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CNC Part Programming & Manufacturing of a Piston

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I. 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 7200C 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 Ø52.00 mm 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.

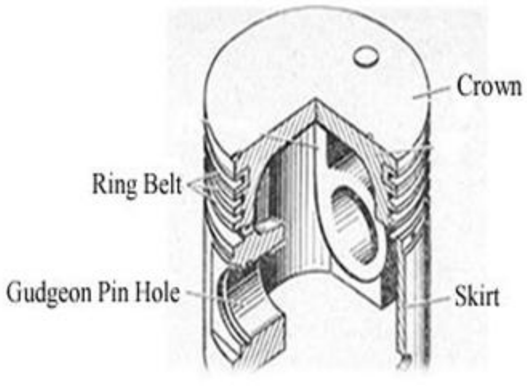
Keywords:

Computer Numerical Control, Turning, Grooving, Boring.

II. 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. 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. Gas tightness is ensured by means of flexible piston rings fitted closely in grooves turned in the upper part of the piston.The main features of the piston are shown in Fig. 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. 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.

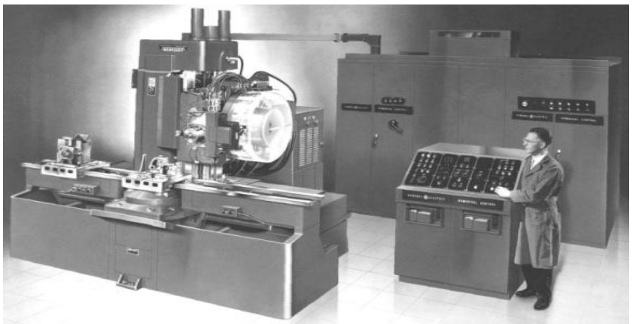


The major factor of difficulty in piston production is the CNC machining process. To obtain the desired clearance, the piston skirt should be machined with a tolerance of about ±0.004mm. This is because the piston must fit loosely enough to allow the piston to move, but tight enough that virtually no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

III. BRIEF HISTORY:

The first commercial NC machines were built in the 1950's, and ran from punched tape. By the end of 50's, NC was starting to catch on, though there were still a number of issues. A number of key developments brought CNC rapidly along during the 1960'S



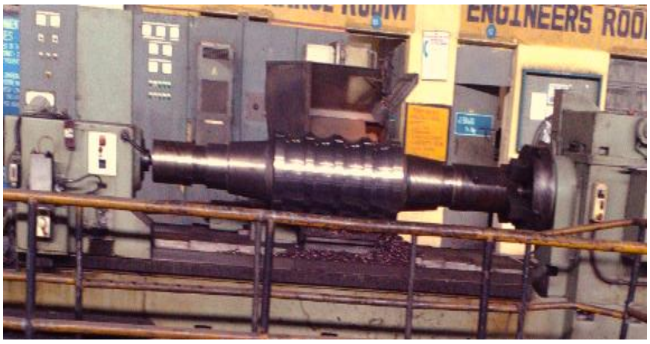
The above fig is the Milwaukee-Matic-II was the first machine with tool changer. More recently, microprocessors have made CNC controls even cheaper, culminating with the availability of CNC for the hobby and personal CNC market. The Enhanced Machine Controller project, or EMC2, was a project to implement an Open Source CNC controller that was started by NIST, the National Institute of Standards and Technology as a demonstration. Some time in 2000, the project was taken into the public domain and Open Source, and EMC2 appeared a short time later in 2003.

Kinds of CNC Machines:

The most common types of CNC machines are as follows.

CNC Machine Lathes:

Some view Lathes as the only universal machine tool because a lathe can make all of the parts needed for another lathe. A lathe spins the work piece in a spindle while a fixed cutting tool approaches the work piece to slice chips off of it. Because of this geometry, lathes are ideal for parts that have symmetry around some axis that could be chucked up in the spindle.CNC Lathes have at the very least the ability to drive the cutting tool under g-code control over 2 axes, referred to as X and Z. They may have a considerable amount of other functionality as well, and there are many variations on lathes such as Swiss Lathes.The act of cutting a work piece on a lathe is called "Turning".



