemented.

Maxwell`s equations predicted an infinite number of frequencies of electromagnetic waves, all travelling at the speed of light. This was the first indication of the existence of the entire electromagnetic spectrum. In 1886 the physicist Heinrich Hertz built an apparatus to generate and detect what is now called radio waves. Hertz was able to find the waves and was able to infer [by measuring their wavelength and multiplying it by their frequency] that they travelled at the speed of light. Hertz[12] also demonstrated that the new radiation could be both *reflected and refracted by various dielectric media in the same manner as light.* For e.g. Hertz was able to focus the waves using a lens made of tree resin. In a later experiment Hertz similarly produced and measured the properties of micro waves. These new types of waves paved the way for inventions such as the wireless telegraph and the radio.

Electromagnetic waves have three properties namely frequency, wave length, photon energy. Wave length is inversely proportional to the wave frequency; photon energy is directly proportional to the wave length; whenever electromagnetic waves exist in a medium with matter, their wave length is decreased; wavelength of electromagnetic radiation, no matter what medium they are travelling, is quoted in terms of vacuum wave length. Generally electromagnetic radiation is classified by wavelength into radio wave, micro wave, terahertz radiation, infrared, the visible region is perceived as light, ultra violet spectrum, X-rays, gamma rays.

When electromagnetic radiation interacts with atoms and[13] molecules its behavior depends on the amount of energy/ quantum [photon] it carries; many hydrogen atoms emit[14] a radio wave, photon that has a wave length of 21.2 cm. UV rays produce photo electric effect; radio waves produce plasma oscillation. Radio waves are used for transmission of data via modulation, mobile phones, television, wireless networking, amateur radio-all use radio waves; skin effect of radio waves is used in antennas; microwaves are absorbed by molecules that have a dipole moment in liquids, this effect is used to heat food; high frequency waves can interfere with electronic equipments.

The concept is due to decreasing density of human resources, secondary to wantonly implemented global contraception, abortion, the medium of interference to electromagnetic waves have decreased. People with their micro waves, radio waves formation, would have prevented, a remote controlled, devastator operation; for e.g. when someone looks at us without our knowledge, automatically, unaware our eyes turn to glance at them; similarly when we comb our hair in uniform direction and lift the comb to repeat the action the hair rises towards the comb; probably atomic, molecular interference of cells of live human body; as cautioned in the [15] Word of God in the book of Joel, its mentioned that multiple devastator robots of ~2-3 feet height, shaped like horses, will descend like the dew on the streets, probably let down in thousands by air carrier for different, specific areas, streets, with command to climb walls, guided by global positioning system to enter the houses through window`s, all along spewing fire of destruction; the Word of God suggests a solution to be obtained to reroute the former devastator to right hand sea, rear end robot to left hand sea to be drenched and quenched; because to go forward, backward is a dominant, simple command; thereafter the land will bloom again, hence this devastator robotic war has to be non nuclear.

As the Gospels mention emergency solution to the people is, a caution not to enter houses, but to flee to mountains, where global positioning system does not exist, hence devastators cannot approach.

Hence the *concept of `patriotic Godsintel robot` to be made to reach the former, rear ends of the devastator robots in two split batches, should be geared to emit a million or lakh micro waves, or radio waves or cordless phone waves,[akin to live people`s emissions] to interfere and inactivate the devastator operation; simultaneously another remote controlled incorporated command with alternate global positioning system, to reroute the devastator robot – the former group to the right hand sea and the rear end devastator robots to the left hand sea, wherein the devastators can be drowned and quenched.*

The ultimate answer would be, to undertake global emergency measures for Baby Boom; to eradicate contraception, abortion from the face of the earth, by which the globe is committing self destruction and to revert contraception including tubal recanalisation wherein, agonizingly permanent sterilization has been achieved. This will restore womanhood, the royalty of blessed motherhood, after Holy matrimony with her beloved husband, from today`s belittled womanhood status of use and throw napkin [abort] policy.

IV. Conclusions

Global contraception, abortion achieved successfully has resulted in drastically declining fertility

rates, dangerous reduction in human density, to the score of anticipated drop in <5 years population, to ~5% in another 2-3 decades. Documented rising environmental estrogen, α feto protein, ß Human chorionic gonadotropins in river, oceanic waters and air confirms aborted blood pollution, contraceptive menstrual blood contamination, depleting ozone by progressive cumulative depletion of oxygen by the blood pollutant which cannot be replaced by plants, unlike emissions of live humans, which will generate replacement of utilized oxygen by the plants, as God ordained eco balanced cycle.

Sparse people, reduced human density, with aborted blood polluted rivers, though away from the virgin forests, attracts the daring animals like Tigers, Cheetahs, to frequently enter human habitat at foot hill townships, progressing even to the heart of cities with rivers flowing within; this study`s analysis reveals >20 fold increase in frequency of visits of Tigers to busy roads of foothill townships over the past 15 years. These daring animals` cubs had been purposely introduced into the virgin forests a few decades back, to safe guard precious trees like sandal wood, from theft.

