THE STUDY AND ADD PORTABLE ROTARY 4TH AXIS ON 3-AXIS CNC MILLING MACHINE

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ABSTRACT

The purpose of this paper is to Companies are always looking for new ways to increase productivity and help the company save money. The way this is done is by researching new and more efficient ways to produce whatever it is the company is selling. Since there are always new technologies coming forward it can be difficult to distinguish which ones are viable and which ones are not. This paper looks at the decision of moving a company from a traditional 3-axis milling set-up to a 4-axis milling set-up. Through research and analysis this report will guide a company the decision making process and help decide to move 4-axis or machinery is the correct move for them. In the end, every company is different and a switch to a 4-axis machine may not be for every company but it can be the right decision for some.

KEY-WORD: Part Programming, CNC Milling Machine, Milling Tool, Lubricant, Rotary axis, Driver

INTRODUCTION

HISTORY

The invention of the NC (numerical controlled) machine made by John T. Parsons during The 1940s-1950s. The NC was a breakthrough invention that led the way towards modern automated machines In the process of developing smoother rotors; they managed to generate an early version of the NC, where generating numbers for complex and précised outputs was possible. At that point, Parsons considered a fully automated tool that can surpass the performance of the current NC. In 1949, he turned to Gordon S. Brown's Servomechanisms Laboratory at MIT to develop a feedback system that can gauge how far the controls had actually turned. [2]

The Air Force halted its funding in 1953, but Giddings and Lewis Machine Tool Co. resumed the project by producing NC that can reduce the expenses and improve quality and efficiency. With their direction of the project, the Numerical controller was created, replacing punch type readers with magnetic tape readers. [2]

The CNC machine first appeared when John Runyon managed to produce punch tapes under computer control. This showed results in terms of time, reducing the normal production duration of 8 hours to 15 minutes. In June 1956, the Air Force accepted the proposal to produce a generalized "programming" language for NC [2]

Eventually, the Air Material Command at the Wright-Patterson Air Force Base and the Aircraft Industries Association (AIA) collaborated with MIT in 1957 to generate a fully computer controlled NC system. The invention of CNC machines is the way for automated tools that meant cost efficient production for manufacturers. [2]

DEFINE: CNC system in which a dedicated computer interfaced with machine and it use to perform some or all the basic NC function. Some NC function in accordance with control program stored in the memory of the computer.

Computerized Numerical Control (CNC) milling machine plays an important role in Today's manufacturing processes. The machines are applicable with procedure to drilling, spreading, weaning and threading with a lot of precise holes. CNC milling machine can be classified as CNC Printed Circuit Board (PCB) drill, CNC vertical drill, CNC deep-hole drill, drilling center and other large CNC milling machine ([1] [2]). This machine is use for drilling holes with numerical control and widely use in hole processing technology for the PCB [3].

There are two types of CNC milling machines available in the market, automatically by the Personal Computer (PC) based controlled and semi-automatic machines. Machine usually provides software to create work order for CNC milling machine and also provide interface in CAD software.

SELECTION OF PROJECT

Before section of project collection of technical data, market survey has to be carried out, we have to see whether a similar product is available in the market or not and if so, we can produce a modified product with more future at reasonable prices. Also we have to consider the feasibility, as well as suitability of manufacturing with our available resources.

REASON FOR SELECTION

1. It is very new project in our college.
2. All the equipment required manufacture the project were available in nearby areas.
3. It is advance and very useful project in our mechanical department.
4. This project prompted the spirit of term work and corporation.
5. Is very much useful to understand some of the basic concept of newly offered subject namely AMS and CAD/CAM.

CLASIFICATION OF CNC SYSTEM

A. **POINT TO POINT:** The point to point systems is make the tool to move from one point to the other in rapid motion, while performing a certain operation at each of these points as shown in figure. That system is generally used for drilling and punching operations. The controllers are relatively simple and low cost for such operations. The type of applications can be PCB drilling machines or sheet metal punching presses. The motion path taken between the points is generally at the fastest speed possible, thereby reducing the idle time.

