Development of CNC Program for Piston Production

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Abstract

Development of a computer numerical control program for the machining of a piston is a work that involves the casting and machining of a piston on a computer numerical control machine tool. Aluminum scraps were collected and heated. The molten metal at 720^0C was poured into a mould and allowed to cool under atmospheric conditions. A computer numerical control program was written for the turning, grooving and boring of the piston. After cooling, the piston was mounted on a Computer numerical control lathe machine and the program was used to machine the piston. Examination of the dimensional accuracy of the piston showed that the piston with Ø52.553mm had a tolerance value of ±0.004mm which falls within acceptable standard of limit for a piston. Comparison of the piston produced shows that it is of reduced price compared with what is present in the market and with shorter time of production.

Keywords: Computer Numerical Control, Turning, Grooving, Boring

1.0 Introduction

A piston is a metal cylinder that slides up and down inside a tubular housing, receiving pressure or exerting pressure on a fluid, especially one of several in an internal-combustion engine [1]. It is the main moving/reciprocating component of a reciprocating engine and is contained by a cylinder. The usual form of a piston is an inverted bucket-shape, machined to a close (but free sliding) fit in the cylinder barrel [2]. Gas tightness is ensured by means of flexible piston rings fitted closely in grooves turned in the upper part of the piston [3].

The main features of the piston are shown in Fig. 1. Pistons are used in a variety of machines to convert one form of energy to another or to transfer fluids (such as water or air) or energy from one place to another.

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In an automobile, pistons are found in the engine, the braking system, the water pump and air conditioners. They are also used in power plants, vacuum pumps, condensers etc

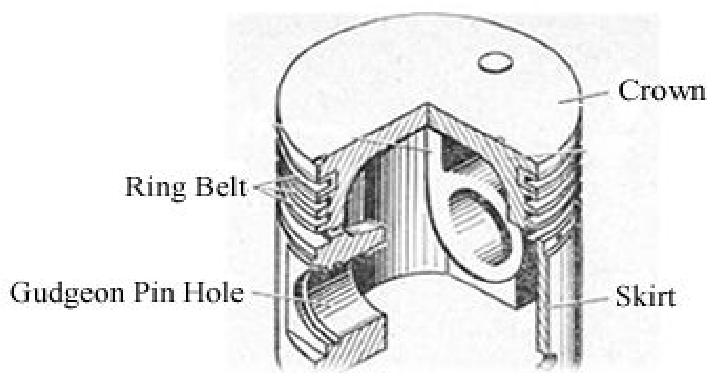

Fig. 1: Main features of a piston [4]

Considering the wide uses and importance of pistons, one could possibly imagine that piston manufacturing should be done in every country. Surprisingly, this is not the case. Nigeria and many other third world countries have no piston production company. All the pistons used in these countries are therefore imported from countries like USA (Wiseco piston company Inc.), Japan (Izumi industries Ltd), India (Anand piston Inc.) etc. Producing pistons in these countries, with Nigeria as an example, will reduce the price considerably since there would be no longer be need for importation.

The major factor of difficulty in piston production is the CNC machining process. To obtain the desired clearance, the piston skirt should be machined with a tolerance of about ±0.004mm. This is because the piston must fit loosely enough to allow the piston to move, but tight enough that virtually no air or fluid in the cylinder can leak past it.

Computer Numerical Control (CNC) machines are electro-mechanical integrated products, composed of numerical control systems of machine tools, machines, electric control components, hydraulic components, pneumatic components, lubricant, coolant and other sub-systems (components) that can reduce human intervention in spare parts production. For consistency in quality especially in the manufacture of complex components, human intervention has to be reduced as much as possible [5].

A typical CNC machining procedure is shown in figure 2.