This reminded about a non nuclear robotic war postulated in the book of Joel, of the Word of Author of Life, made possible by absent human beings by global abortion, contraception, whose presence, with their sound waves, radio waves, cordless phone waves, would have interfered and nullified the portrayed operation of devastator robots, walking with stability on four feet, resembling horses, spewing fire of destruction, let down probably by air carrier for different specific areas, climbing walls, entering houses through windows, guided by global positioning systems; the caution follows in the Gospels recommending people not to enter houses, but to flee to mountains, wherein global positioning system does not exist.

The concept of *patriotic Godsintel robot* figured, as the solution mentioned in the book of Joel, of rerouting the former devastator to the right hand sea and rear devastators to the left hand sea to be drowned and quenched, by some means, was pondered upon. So the patriotic robots split in two batches, to address the former devastators and the rear end devastators, should be made to reach the devastators and have the two incorporated components of [1] to emit a million or lakh micro waves, or cordless phone waves or radio waves, to nullify the devastator operation by interference and [2] simultaneously activate another command, to reroute former devastators to the right hand sea, rear end devastators to the left hand sea, by alternate global positioning system.

Ultimate answer to global threats, including frequent entry of Tigers to human habitat and possible non nuclear robotic war is, urgent global measures to initiate, *achieve uncurbed Baby Boom*; eradicate contraception, abortion including policy of small family norms, one child policy, from the face of this earth; to *revert contraception, specially by tubal recanalisation,* wherein permanent sterilization with its constant, perennial, unabated offense plays the doom of young parents. *May the woman hood receive her royalty by blessed, uncurbed, God ordained, enriched childbirth of mother hood, after Holy Matrimony; let the present belittled womanhood of use and throw napkin [abort] status come to a grinding halt. Let virginity be coveted prior to Holy Matrimony.*

a) Key Points
- 20 fold rise in frequency of entry of tigers, cheetahs to human habitat of foot hill townships, by aborted blood, contraceptive menstrual blood polluted environment of river, sea waters, air.
- Non nuclear robotic war made possible with absent human beings by global contraception, abortion, with their sound waves, radio waves and phone waves being absent, otherwise capable of interfering with remote controlled devastator robots.
- Patriotic robots able to generate million sound waves, microwaves, radio waves, mobile phone waves, will interfere and inactivate devastators to be rerouted to seas, by alternate Global positioning systems.
- Ultimate answer to global threats is emergency Baby Boom, eradication of global contraception, abortion, coupled with mandatory contraception reversal, including free tubal recanalisation for the entire globe.
- Urgent solution/caution for people during devastator operation [if it succeeds], is not to enter houses, but to flee to mountains, lacking the global positioning system.

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Job Shop Scheduling Problem for Machine Shop with Shifting Heuristic Bottleneck

By Jilcha Kassu & Berhan Eshetie

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Abstract- Job shop scheduling is an Np-Hard combinatory in the field of scheduling problem. Due to this reason, Dejena Aviation Industry (DAVI) has faced a problem to determine the optimum sequences of jobs on machines that can optimize the makespan. The purpose of this study is therefore, to minimize the makespan of the job shop production system of DAVI production system using shifting bottleneck algorithm. Secondary data was collected from the production log book five machines were considered during the production of five jobs. The findings of the shifting bottleneck algorithms showed that an 8.33% reduction in the total makespan of the company job shop production system. Moreover; machine one (41%) and three (36%) are found to be least utilized machines whereas machine three (64%) and five (59%) are relatively the busiest machines.

Keywords: job shop scheduling, machine shop, make span, shifting bottleneck.

GJRE-J Classification : FOR Code: 091599

JOBSHOPSCHEDULINGPROBLEMFORMACHINESHOPWITHSHIFTINGHEURISTICBOTTLENECK

Strictly as per the compliance and regulations of :

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Jilcha Kassu [α] & Berhan Eshetie [σ]

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I. Introduction

In today's competitive markets, manufacturers have to respond quickly to orders and meet shipping dates promised to the customers, as failure to do so, at least, may result in a significant loss of good will [1]. Among many techniques that makes manufacturers competent in the business arena scheduling is one of the operation to accomplish activities on time and deliver products in their lead time. Customer satisfaction is the last outcome of organizations. This requires an optimum scheduling system that allocate scares resources.

Scheduling is the allocation of shared resources over time to competing activities to satisfy customers' requirement. It has been the subject of a significant amount of literature in the field of operations research. Emphasis has also been given on investigating machine scheduling problems where jobs represent activities and machines represent resources so that each machine can process at most one job at a time [1,2].

Machine scheduling is viewed as a dynamic problem usually an NP-complete combiner's in the production scheduling problems [3, 4, 5,1, 2, 6, 7, 8]. After a job is processed in a particular machine, the condition of the jobs waiting to be processed on the same machine may be changed due to any of several reasons. For example, new jobs may arrive or the remaining slack times or may be changed even though

no job arrives during the processing time of the previous job on the machine [8, 9]. Therefore, it requires a rescheduling effort to determine which job to be processed next.

Scheduling is a multifaceted in nature and it consumes large resource. Even for small problems, there is absolutely no guarantee that an optimal final solution can easily be obtained. To this effect, heuristic approach have been used by researchers.