B. **CONTINUOUS PATH:** In the case of continuous path movement, the tool will move in any of a number of valid axis simultaneously through a specified path such as a straight line or circular as shown in figure. This calls for an interpolation to be work out by the

controller for all the intermediate points so that the tool will be able to trace the path properly. The capability of the contouring machines is such that they may have simultaneous interpolation from 2 to 5 axes depending upon the profile geometry being generated. These controllers are generally expensive because of the capability of the computers involved.

C. AXES DESIGNATION: In order to generate the part shape the tool needs to move through the contour of the part geometry. As a result, the major part of a NC part program requires the input of co-ordinates of the tool end point. For this purpose, It is necessary to identify an appropriate co-ordinate system for the NC machine tool. The axes designations have been standardized by EIA (Electronics Industry Association, USA) and ISO.

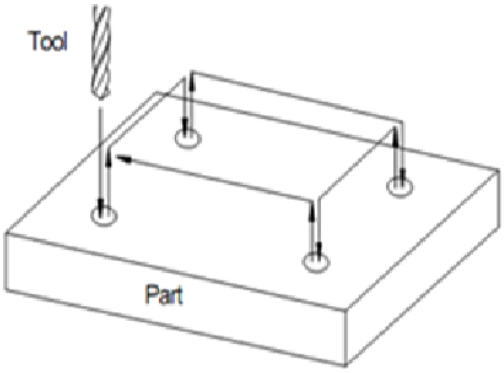

Figure-1 Point to point tool movement

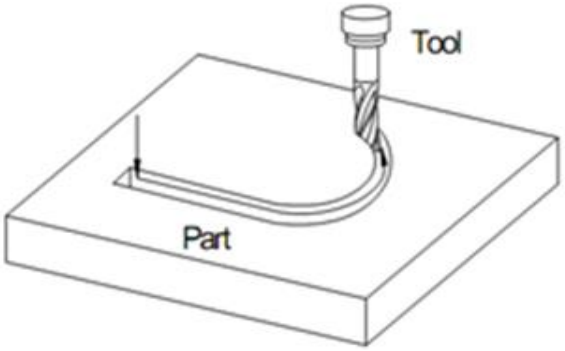

Figure-2continuous path tool movement

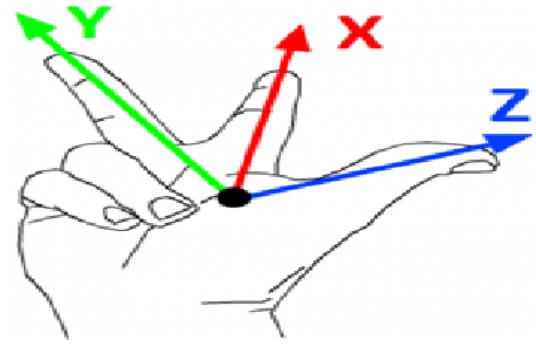

Figure-3Finding direction in a right hand co-ordinate system

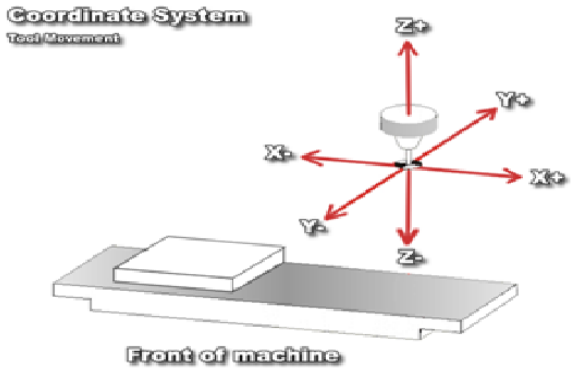

Figure-4 Vertical axis milling machine

D. CO-ORDINATE SYSTEM: All the machine tools make use of the right hand Cartesian coordinate system. The main axes to be designated are the rectangular axes and the rotary axes. typical right handed co-ordinate system is shown in figure. One could use is right hand (As shown in figure) to arrive at the correct orientation of the system. The positive direction of the rotary axes can also be obtained by the use of right hand as shown in figure.