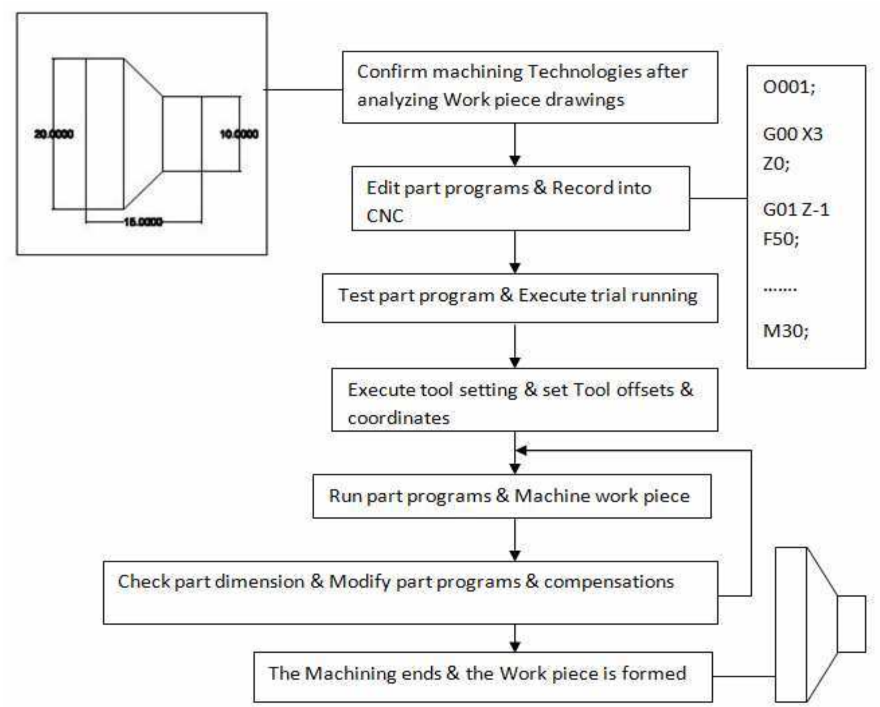

Fig.2: Technological flow of CNC machining process [6]

2.0 Materials and Methods

The following modalities were adopted in the execution of this work:

i) Collection and analysis of various types of already existing pistons.

(ii) Preparation of mold according to the desired specifications. Melting, casting and cooling under appropriate conditions.

iii) Development of turning, boring and grooving program using GSK980TD turning software.

vi) Machining of the Piston casted in (iii), using the program developed in (iv).

2.1. **The Casting Process**

Casting is a *manufacturing* process by which a liquid material is usually poured into a *mold*, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process [7]. There are five different types of casting processes but the type of casting process used in this work is the sand casting process due to its numerous advantages.

2.2. Programming Codes and Format

The program was written in the Fanuc compatible control mode which is used in over 80% of the CNC application throughout the world. The flowchart that led to this program is shown in Figs. 3-5.

The flowchart consists of three basic machining processes which are: turning, grooving and boring. One important feature of this flowchart is the presence of a decision box after the facing operation. This serves as a means of checking the accuracy of the set tool offset.