Shifting bottle neck heuristics (SBH) is one of the procedures intend to minimize the makespan in a job shop. It follows that in the pre-defined machines sequence there is always one machine with bottleneck in the processing sequences. This heuristic algorithm tries to minimize the effect of the bottleneck process through iterative method in finding maximum makespan (C_{max}) and maximum lateness time (L_{max}).

Dejena Aviation Industry (DAVI) which is a job shop manufacturing company in Ethiopia faced similar problem in its production system. It experiences a longer makespan in its production system. Therefore the objective of this study is to minimize the makespan of DAVI using shifting bottleneck heuristic algorithm.

II. Literature Review

Many literatures conducted regarding scheduling, job shop, and shifting bottleneck in the manufacturing systems of a job shop production system. Scheduling is defined as "It is to forecast the processing of a work by assigning resources to tasks and fixing their start times" as defined by [24,25,26]. Job shop scheduling is a work location in which a number of general purpose work station exist and are used to perform a variety of jobs such as a traditional machine shop with similar machines type located together, batch or individual production.

The job shop problem studied in the present paper consists in scheduling a set of jobs on a set of machines with the objective to minimize the makespan, i.e., the maximum of completion times needed for processing all jobs, subject to the constraints that each job has a specified processing order through the machines and that each machine can process at most one job at a time [10].

In the job shop scheduling problem (JSP), there are n jobs that must be processed on a group of m machines. Each job i consists of a sequence of m operations (O_{i1}, O_{i2}..., O_{im}), where O_{ik} (the kth operation

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of job i) must be processed without interruption on a predefined machine m_{ik} during p_{ik} time units. The operations O_{i1}, O_{i2},.., O_{im} must be processed one after another in the given order and each machine can process at most one operation at a time [5, 1, 2, 6].

In a flexible job shop, each job i consists of a sequence of n_i operations (O_{i1}, O_{i2},...,O_{in}), and each operation O_{ik} can be processed on any machine out of a set A_{ik} of given machines. The processing time of operation O_{ik} on machine j is Pikj > 0. The scheduling problem is to choose for each operation O_{ik} a machine M, such that O_{ik} $|$ A_{ik} and a starting time S_{ik} at which the operation must be performed [11, 5, 1, 2, 6].

The job shop scheduling problem, which is among the hardest combinatorial optimization problems that is strongly NP-complete [11]. During the past decades, many researchers have been focusing on the problem and proposed several effective algorithms for it. These algorithms can be classified as optimization and approximation algorithms. The optimization algorithms, mostly used, are based on the branch and bound scheme [11]. These algorithms have made considerable achievement, however, their implementation needs too much computational cost. On the other hand, approximation algorithms, which are more effective for large size problem instances, use several approaches classified as: (a) local search, (b) dispatching priority rules, (c) shifting bottleneck approach, (d) stimulated annealing, and (e) tabu search [11].

Various scholars have been used different approach to solve job shop scheduling problem. Among the many researchers one, Katuri propose Optimization of job shop scheduling using shifting bottle neck technique to reduce total flow time of job shop scheduling problem and arrive the optimal solution [12]. Kai-Pei Chen (2007) proposes an assembly job shop scheduling problem with component availability constraints, a modified disjunctive graph formulation. Also he developed a mixed integer programming model with objective of minimizing the total weight tardiness [13]. Zhi Huang propose a modified shifting bottleneck procedure for job shop scheduling with objective to minimize the make span. In this study dispatching and heuristic approach was used due to the job shop operation practice of the case company.

a) Model Representation and algorithm

Generally, JSP uses various representation in its model. In this project let a job shop consists of a set of Mj machines where j=1, 2... m, n jobs, and a pre-defined plan which states the assignments of these jobs in different machines in some desired sequences (constraints). Each job has a specified number of operations to be carried out in different machines, with individual setup times, processing times, a due date, etc. The job shop sequencing problem deals with the study of an optimal sequencing of the operations (of the jobs) in different machines within the specified constraint requirements [14].

A job-shop does not have the same restriction on workflow as a flow-shop. In a job-shop, jobs can be processed on machines in any order. The usual job shop, from a research standpoint, is one in which there are m machines and n jobs to be processed. Each job requires m operations, one on each machine, in a specific order, but the order can be different for each job [15, 16].

The shifting bottleneck heuristic is an efficient method to find C_{max} and L_{max} objectives in a job shop [13] with an iterative method. At each iteration of the method, a bottleneck machine was identified using 1 /r_j / L_{max} approach. A processing sequence of job on the machine bottleneck machine was found so as to minimize L_{max} [13]. The shifting bottleneck algorithm used in this paper is represented as follow:

1. *initialize*
2. $M_o = \emptyset$ *(scheduled machines)*
3. *G = only conjunctives arcs*
4. G_{max} = *critical path in G*
5. *Choose a machine Mi;*
6. *for each machine $M_i \in \{M-M_0\}$*
   Generate the $1|r_j|L_{max}$ schedule
   Compute $L_{max}(i)$
7. *Scheduling the bottleneck machine*
   - *Let k be the machine that minimizes $L_{max}(i)$*
   - *Schedule k by the $1|r_j|L_{max}$ solution*
   - *Update G*
   - *Mo= Mo ∪{k}*
8. *Re-Sequence already scheduled machines*
9. *For each Mi ∈ M0− {k}*
   do
   Delete disjunctive arcs for Mi from G
   Form the 1|rj|Lmax
   Reschedule M_i according to this schedule
10. *While M = M_0 stop,*
    else go to 2

and continue the same iteration until optimum solution is obtained [1, 2, 6, 7, 8, 9, 17].

