Production of Multiple Steps Shaft on CNC Lathe Using G-Code Programming

Aderemi DADA[1], Adedayo ADELEYE[2]
[1,2]*Department of Mechanical Engineering, The Federal Polytechnic, Ilaro, Ogun State, Nigeria*

***Abstract:*-Different kind of parts can be machined on the CNC lathe employing g- code as the programming language. The TPS3910 training lathe series were procured for practical exercises in the CNC laboratory to enhance student's knowledge of CNC parts programming. The paper profiles the procedures for producing a four step shaft on lathe using g-code programming. Plastic work piece of 70mm in length and 20mm diameter was used as the blank because only non-metallic material can be machined on the training lathe equipment.. The required parameters needed for the programming are the dimensions of the shaft to be produced. After the set-up of the machine, necessary data for x, y, and z coordinates were determined. The programme was run on simulation mode before machining mode to prevent any error during the actual machining operation. The result validates CNC machining operation high dimensional accuracy and absence of error using g-code programming.**

***Keywords:* CNC machining, g-code programming, work piece, shaft, lathe**

I. INTRODUCTION

Computerized numerical control (CNC) machining can be described as a programmable automation of machine tools in manufacturing process that involve the manipulation of numbers and letters, in form of digital codes, to control and monitor machine tool operations such as turning and milling operations. The g-code, commonly referred to as preparatory word, is a set of instructions that activate the computer-controlled machine tools which move at different speeds to generate the desired shape or profile on the work-piece. The g-code programming is the medium of communication between the machine control unit (MCU) and the cutting tool, it also indicates that a given control function or directive (in coded form) such as linear interpolation (GO1) is required to perform the required operation.

Computerized numerical control machining is becoming more popular in computer-aided design and computer-aided manufacturing (CAD/CAM) compared to conventional machining processes because of its high level of productivity and precision, coupled with versatility and ability to machine complex shapes in 2D and 3D (Bawa, et. al., 2014). The concept of computerized numerical control machining was first developed at MIT in the 1950s (Rouse, 2017). Thereafter, the RS274D was adopted as the recommended standard for numerically controlled machine tools by the Electronic Industry Association in 1960 and has been widely used in manufacturing of industrial equipment and consumer products. Computerized numerical control machining with CAD/CAM has evolved over the past three decades and has established itself as the most acceptable and preferable means of manufacturing complex parts because of its flexibility and capacity to replicate parts with high accuracy, especially in high volume manufacturing operation.

CNC machining equipment operates on multiple axes, however standard CNC machine has three linear motions along X, Y and Z axes while five axes machine has two additional axes of rotation (Tsiafis, et al, 2018). CNC machining operation has been employed extensively in the automotive industry largely because of the high precision, product consistency and high productivity and efficiency associated with the process (Dweck, 2018)**.** The application of CNC machining in manufacturing has been identified as a feasible solution to problem associated with additive manufacturing (AM), a manufacturing method that produces components by adding or laying the material on each other) to form a monolithic part (Osman Zahid, 2014).

Furthermore, the possibility for automation and flexible manufacturing system (FMS) has made CNC technology the best option to manufacture complex parts like transmission system and other intricate engineering parts. Therefore, the TPS3910 CNC training lathe with standard machine tool features is designed to machine plastic, fiber or wooding materials to the required dimension and shape. The equipment offers the trainees the opportunity to programme and produce varieties of parts with different configurations, coupled with greater flexibilities. In contemporary manufacturing environment, the design and the production process is highly automated with interconnectivity between computer-aided design (CAD), computer aided-engineering (CAE) -for analysis and validation of results and computer aided-manufacturing (CAM).

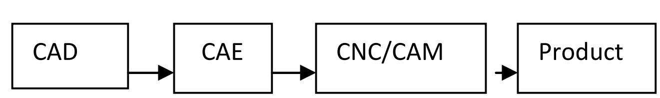

Figure 1: Interconnectivity between CAD, CAE and CAM in manufacturing.