CNC Milling Machines:

In a mill, the cutter is placed in the spindle where it rotates. The work piece then moves past the cutter so that chips may be sliced off. The act of cutting a work piece on a mill is called "Milling".CNC Mills have at the very least the ability to drive cut in 3 dimensions (some older machines may be limited to 2 or 2 1/2 if there are limitations on when that 3rd dimension may be used) which are referred to as the X, Y, and Z axes.

The above illustrated figure is a template milling machine which are used for making templates of a particular dimension as required by the user. This machine is of 2 ½ axis machine.

Types of CNC Machines:

a) Based on Motion Type:
    Point-to-Point & Continuous path
b) Based on Control Loops:
    Open loop & Closed loop
c) Based on Power Supply:
    Electric , Hydraulic & Pneumatic
d) Based on Positioning System
    Incremental & Absolute

How CNC Machine Works:

- Controlled by G and M codes.
- These are number values and co-ordinates.
- Each number or code is assigned to a particular operation.
- Typed in manually to CAD by machine operators.
- G&M codes are automatically generated by the computer software.

Features of CNC Machinery

- The tool or material moves.
- Tools can operate in 1-5 axes.
- Larger machines have a machine control unit (MCU) which manages operations.
- Movement is controlled by a motors (actuators).
- Feedback is provided by sensors (transducers)
- Tool magazines are used to change tools automatically.

Tools:

- Most are made from
  high speed steel (HSS),
  tungsten carbide or ceramics.
- Tools are designed to direct waste away from the material.
- Some tools need coolant such as oil to protect the tool and work.

Advantages of CNC Machines

1) Reduced Lead Time
2) Elimination of Operator errors
3) Use of Part Program and Tape Recorder only once
4) Greater Flexibility
5) Longer Tool Life
6) Less Scrap
7) Accurate cost and scheduling
8)Lower Labour cost and less operator intervention

Flow of CNC processing:

- Develop the part drawing
- Decide which machine will produce the part
- Choose the tooling required
- Decide on the machining sequence
- Do math conclusions for the program coordinates
- Calculate the speeds and feed required for the tooling and part material
- Write the NC program
- Prepare setup sheets and tool lists
- Send program to machine
- Verify the program
- Run the program if no changes are required

Major Phases of CNC Program:

The following are the three major phases of a CNC program. They are:-

1) Program setup
2) Material Removal
3) System shutdown

Program Setup:-

- The program setup phase is virtually identical in every program. It always with the program starts flag (%sign). Line two always has a program number (up to four digits, 0000 to 9999).
- Line three is the first that is actually numbered. It begins with N5 (N for

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sequence number, 5 for block number 5). We can use and number incrementing upward. We use increments of 5 in example. Incrementing in this way enables you to insert up to 4 new lines between lines when we are editing program.

- Block 5 tells the controller that all distances (X and Z coordinates) are absolute, that is, measured form the origin point. It also instructs the controller that all coordinates are measured in inch units.

The program set up contains all the instructions that prepare the machine for operation. The setup phase may also include such commands as coolant on, cutter compensation cancel, or stop for tool change.

Material Removal:

- The material removal phase dealer exclusively with the actual cutting feed. It contains all the commands that designate linear or circular feed moves, rapid moves, canned cycles such as grooving of profiling, or any other function required for that particular part.

System Shutdown:

- The system shutdown phase contains all those G- and M- codes that turn off all the options that were turned on in the setup phase. Functions such as coolant and spindle rotation must be shutoff prior to removal of the part from the machine. The shutdown phase also is virtually identical in every program.

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 appropriateconditions.

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).

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.

Programming Codes and Format:

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.