III. Results and Discussions

In this study, the jobs selected from list of spare parts manufactured in DAVI which covering 8% of job orders. The data was collected from jobs: spur gear (J_1), shaft with key (J_2), adapter (J_3), flange (J_4) and fitting (J_5). These jobs were processed by machines namely power hack saw (M_1), lathe machine (M_2), milling machine (M_3), drilling machine (M_4) and grinding machine (M_5). The precedence matrix constraint contains for all selected jobs only and machines are presented in Table 1.

Table 1 : Routing matrix the five jobs and five machines

Jobs	Precedence constraints				
J1	M1(2)	M2(2)	M3(5)	M4(2)	M5(3)
J2	M1(2)	M3(2)	M4(1)	M2(2)	M5(2)
J3	M1(2)	M4(2)	M3(3)	M2(2)	M5(3)
J4	M1(1)	M2(2)	M3(2)	M4(1)	M5(2)
J5	M1(2)	M3(2)	M4(2)	M2(2)	M5(3)

Once the precedence constraint development of the jobs on each machine were developed by considering machining operation requirements as shown Table 1 and setting all the parameters, Lekin scheduling software were used to find the optimum sequences of operations. The findings of the research result with shifting bottleneck heuristic is shown in Table 2 and gnat chart for optimum job sequence is shown in Figure 1. There are methods that are built-in-heuristics in minimizing flow times of job shop scheduling. These are:

a) Shifting bottleneck heuristics
b) Local search heuristic
c) Hybrid methods

Here in this study shifting bottlenech heuristic has been considered with its three policies/options. The following three policies/options has been utilized in Table 2 resulting in performance measurement of the case.

- General SB Routine (most objectives)
- Objective Specific routines: SB/sumwT (Total Weighted Tardiness) and
- Objective Specific routines: SB/Tmax (Maximum Tardiness, Makespan)

The key performance measurements are define below.

Where;

$Cmax = makespan$;

$Tmax = Total\ tardiness$;

$\sum Uj = total\ number\ of\ late\ jobs$;

$\sum Cj = total\ flow\ time$;

$\sum Tj = total\ tardiness$;

$\sum wjCj = total\ weighted\ flow\ time\ and$

$\sum wjTj = total\ weighted\ tardiness$

Table 2 : Output from different simulation run using heuristic options built in lekin software

Job –machine sequence	Methods in heuristics	$Cmax$	$Tmax$	$\sum Uj$	$\sum Cj$	$\sum Tj$	$\sum wjCj$	$\sum wjTj$
4(1)-1(2)-3(3)-5(4)-2(5)	Makespan and maximum tardiness	23	23	5	85	85	85	85
4(1)-5(2)-2(3)-3(4)-1(5)	Total flow, tardiness and total weighted flow and tardiness time approach	22	22	5	73	73	73	73
4(1)-5(2)-2(3)-3(4)-1(5)	Shifting bottleneck/Sum(wT)	22	22	5	71	71	71	71
4(1)-5(2)-1(3)-3(4)-2(5)	Shifting bottleneck/T$_{max}$	22	22	5	79	79	79	79

From Table 2 and Figure 1, the findings of the simulation run show that the shifting bottleneck heuristic with the option of shifting bottleneck sum weighted tardiness approach resulted in a minimum makespan of 22 hours with job sequences of job 4-2-5-3-1. The optimum sequence has improved the makespan of DAVI by an 8.33%. In this sequence the operation started on machine one with job 4 and ends on machine five with job one. The findings of the study also showed that the percentage utilization of each machine. Accordingly, the percentage utilization of machine one is 40.91%, machine two 45.54%, machine three 63.63%, machine four 36.4% and that of machine five 59.09% of their available time.
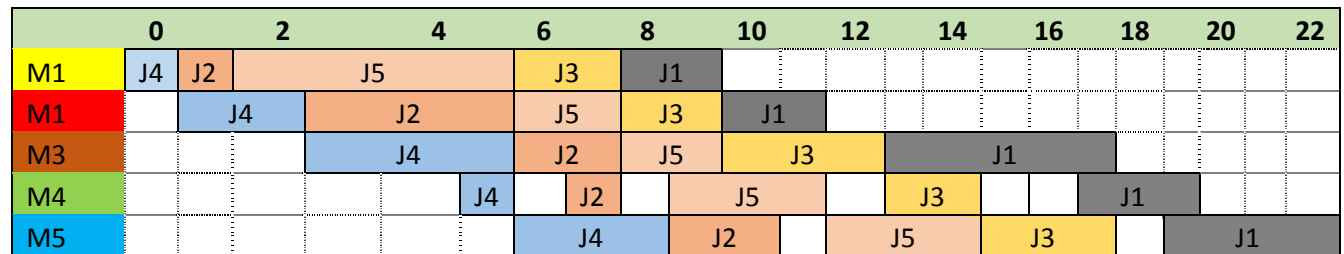
Figure 1 : gnat chart for optimum job sequences

IV. Conclusion

Job-shop scheduling is an NP-complete combinatorial optimization problems which comprises m machine and n jobs. This research paper aims at scheduling of 5-machines and 5-jobs using shifting bottleneck heuristic algorithm methods built-in-heuristic Lekin scheduling software based on secondary data collected from DAVI production system. The findings of the study showed that the SBH resulted in a total makespan of 22 hours with 8.33% improvement as compared to the current scheduling system that DAVI operates in its production line. The percentage utilization of machines shows that machine three is the busiest machine whereas machine one and four have relatively the lowest percentage utilization which is less than 50%.