The sequence of steps required to manufacture any component on CNC machine is highly automated and the programme produces a part that is similar to the original CAD design (Anuradha, et.al, 2017)

The primary purpose of the CNC laboratory is to address the challenge of producing competent and technically capable mechanical engineering graduates for the industry in Nigeria by adequate training that will expose the students to modern manufacturing techniques. The mismatch and the gulf between the academic curriculum and industry requirements for employment can equally be resolved by producing graduates with relevant hand-on experience in the use of modern manufacturing equipment. The CNC lathe and the g-code programming are meant to acquaint the students with necessary knowledge of parts programming. The experience gained from the practical exercises conducted in the laboratory and workshop will enhanced the student's employability in the job market as well as scale up their skill in manufacturing engineering. The TPS3910 lathe system and g-code programming are meant to acquaint the students with the fundamental knowledge of CNC, thereby addressing some of the observable lapses in basic competencies in manufacturing engineering.

II. METHODOLOGY

Plastic material was selected as the work piece because the TPS3910 training lathe can only machine non-metallic materials. The diagram of the shaft was drawn and dimensioned appropriately. The TPS3910 lathe equipment was set up to accommodate the work piece. The codes were generated based on the dimensions of the shaft. The shaft dimensions (70mm in length and 20mm in diameter) were the data provided for the actual machining operation. The dimensions were assigned at the appropriate coordinates, X and Z for turning on CNC bathe. The codes were generated based on the exact points on the working drawing of the shaft. The set-up is as shown below:

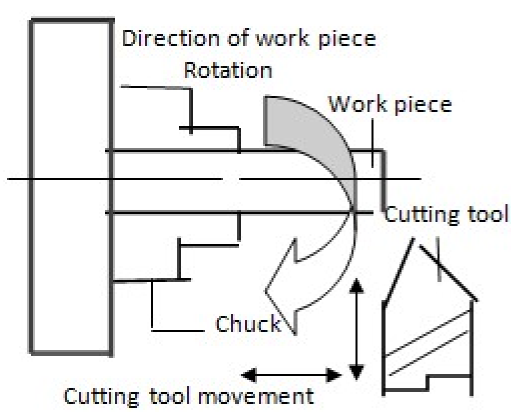

Figure 2: Typical turning operation arrangement.

2.1 Procedure for Production of shaft on CNC Lathe

Generally, the production process begins with conceptualization of the product (shaft) and the starting point is the selection of the appropriate material and the type of equipment to be used. CNC lathe is the appropriate equipment for the production of the multiple steps shaft. The process for the production of the multiple-steps shaft can be depicted in form of flow chart below:

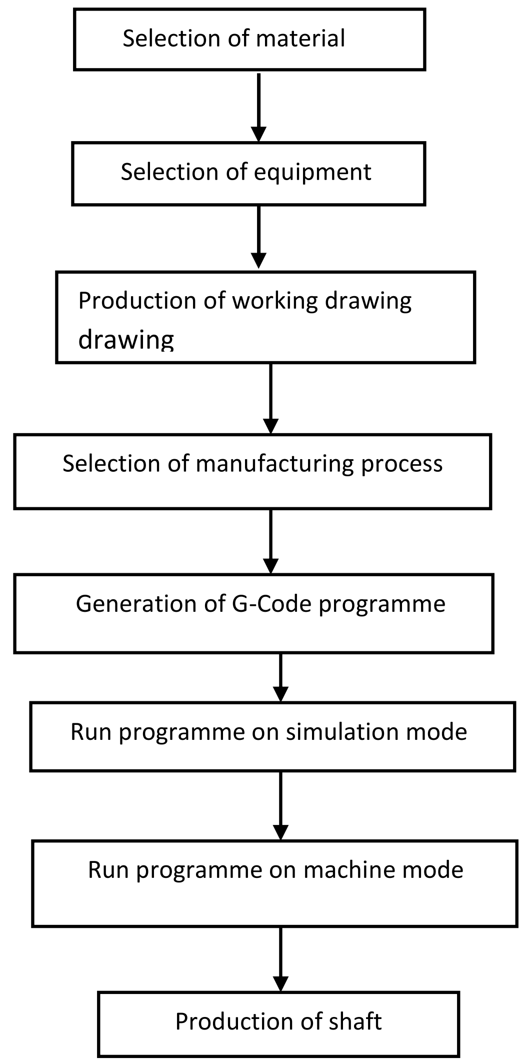

Figure 3: Procedure for production of shaft on CNC Lathe

2.2 Generation of the G-Code Programme for the Shaft

M4 S 2000

GO X-9

G1 Z-66 F 200

G1 X -10 Z-70

G0 Z 0

G0 X-8

G1 Z-38

G1 X-9 Z-50

GO X-10

GO Z 0

GO X-7

G1 Z-36

G3 R2 I-8 K36 C150 E180

GO-X-9

GO Z0

G1 X-6

G1 Z-36

G3 R2 I-8 K36 C90 E150

GO X-8

GO Z0

M5

M30

2.3 Production of the Shaft on CNC Lathe

The machining operation was carried out at the CNC laboratory. Although plastic material was used as the work-piece, the major parameters for machining such as cutting speed, feed rate, and the depth of cut were considered. Cutting speed of 250rpm-350rpm, and feed rate of 0.5mm were adopted. The depth of cut was carefully considered because of the nature of the work-piece while the machining operation was carried out at room temperature of about 28^0C, due consideration was given to the measurements to obtain desired result.

The lathe software is a window application turning operation programme. The system operates on two modes: the simulation mode that allows correction to be made to avoid error during the actual machining process and the machining mode that send a movement command to the system control unit to carry out the actual machining operation. When the monitor buttons is activated it brings the turning tool closer to the edge of the rod as shown in figure 2. With the monitor button, the turning tool can move about 1mm to the right and about 10mm to the centre of the shaft for proper orientation. When the tool moves on Z coordinate it removes material from the plastic work-piece. Facing and chamfering operations were carried out prior to the reduction of the diameters. The 20mm diameter was reduced by machining to 14mm, 16mm and 18mm from one end to achieve the four steps required.

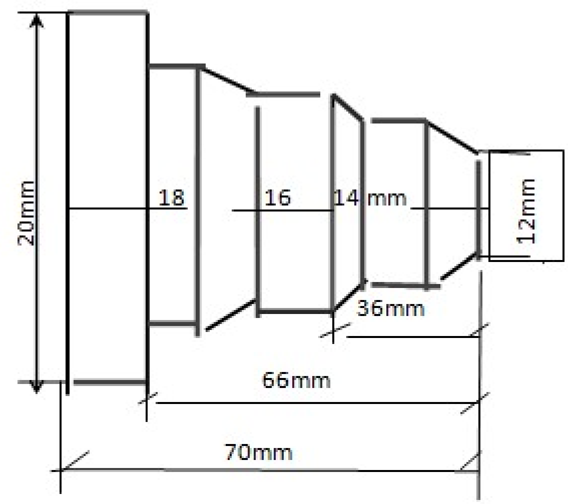

Figure 4: Diagram of the multiple steps shaft.

III. RESULTS AND DISCUSSION

The result of the g-code programming, based on the point located at each step of the shaft on the working drawing (20mm, 18mm, 16mm, and 14mm), validates the accuracy and precision of CNC machining operation. This was possible because the programme was run on simulation mode before the machining mode to avoid error during machining operation. The generated g-code programme was saved in the computer hard disc (HD) for possibility of retrieval for future application. The programme can also be modified and run for demonstration during student's practical exerc*ise.*

IV. CONCLUSION

The part programming of the multiple step shafts and the machining operation was carried out and the result conforms with the desired result. The TRS3910 CNC training lathe has almost the same features like the industrial CNC lathe with the exception that only plastic and fiber materials can be machined successfully with the equipment.

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Appendix 1: TPS 3910 Training Lathe