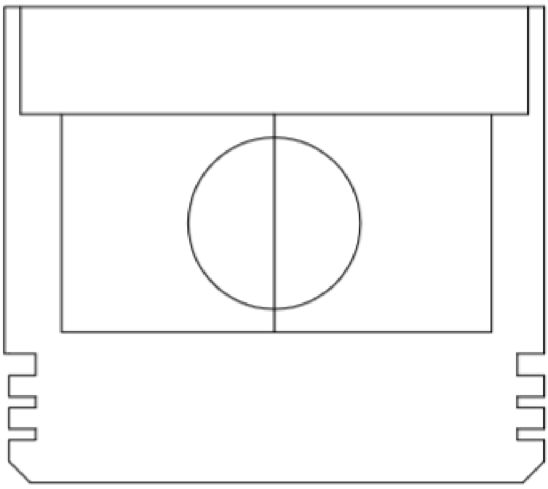
PART PROGRAM FOR PISTON

1. FACING & OUTER DIAMETER TURNING

```
GO TO X0.0 Z-400.0;
TO101;
G97 MO3 S600;
MO7;
GO X 55.0 Z 2.0;
G72 W0.5 R0.5;
G72 P10 P11 U0.0 W0.O F0.1;
N10 GO Z0.0;
N11 G1 X-0.5;
GO Z20.5;
G1 X52.0 Z 2.0 F2.0;
```

```
G71 U0.5 R0.5;
G71 P12 P13 U0.2 W0.0 F0.15;

N12 G0 X498;
G1 Z-14.0;
G1 X50.2;
G1 Z-47.5;
N13 G1 52.0;
GO Z20.0;
M05;
M09;
GOTO X0.0 Z-400.0;
M01;
```



2.FINISHING

```
GOTO X00 Z-4000;
T0202
G97 M03 S800;
M07;
GO X45.8 Z5.0;
G1 G70 Z0.0 F0.15;
G1 A135.0 X49.8;
G1  Z-14.0;
G1 A135.0 X50.2;
G1 Z-47.5;
G1 X55.0;
G0 Z20.0;
M05;
M09;
GOTO X0.0 Z-400.0;
M01:
```

3. 1mm GROOVING:

```
GOTO X0.0 Z-400.
 T0303;
G97 M03 S600;
 M07;
   G0X51.0 Z 10.0
   G1 Z – 5.0 F2.0
   G1 X 44.8 F0.05;
  G1 X51.0 F0.5;
 G1 Z-8.0 F2.0;
G1 X44.8 F0.05;
   G1 X51.0 F0.5;
G0 Z-20.0;
M09;
  M05;
 GOTO X0.0 Z-400.0;
  M01;
```

4.2MM GROOVING:

```
GOTO X0.02 Z-400.0;
TO404 G97 M03 S600;
M07;
G0 X51.0 Z-10.0;
G1 Z-12.0 F2.0;
G1 X44.8 F0.05;
G1 X51.0 F0.5;
G0 Z-20.0;
M09;
M05;
GOTO X0.0 Z-400.0;
M01;
```

5.4MM PARTING TOOL:

```
GOTO X0.02 Z-400.0;
T0505;
G97 M03 S500;
G0 X52.0 Z-10.0;
G1 Z-48.0 F2.0;
G1 X51.0 F0.05;
G75 R100;
G75 X2.0 Q1000 F0.1;
G0 X100.0;
M05;
M09;
```

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```
GOTO X0.0 Z-400.0;
M30;
```

6.INNER DIA BORING:

```
GOTO X 0.02 Z-400.0;
T0101;
G97 M03 S600;
M07;
G0 X55.0 Z-2.0;
G71 U0.5 R0.5;
G71 P12 P13 U0.2 W0.0F0.15;
N12 X47.0;
G1 Z10.0;
N13 X47.0;
G0 Z-10.0;
M05;
M09;
GOTO X0.0 Z-400.0; M30;|
```

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:

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**

FUTURE SCOPE:

8 channel
1
3
1
1
1

Beyond next-generation computer numerical controls (CNC), there may be virtual reality for CNC programming, advanced CNC intelligence, and advanced automation and programming for additive manufacturing and robotic assembly of microstructures. Each article below is linked to more information and images. This leads to increase of Flexible Manufaturing System Productivity and decreases the cost of labour. For Preparing the Template recently introduced program is R-Parameter Programming. This includes in preparation of many no. of similar templates with different sizes at a time. This programming includes in just changing the dimensions required as per the user or designer.

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Conclusion and Recommendations

> 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.

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 INDIA.