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Experimental Analysis and the Development of Ground Nut Oil for Machining Operation

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Abstract- Metal removal process is one of the major methods of shaping materials to meet its environmental need. It requires the use of forces thus, heat would be generated and if not controlled, it could affect the expected end results. One of the major ways of controlling the heat during cutting is the use of lubricant. The cutting fluid commonly used for machining in a standard machine shops, are imported at exorbitant cost, hence, analysis was carried out on a vegetable oil from ground nut (GNO)and its properties were integrated by adding additive and emulsifying agents to develop it to a suitable soluble oil for machining operation. The experimental results concluded that the saturated solution of NaOCl and NACO3 when added to the GNO in ratio 1:2 formed perfect emulsiable oil (GNSO). The GNSO and conventional cutting fluid (CCF) were used to carry out machining of mild steel on a Lathe Machine. The results obtained shows that the surface finish of the sample cut with the GNSO is the finest. The two samples were observed for 70days for corrosion effect and their microscopic structure picture were observed, the sample cut with CCF was majorly affected. The reliability of the GNSO was further determined through the various soluble oil ASTM tests, least square regression analysis was used to interpret the correlation coefficient data collated which shows that GNSO is equally reliable and more cost effective than CCF since it can be sourced locally in abundant.

Keywords: metal cutting theory, development, and experimental analysis of GNO for machining.

GJRE-J Classification : FOR Code: 291899

EXPERIMENTALANALYSISANDTHEDEVELOPMENTOFGROUNDNUT OILFORMACHININGOPERATION

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Experimental Analysis and the Development of Ground Nut Oil for Machining Operation

Engr Ekundayo [α], Gbenga [σ] & Ogunyankin, N.A [ρ]

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Keywords: metal cutting theory, development, and experimental analysis of GNO for machining.

I. Introduction

Cost of acquiring materials for further processing to acquire the desire shape is of high critical concern for the determination of the method needed for its process, this is done to minimise waste. Materials processing is all that is done to develop either its chemical properties or physical shape. (Ekundayo, 2004); Smith (1987), admitted that in acquiring the desire shape, many methods can be used and that each method are chosen on their merits of how it may be easy to generate the desire shape and the overall cost of doing that. Ekundayo (2004), listed out the following processes of materials processing as a means of generate the require shape such as: casting process, metal removal (Machining) process, deformation and consolidation processes. This paper limit its consideration on machining process since it is where the use of soluble oil is mostly needed for cooling during machining.

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Metal removal (Machining) involves forcing of cutting tool through the excess materials of the work-piece, this is done progressively by separating the excess from the work-piece in form of chips. The process of metal removal and its technology is otherwise called metal cutting theory. This theory is a complex theory and it is difficult to predict accurately the number of forces involved. This involves the traditional machining processes such as metal cutting and grinding, as well as various non-traditional methods of machining.

II. Principle of Metal Cutting

To successfully carry out cutting of metals to the desirable shape, some principle must be well understood since the operation involves the use of cutting tools. Hence, the following principles must be taken into consideration before embarking on any cutting.

- The relative motion of the work- piece to the hard edge of the cutting tool

- The chemical and physical properties of the work-piece

- The cutting tool material

- The cutting fluid(Soluble oil) (Ekundayo, 2004)

Smith, (1987), opined that, in a modern workshop practice of any industry where power is needed for cutting, enormous amount of power is lost either through heat generation or friction between tool surface and work- piece. In Metal removal process, heat is generated due to plastic deformation and the chip/tool friction on the rake and flank faces. Smith (1987), estimated the energy lost due to heat generation during cutting to be between 20 and 30 percent of the total energy invested in the metal removal process and to considerably reduce this, cutting fluid is needed, hence this paper discusses the possibility of replacing GNO with the convention soluble oil.