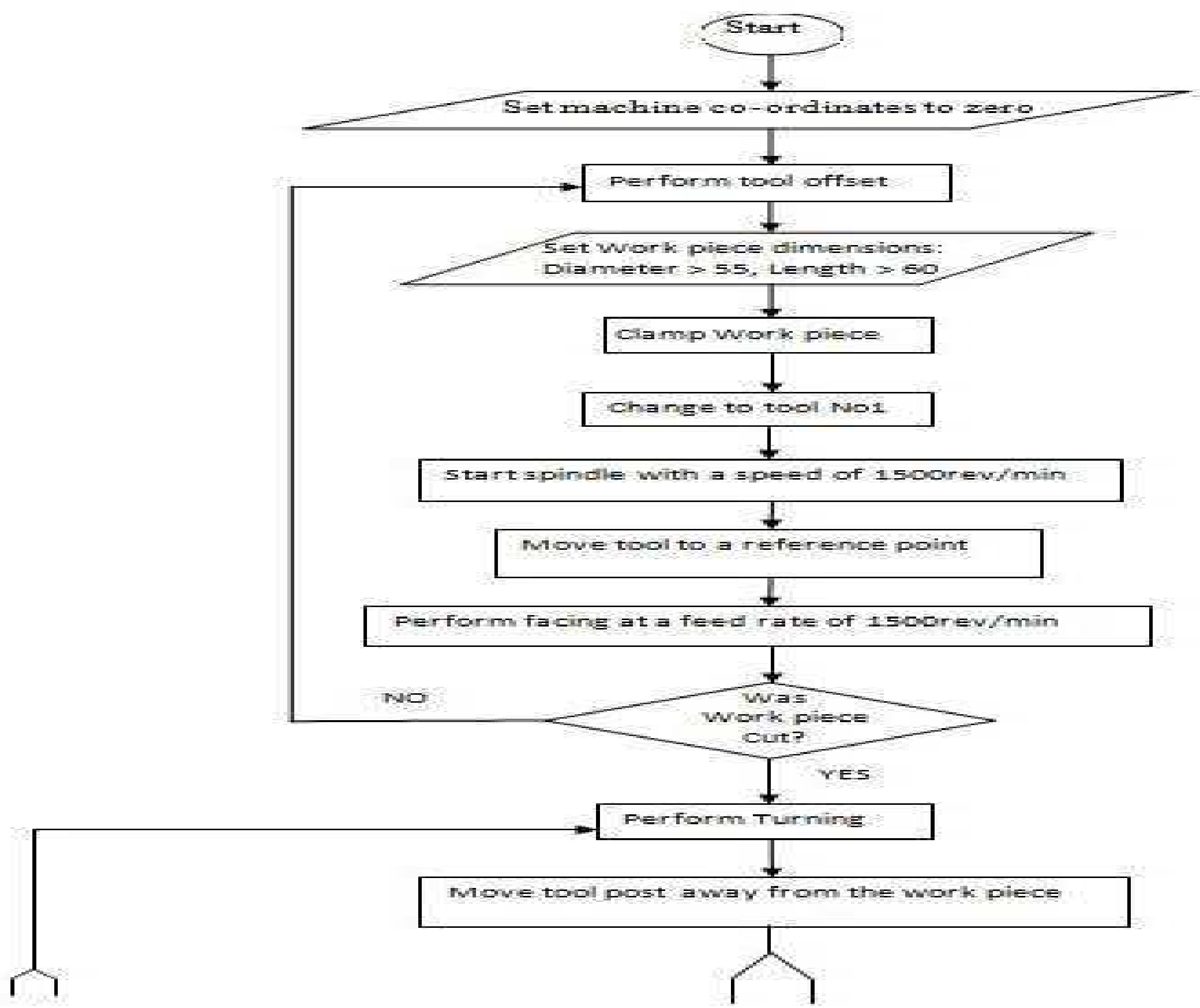

Fig. 3 Flowchart of CNC machining of piston up to the turning step

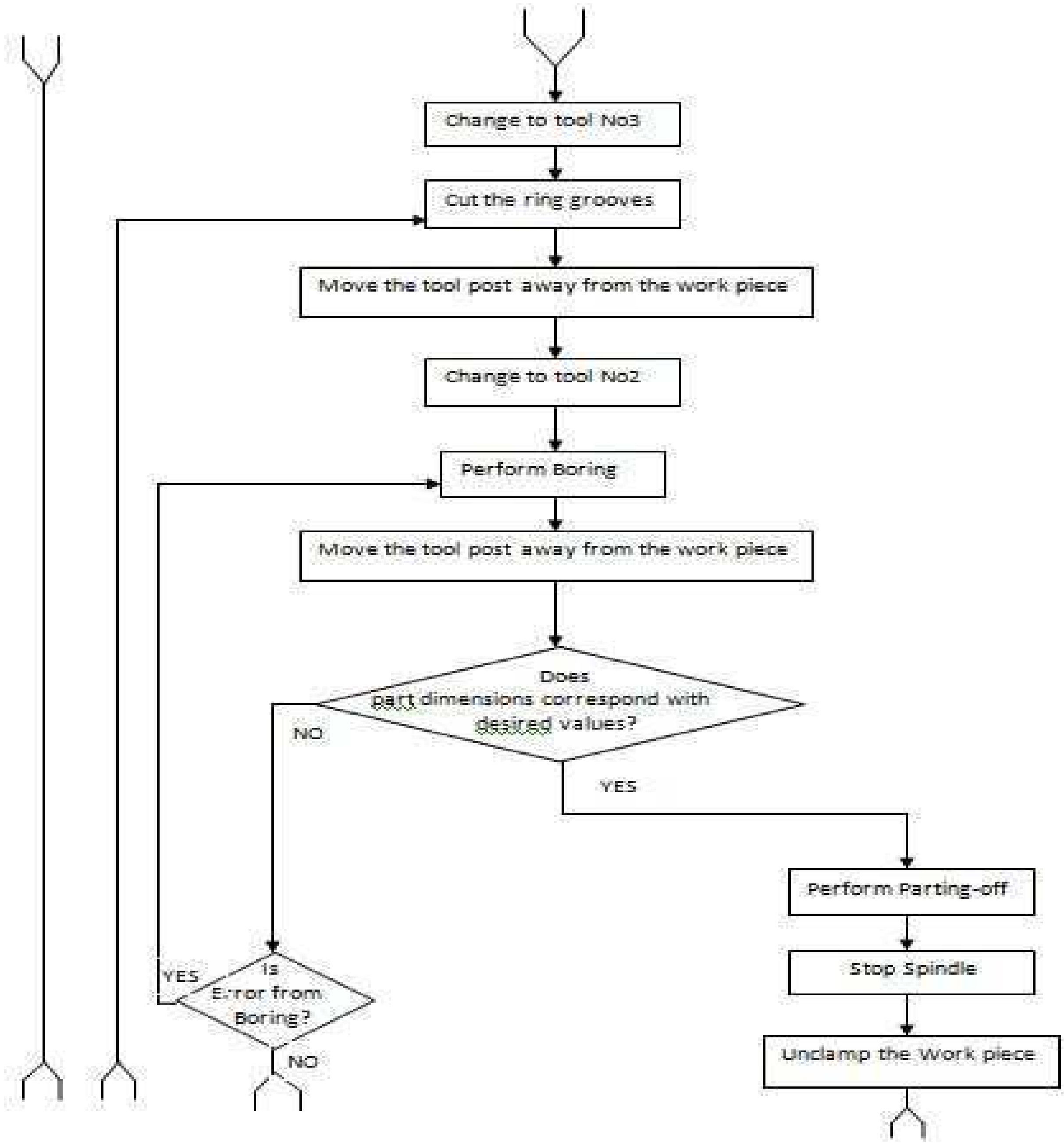

Fig. 4: Flowchart of CNC machining of piston showing the grooving, boring and parting off steps respectively