E. DESIGNATING THE AXES: As per the standards, The first axes to be identified is the Z axes, followed by the X and Y axes.

Z-AXIS: The principal axis is considered as the Z axes. The Z axis is considered coincident or parallel to the spindle axes. The positive direction of the Z axes is the tool moving away

from the work holding surface towards the cutting tool. In the case of machine without a spindle as shaper and planners, it is identified as the one perpendicular to the work holding surface.

X-AXIS: The X-axis is the principal motion direction in a plane perpendicular to the Z- axis. It is perpendicular to the Z-axis and should be horizontal and parallel to the work holding surface wherever possible. When an operator is standing in front of the machine tool, the positive (+) X is to his right side. For turning machines, it is radial and parallel to the cross slide. X is positive when the tool recedes from the axis of rotation of the work piece.

Y-AXIS: It is perpendicular to both X and Z axis and the direction is identified by the right hand Cartesian co-ordinate system. In the case of several spindles and slide ways, one of the spindles, preferably the one perpendicular to the work holding surface may be chosen as the principal spindle and associated with the Z axis. The motion of the other spindles or slides may be treated as secondary and tertiary motion and accordingly designated as U,V,W, and P,Q,R respectively.

F. ROTARY MOTIONS: A, B and C are defined as the primary rotary motions and are assigned about the axis parallel to X,Y and Z respectively. Additional rotary motions if present are designated as D or E regardless of the whether they are parallel or not to A, B and C.

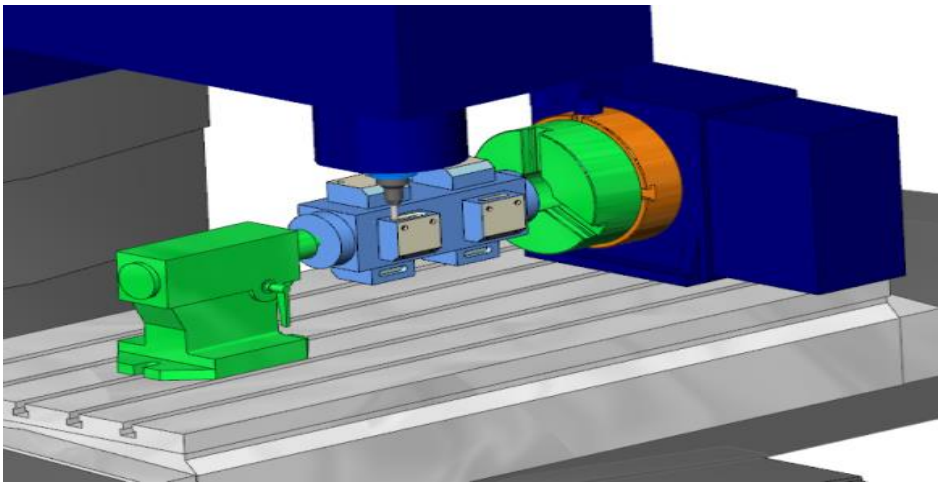

Figure-5 CNC milling machine

LITERATURE REVIEW

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SUMMARY OF ARTICLS

1. **Octavian Bologa et.al** this paper presents 3-axes milling machine convert to 5-axes milling machine is a difficult decision for any workshop manager, taking into consideration the costs involved. In order to assist this decision, the authors proposed a decision-making tool, based upon fuzzy systems. The tool was built under Matlab software package and structured in an interactive way, in order to be user friendly to be able to provide fast results, based upon real or simulated inputs. [12]
2. **Armin Afkhamifar et.al.** The authors illustrates the analysis of tooltip positioning error in a CNC machine. Several error sources are analyzed to develop, during the design phase, the best solution to reduce the tooltip position error:
    - Dimensional and geometrical tolerances
    - Kinematic of CNC machine
    - Thermal effects
    - Static and dynamic loads