III. Type of Cutting Operations

There are many methods of metal cutting here-in refers to as machining. According to Encyclopaedia (2012), Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. This

processes are today refers to as subtractive manufacturing in distinction from processes of controlled material addition, which are known as additive manufacturing. The world machining has been in use for the past two centuries (Machine age) and today engineers call these traditional (conventional) machining processes such as turning, boring, drilling, milling, sawing, broaching etc. These involve the use of sharp cutting tools to remove the materials to achieve the desire geometry on machine tools such as Lathe, Milling machines and drilling press. The world conventional or traditional is used to differentiate the old methods from the newly developed technologies methods of machining processes such as EDM, ECM, EBM, PCM and UM(today most of the traditional processes have been upgraded to Computer Numerical control Machine, CNC). This paper is concern about the traditional machine tools where the use of soluble oil for cooling during machining is very important. There are many kinds of machining operations, each of which is capable of generating a certain part geometry and surface texture. During turning, a single point cutting tool is required; the tool is moved toward the work piece while the work piece rotates on its axis to generate cylindrical shape. Drilling uses a rotating tool that typically has two or four helical cutting edges to create hole. The tool is fed in a direction parallel to its axis of rotation into the work piece to form the round hole, while milling uses multiple cutting edge tools to generate a plane or straight surface, the direction of the feed motion is perpendicular to the tool's axis of rotation. The speed motion is provided by the rotating milling cutter. Other conventional machining operations are shaping, broaching, sawing, and grinding. According to Groover (2002), approximately 98% of the energy in machining is converted into heat which can cause very high temperature at tool-chip zone while the remaining energy (about 2%) is retained as elastic energy at chip. To reduce the heat generated at the tool-chip tips, correct cutting fluid is required for cooling and lubrication during machining so as to prolong the life's of the cutting tools and creates good surface finish.

IV. Cutting Fluid

Tools failure, poor surface finish and seizure between tool and chip occur during metal cutting. The reasons for this had been traced to heat generated during cutting as tools are forced through the excess materials of the work –piece, hence chips are formed due to the plastic deformation of the work- piece which normally take place ahead of the cutting area. According to the British Petroleum Company (1972), work done in deforming metal is converted to heat due to the very high local forces applied to the metal, which set up tremendous pressure on the cutting tip. Heat can also be generated during cutting due to the friction between the chip/tool faces when the chip moves under high pressure across the tool face, some of these heats affect the cutting tool. Smith (1987) opined that 20 to 30% energy lost during cutting are due to heat generation resulting from the friction between the tool surface and the work – piece. Muktar and Ibhadode (1999) described friction and heat as the two major effects that accompanying machining operation. Therefore, to minimise energy lost, generate good surface finish and protect the life of the cutting tool, the British Petroleum Company (1972), propounded that even if the structure of the materials are modified and cutting tools are well designed heat will still be generated. Hence, it can only be reduced by using three means, such as the use of refrigerant (Carbon dioxide), air blast and cutting fluid. Smith (1987) agreed with the British Petroleum Company (1972) but stated that cutting fluid is the most widely used among all these methods and to reduce power lost during metal cutting, cutting fluid is inevitable.

Many definitions had been given to cutting fluid. Bello (1994), described cutting fluid as a material that make surface smooth and slippery and they are used to reduce heat, friction, wear and vibration during cutting operation. The British Petroleum Company (1972), refers to it as a cooling system which carries away heat generated during cutting from the cutting area. Adejuyigbe (1999), defined cutting fluid as an auxiliary materials that embraces lubricant which reduces friction between moving parts and as well as protecting the component against corrosion. Ekundayo (2004), summarised that cutting fluid is any substance that is able to provide cooling and lubrication during machining operations.

V. Types of Cutting Fluid

According to Smith (1987), cutting fluid may be in three forms, Solids, Liquid and gasses. Their purposes are, decreasing friction between the tool face and chip formed during cutting. Examples of the solid lubricants are graphite, molybdenum, disulphide and stick waxes. Liquid and gases used in cutting operation are broadly referred to as cutting fluid and they appeared in two forms:

- Mineral having water based oil

- Mineral having mineral based oil

Many additives are added to the cutting fluids which assist them in performing specific functions during cutting.

Water based oil are generally used where cooling is required. While mineral based oil are used where lubrication is needed. Krar (1984), grouped cutting fluid into active and inactive, Active cutting fluid darkened copper strip when it is immersed in it for three hours at a temperature $100^{\circ}C$ or $212^{\circ}F$. Inactive cutting fluid is made of the following:

- Straight oil
- Fatty oil
- Fatty and mineral oil blends
- Sulfurized fatty- mineral oil blends.

They can be used where ferrous and the non-ferrous were been machined at the same time. British Petroleum company (1972) categorised cutting fluid as; Soluble oil Emulsion, Chemical coolant and neat cutting oil. The soluble oil emulsions are generally used where very high cutting speed and relatively low pressure on the surface of the tool are applied.

Muktar and Ibhabode (1999) said that 90% of the cutting fluids used were from soluble oil emulsion. Water – mixable oil or emulsifier oil are non-expensive coolant, it contains soap like materials that make them soluble in water and cause them to adhere to work-piece. They appeared in form of cream or milk-water colour. The portion of water for one pan of oil varies from 1 to 50. When not properly mixed (weak mixture), it causes rusting. During use, air circulation is required to reduce the removal of water via evaporation. Cutting fluid is an important factor in metal removal process to obtained the desired shape, hence they are not available in abundant and even when available the cost of purchasing them are beyond the reach of small-scale machine shops considering the exchange rates. Thus, many operators of these machines resulted into the use of ordinary water, soap mixed with water, ordinary palm oil, diesel-in–water, kerosene or dry cutting. (Ekundayo, 2004). The overall effect s of these actions on cutting process are; poor machining, quick tool wear, rough surface finish, rusting and changing of the work-piece internal structure due to chemical reaction.