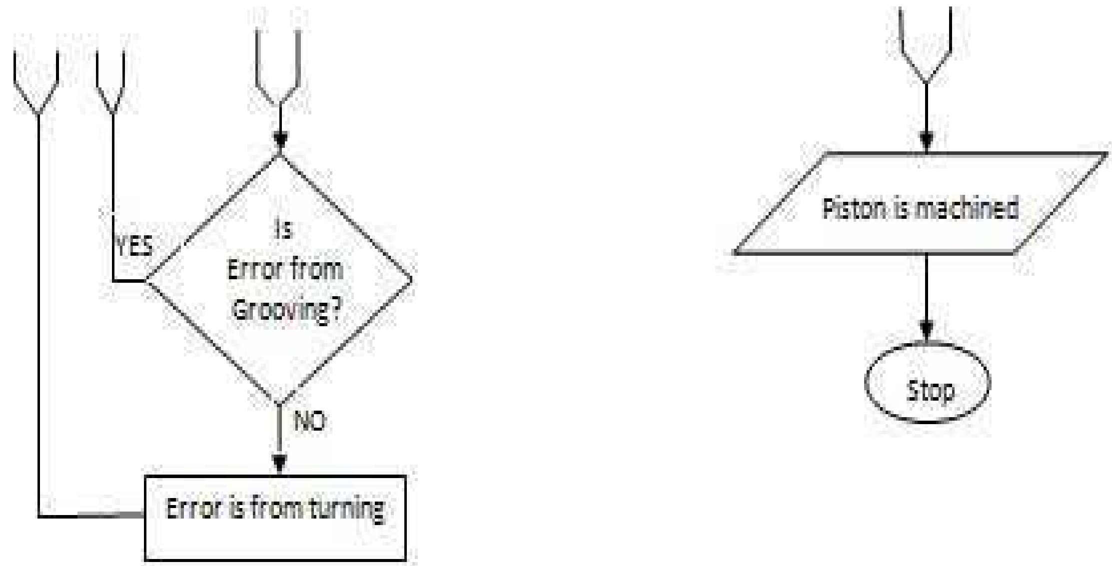

Fig. 5 Flowchart showing the end of the CNC machining of the piston

The most common codes used when programming CNC machine tools (which were used in this program) are G-codes (preparatory function) and M-codes (miscellaneous functions). Other codes such as F, S, D and T are used for machine functions such as feed, speed, cutter diameter offset and tool number [8].

3.0 Results and Discussions

The co-ordinate values of the entire work piece were defined and the CNC program was developed following the flow chart in Fig.3. Fig.6 shows the co-ordinate values of the work piece in the absolute system. This was the first stage of the CNC programming process [9]. Here, the diagram of the work piece was drawn using AutoCAD software and dimensions taken. The dimensions were then used to write the program.

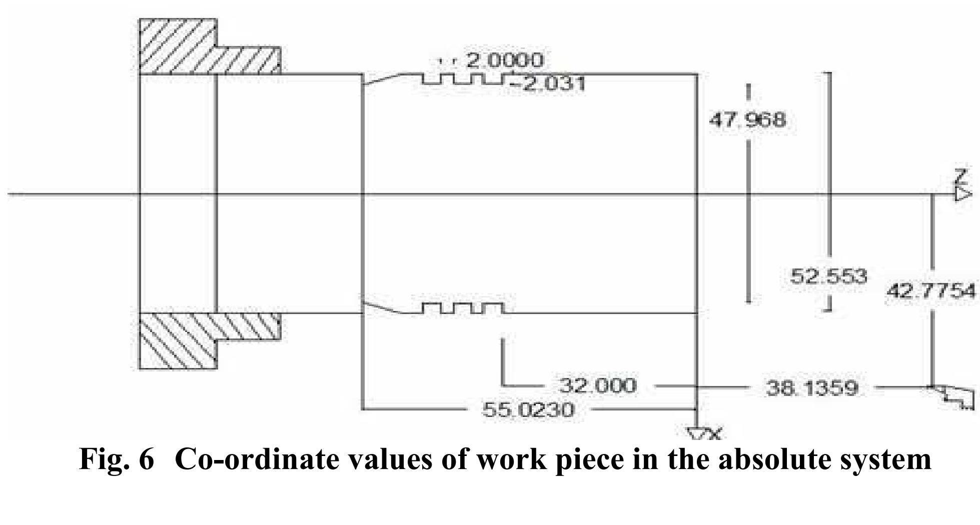

Fig. 6 Co-ordinate values of work piece in the absolute system

The CNC program for turning, grooving and boring of a piston was developed. After writing the program, it was input to the CNC lathe machine and run. Figure 7 shows the work piece after running the program on the GSK980TD software, before the actual machining on the CNC lathe machine. After machining the piston, a micrometer was used to measure the dimensions of the piston. These dimensions were then compared with the dimensions of an existing (imported) piston which was used as a model for this production. The errors recorded ranged from 0.001-0.003mm. This can be termed as "acceptable error".

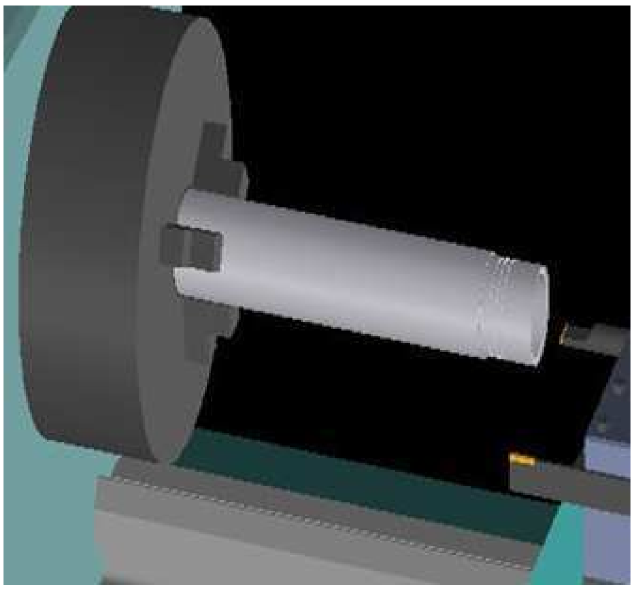

Fig. 7 Work piece after machining

The CNC program for turning, grooving and boring of a piston developed in this work is shown below:

[O0001]…………………………………(Program name)
N0001 M12;……………………….(Clamp workpiece)
N0002 T0101;……………………..(Change to tool no1)
N0003 M3 S1500;………………...(Start the spindle with 1500rev/min)
N0004 G0 X38.1359;
N0005 Z42.7754;
N0006 G94 X-2 F1500;
N0007 G71 U0.5 R2;
N0008 G71 P8 Q10 U0.5 W0.5;

3.1. GSK980TD Progam Code for Turning, Grooving and Boring Of A Piston

N0009 G01 X52.553;
N0010 X55 Z-2;
N0011 Z-32
N0012 G70 P8 Q10;
N0013 G0 X57;
N0014 Z10;
N0015 T0303; ……………………..(Change to tool no3)
N0016 G0 X50.553;
N0017 Z-32;
N0018 G94 X49.5;
N0019 G0 X55;
N0020 Z-55.0230;
N0021 G94 X49.5;
N0022 G0 X57;
N0023 Z-39;
N0024 G94 X50 F500;
N0025 G0 X55;
N0026 Z3;
N0027 G0 X58;
N0028 Z10;
N0029 M98 P0002;………..………..(Switch to program no2)
N0029 M30;……………………………(End program)
%
[O0002]
……………………..…………(Program name)
N0001 M12;
……………………….….(Clamp workpiece)

N0002 T0202; ………………………...(Change to tool no2)
N0003 M3 S590; ………………...(Start the spindle with 590rev/min)
N0004 G0 X58;
N0005 Z0;
N0006 G71 U0.5 R1 F592;
N0007 G71 P8 Q9 U1 W1;
N0008 G01 X50;
N0009 Z-15;
N0010 G70 P8 Q9;
N0011 G0 X53;
N0012 Z10;
N0013 M30; ……………………………(End program)
%

3.2. Economic Analysis

Adoption of the program developed in this work will lead to production of cheaper pistons with a reduced production time. This program takes advantage of the high flexibility of the GSK980TD turning machine to perform turning, grooving and boring on the same machine. This reduces the number of machines involved in piston production and the time of production, while the standard of the piston is maintained. It took a total of two and half man hours to produce one piston from casting to finished stage. A breakdown of the cost of producing one piston is shown in Table1:

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Table 1 Cost of producing a Piston

S/N	**ITEM/EVENT**	**RATE**	**QUANTITY**	**PRICE(₦)**
1	Aluminum	₦100 per kg	1kg	100
2	Diesel	₦130 per ltr	3ltrs	390
3	Electricity consumption	₦85 per hr	1hr	85
4	2’’ by 3’’ ply wood			150
5	Glue			200
6	Transportation			350
7	Labour	₦550 per man hr	$2\frac{1}{2}$	1375
8	**TOTAL**			**2,650**

If this piston is sold with a gain of 10%, the price of the piston will be ₦2,915. An imported piston with the same specifications as the one produced in this work is sold in Nigeria between ₦3,500 - 4,000.

4.0 Conclusion and Recommendations

4.1. Conclusion

In this work, an aluminum piston was produced using sand casting process and a standard CNC program was developed for the machining. The CNC machining operations included turning, grooving and boring. Adoption of this program by indigenous manufacturers will lead to the production of pistons at cheaper cost and shorter time. The same technology or method can be applied to produce other delicate or intricate machine parts and components.

4.2. Recommendations

Based on this research, the recommendations are made:

a) Use of CNC machining Procedures should be encouraged.

b) detailed procedure of piston Production presented in this research work should be encouraged in Nigeria.

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