    The paper illustrates, with different level of the detail, the different approaches for contributors' analysis and their integration. [7]
3. **Bankole I. Oladapo et.al** This paper presents the results of the modeling of a smart electro-pneumatic clamping control device for CNC milling in industrial operations. The cost of expensive energy is saved. The electro-pneumatic clamp of 24Vs is fast, accurate of load independent and it is a development of an SCFC system with a variable clamping method of force control. The purpose of electro-pneumatic clamping control device to adjust the forward movement of the clamp and reduce the damage caused by the clamp on the work piece. The clamping force is controlled by the magnetic cushion in the cylinder. The clamp is timed according to the operational time of the machine and the cutting tool which has a time delay relay attached to it, this is to be set according to the compacted circuit and the wiring circuit. The clamp then automatically opens on its accord by the actuation of the magnetic proximity switch. [16]
4. **Antonín Max et.al** They use a simple method, the color palette, to recognize purchased parts or machined parts and also to recognize manufacturing processes of machined parts. The next part of the study texts helps students to understand calculation of simple standard parts (parallel keys, screws..) and also complicated calculations of linear guides, ball screw, etc. Because all the materials are available to academics, they can modify specifications and provide them to students in the form of a new task. With the original

specifications as a pattern, the student can create a new design and understand the obstacles faced when changing specifications and traceability of other changes in the structure. [10]

5. **Balinder Singh et.al** This study evaluates the machining performance of EN24 Steel using CNC Milling Machine which employed carbide End Mill cutting tool. All the experiments trials, planning and analysis were executed using Taguchi design of experiment. In this study were to determine the optimum condition of machining parameters and the significance of each parameter to the performance of machining characteristics. The total experiment runs performed in this study was 27 trials using randomized parameters which done by MINITAB 15 software. [17]
6. **Gustavo M. Minquiza et.al** two CAM software used produced different NC part programs for the case study part. And The two commercial software generated different process parameters and machining strategies. As concluded by Díaz et al. the energy consumption is influenced by the cutting tool, its number of flutes and the feed rate. To generate NC programs directly on the software consumes much time due to the fact that it is necessary to calculate the required intersection points of the part's geometries. Besides, to generate the code for a part with complex surfaces is not feasible. [9]

OBJECTIVES OF PROJECT

The following are the main objective of project.

- To make improvement in the control of manufacturing.
- To improve the machine flexibility by adding 4^{th} axis in CNC milling.
- To add portable extra axis for rotation of the job
- To increase accuracy.
- To increase the productivity & Reduce the lead time for a complex geometry.

BLOCK DIAGRAM 0F MODIFIED CNC MILLING WITH 4^{TH} AXIS

The CNC machine is a system that is able to accept numerical control inputs to machine a part specified by the exact positioning of the inputs. The machine is able to accept commands either through a directly connected personal computer or a flash drive that is activated through the pendant subsystem. The personal computer is use for three direct forms of communication to the main controller subsystem either through Ethernet, USB, or serial link. With direct connection to the main controller system, the pendant subsystem is able to accept jobs uploaded through a flash drive and access information through one of the three communication ports that are active, and can change specified rates of speed and the direction of movement of the machine.

IMPORTANCE OF PROJECT

- The process of project work depends on intelligence, skills, creativity and energy of group of student.

- Project work has been required studies of number of subject project work will provide an opportunity for coordination and integration of theory and practices a wide of cognitive skill and necessary in a technician.
- The purpose of providing project work is to expose to problems and to introduce you to the procedures used to reach e efficient acceptable solution.

WORKING

- The PC parallel port that sends the signals to the machine's controller, according to the program.
- The controller reads the signals that generated by the PC via the program and the parallel port, which operates motors in a controlled manner.
- The motors move the axis of the machine to the requirement of the instruction get form the controller.
- With the control of computer software, the drive motor of X, Y, Z-axes begin to work accordingly and the main shaft motor can be drove according to program order.
- The main shaping motor drives the cutter to process the work piece that the use requires.