Hence, in this paper, groundnut oil (GNO) a local vegetable oil was developed into emulsiable oil using emulsifiable agent, and extreme-pressure (EP) agent. The emulsifiable GNO is herein refers to as Ground Nut Soluble Oil (GNSO), and used for straight turning on a lathe machine and the results were compared to that of conventional cutting fluid (CCF).

VI. METHODOLOGY

In a bid to achieve the objectives of this research GNO was extracted from endosperm which was obtained after the removal of the ground nut kernel shell (nut), .The extraction was done by using solvent extraction method and this was done in an oil producing industry (JOF Ideal family Farm, Owo). Laboratory test was carried on it to determine its chemical composition. Reagents (Emulsifier and EP additive) and water were mixed with the GNO to develop the GNSO, and its physical properties were compared to that of CCF.

Experimental analysis was further carried out on the GNSO and its results were also compared with that of CCF. The two cutting fluids that is, the GNSO and CCF were used in carrying out machining operations on mild steel, using the same cutting speed, same chip thickness and the same Lathe machine. The physical properties of the two machined samples were compared and placed under observations for 70 days and observed for corrosion resistant. The data collated were analysed using the simple statistical analysis such as mean value, standard deviation and least regression method and their microscopic picture were also compared.

VII. EXPERIMENTAL PROCEDURE

The GNO extracted from JOF Ideal Family Farm was initially tested to confirm its chemical composition, this was done when it was extracted at its crude state and the results were as shown in the table 1 below:

Table 1 : The laboratory Chemical composition of the extracted GNO

Properties	Crude GNO
Sponification value(mgKOH/g oil)	196
Iodine value(Wijs)	102
Unsaponifiable value	10g/Kg
Peroxide value	$5mgO_2$ /Kg
Refractive index (nD 40°C)	1.465
Moisture	0.2%
Acid value	0.6mgKOH/g
Relative Density 25°C/water at 25°	0.917
Soap value	0.05%

Sources: Author's laboratory tests result carried out at JOF ideal family farms (2004).

VIII. SOLUBILITY OF GNO IN WATER TO FORM SOLUBLE OIL (GNSO)

At the natural state of oils, they will not dissolve in water that was why British Petroleum Company (1972) regards the use of soluble oil as a general terminology for cutting fluid as misnomer. According to Krar (1986) soluble oil or emulsifiable oil are those mineral oils that contain soap like mineral (emulsifier), which make them soluble in water. The emulsifiers break the oil into minute particles and keep them separated in the water for long. Hence, GNO was tested with some emulsifiers and EP additives , these were done in the Federal Polytechnic, Ado-Ekiti and the results obtained were shown in the tables 2 below; The two locally available emulsifiers are Na_2CO_3 (sodium trioxocarbonate iv) and $NaHCO_3$ (Sodium hydrogen carbonate)and they were used for the tests.

Specimen used.

- 10ml (millilitre) of GNO
- 6ml (millilitre) of emulsifier were mixed and samples observed.

Table 2 : Determination of emulsifying properties of the GNO

	Test	Observation
1	10ml of GNO was added to 6ml of Na_2CO_3 in test tube and agitated vigorously and left for five minutes	Both mixed together and form good emulsion. The colour turned from yellow to milky. The mixture remains in the form of fine disperse droplets even for three days
2	10ml of GNO was added to 6ml of $NaHCO_3$ in test tube and agitated vigorously and left for observation	The emulsion remains for 5 minutes and start to separate into two layers

Source: Laboratory experiment carried out at the Federal Polytechnic, Ado–Ekiti (chemistry) lab by the author (2004).

Table 3 : Experimental analysis for the determination of the appropriate EP additive for the development of the GNO into standard soluble oil

	Test	Observation
1	10ml of chloroform + 20ml of GNO in a test tube and agitated vigorously	Both mixed together perfectly
2	A pinch of sulphur was added to 20ml of GNO in a test tube and agitated, then heated to 40°C and above	The sulphur did not dissolve even when heated. At 40°C its melted , at 60°C it form a cake while at 96°C its melted and dissolved completely but the sulphur reappeared during cooling
3	10ml of GNO + 6ml of NaOCl in a test tube and agitated vigorously	It was observed that they both form good emulsion and it was milky in nature even after shake thoroughly.

Source: Laboratory experiment carried out at the Federal Polytechnic, Ado–Ekiti (chemistry) lab. by the author (2004).

Table 4 : Using the formation of saturated solution of $NaOCl + Na_2CO_3$ to form the GNSO

	Procedure	Observation
1	10ml of GNO + 6ml of saturated solution of NaOCl + Na_2CO_3, and agitated very well	They form good emulsion even when agitated vigorously. it was milky in nature

Source: Laboratory experiment carried out at the Federal Polytechnic, ado–Ekiti (chemistry) lab. by the author (2004).

IX. Results

From the various experiments carried out as shown above, the saturated solution of NaOCl (EP) and Na_2CO_3 (emulsifier) when added to the GNO formed perfect emulsifiable oil at ratio 1:2 without separation, flocculation and sedimentation even after being kept for over one hour. Other tests carried out following the ASTM to be sure of the suitability of the properties of the GNSO were: foaming test, pouring point, emulsion stability, PH test, viscosity and specific heat capacity.

a) The Determination of the Reliability of the GNSO for Machining

Adejuyigbe (1997), defined machine tool as power driven machines, while Oswald et al (1985), described it as an equipment that are capable of producing work piece to extremely fine tolerance. The developed GNSO and CCF (soluble oil emulsion) were used separately for cutting on a Lathe Machine in the Rufus Giwa Polytechnic workshop, Owo, Ondo State, Nigeria.

The method used for pouring was manual down pour cooling at an average of 20ml per minute. The work piece used was Mild steel of 25mm diameter. The length of cut was 38mm long. Observations were taken during each cutting to know the effectiveness of the GNSO as compared to CCF (see the table below).

	Local developed soluble oil (GNSO)	Soluble oil emulsion (CCF)
Initial Temp. °C of fluids before cutting	25	25
Final Cutting Temp. °C	36	36
Cutting speed (rpm)	230	230

Observation: During cutting GNSO shown little smoke but not as it was in the case of CCF which shown a visible smoke almost getting to flash point.

The surface finish of the two cutting samples were compared, the sample made from GNSO has a fine surface finish while that of CCF was not too coarse and not as fine as that of the sample from GNSO. The two samples were later left opened under atmospheric conditions and observed for 70days, measurement were taken daily and the final results was analysed. The microscopic pictures of the two samples were also taken and observed and their results show that the sample from CCF was majorly affected. (Fig.1 and 2 below).

Fig.1: Microscopic picture of Sample 1 after 70 days (groundnut emulsion as cutting fluid)

Fig.2: Microscopic picture of Sample 2 after 70 days (soluble oil as cutting fluid)

X. Results Analysis and Discussion

The results obtained from the various experiments carried out during the development of the GNSO to Emulsifiable oil shows that NaOCl and Na_2CO_3 were two major favoured EP additive and emulsifiable agents and that at the mixture of their ratio of 1:2 of the saturated solution of the above agent formed the perfect emulsion of the GNSO as developed.

The mathematical analysis used in interpreting the data recorded from the two machined samples after being observed for 70 days under open atmospheric condition for corrosion tests were as shown below using the formula shown below to calculate for their means values and the standard deviation.

$$\chi = \frac{\sum_{1}^{n} f_1 x_1}{\sum_{1}^{n} f_1}$$ Where $\chi =$ mean value and χ_1 and

f_1 are the variable and frequencies

$$S^2 = \frac{\sum_{1}^{n} f_1(\chi_1 - \chi)}{\sum_{1}^{n} f_1}$$ $S =$ Standard deviation

The various results obtained from the calculation shows that, the mean value of the sample from GNSO = 53.76 while that of the sample from CCF = 53.05, the standard deviation are GNSO = 4.50and CCF = 4.92. To establish correlation between the developed soluble oil and the conventional soluble oil, least square regression method was used and from the graph of line of best fit, the developed GNSO was equally correlated as that of the CCF (0.946 and 0.949 respectively).

XI. Conclusion

It was obvious that metal cutting or metal removal require the use of force to penetrate the cutting tools to remove the excess and create the desired shape. The heat generate during this process if not adequately controlled could render the materials useless by creating poor surface finish, quick tool wear, and other damages to the metal. To reduce therefore the effect of heat generated during metal removal process, efficient cutting fluid is required for cooling and lubrication of the material. The development of GNSO to an emulsifiable oil to replace the conventional cutting fluid which was initially considered to be too costly and beyond the reach of the small- scale machine shops operators, as demonstrated when used for cutting operations, shows that the GNSO is reliable and suitable. This was further confirmed through the various tests carried out it using it as coolant and lubricant during cutting.

The formation of perfect emulsion of the developed GNSO occurs when the saturated solution of $NaOCl + Na_2CO_3$ and GNO were mixed at ratio 1:2. Other experimental analysis and their results showed that the developed GNSO is reliable and stable during cutting as shown from the following test; foaming, flash point, viscosity, PH value and the surface finish of the material after cutting and the correlation coefficient value of 0.946. In overall the sample from the GNSO shows more corrosion resistance than the CCF as shown from the microscopic pictures of the two samples. The cost of developing the GNSO was at an average of #114 per 30ml compared to#300 of equivalent CCF. Hence, this paper concludes that GNSO should be used to replace CCF since according to Kochhar (1981), Indian and Nigeria were rated 1st and 6th major producers of ground nut in the world. The excess production of GNSO could be exported for foreign exchange.

XII. Recommendations

With the reliability of GNSO for metal cutting operation as demonstrated from the various analyses shown above, Government should embark on mass production of the developed GNSO, so as to finally solve the problem of using the imported cutting fluid (CCF) which in all indications it is more costly coupled with its less resistance to corrosion compared to the newly developed GNSO made from ground nut oil, a locally available vegetable oil.

Companies and Individuals should be encouraged to invest on the production of this fluid so as to increase job opportunities and encourage exportation of this product for foreign exchange, this can be done by giving it publicity among the local and international market.

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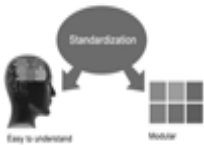
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3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

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The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
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- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

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Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
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Approach

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Approach:

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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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