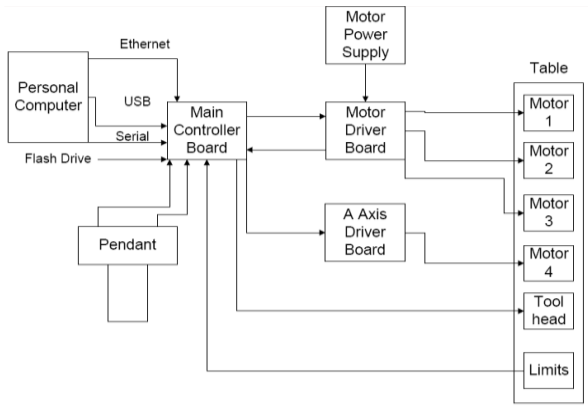

Figure-6 Workflow

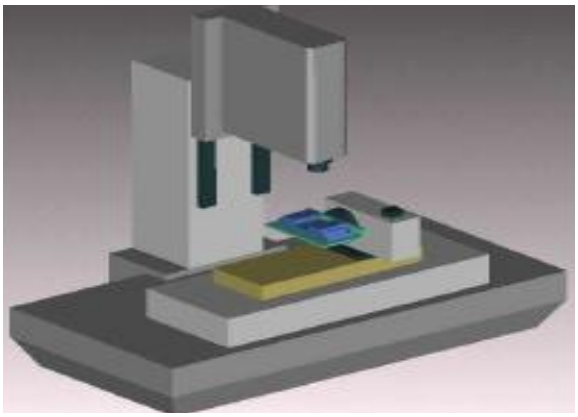

Figure-7 Block diagram

WORKING OF 4TH AXIS

The next level of capability is 4-axis milling. Defined by rotation about one of the 3Primary axes. Depending on which axis the rotation is about, the 4th axis is called A, if about the X-axis, or B, if about the Y-axis, or C, if about the Z-axis. The A, B, C axes are also shown in Figure**.** In order for a machine to be considered 4-axis, the machine must be capable of motion in each axis simultaneously. A simulation of what a 4-axis machine using A-axis is shown in Figure. The 4th axis may be used while cutting or to rotate the part to machine a different surface, also known as indexing. Many machines can mount a separate piece of equipment to add a 4th axis or machines can be purchased with 4-axis built into the machine. The addition of the 4th axis helps with machining more complex part geometries as well as reducing the number of set-ups for parts that run on a 3-axis machine but require more than one set-up to complete. Set-up time is a non-value added aspect of the manufacturing process,

therefore minimizing time spent on set-up reduces non-value added time as well as overall cycle time of a product. [12]

ADVANTAGE

- Reduce lead time, Elimination of operator errors
- Lower labor cost, Smaller batches production
- Longer tool life, Less scrap
- Elimination of special Jig and Fixture
- Flexibility in change of component design
- Reduced Inspection, Planned support facility

DISADVANTAGE

- Higher Investment cost, Higher maintenance cost.
- Costlier CNC machine for one job.
- Complicated maintenance. High tooling cost.
- Skill & training are required for programming and maintenance.
- Some parts are needed to be import from abroad.

APPLICATION

- Machining a gear with a 4th axis
- 4th Axis Continuous Machining
- PCB Drilling, PCB Routing.
- Industries, laboratories and educational institutes.
- Precession work in tool room and workshop.
- Plastic templates, scales and dies.
- Dies for Jewelry, punch, soap, biscuit, coin, embossing etc.
- Art works, logos, letters, signs, gift articles and glow sign boards.
- Shoe sole dies.
- Engraving on the Rotary surface with any angle.
- For Bengals design in Jewellery

CONCLUSION

After the research we cnc conclude that portable 4^{th} axis in CNC milling machine could rotate the job and do milling process in it. A 4th Axis can be a powerful addition in CNC milling machine. It enables all new kinds of machining and can also make existing jobs run faster and require less setup.

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