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Dual Spindle Horizontal Face Milling Machine

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***Abstract* — In this research work, Conversion of 5ft. bed length of a Conventional Lathe in to Semi Automatic Lathe is discussed. In Special Purpose Dual Spindle Face Milling Machine, purpose to establish such system to do face milling on both side of any component in a single cycle which was not possible in the conventional lathe. To do so, special time of fixtures and some changes are made by replacing the part of conventional lathe by more efficient parts to perform the task.**

Keywords—Special Purpose Machine; Conventional Lathe; Face Milling; Semi-Automatic

I. INTRODUCTION

Human beings have always strived to find out a solution for shifting the conventional way of manufacturing to a special purpose machine. The role of automation is increasing day by day in this modern era to improve productivity as well as deliver uniform quality. This paper discusses the case study and comparison of productivity of component using conventional lathe and Special Purpose Dual Spindle Face Milling Machine. There are many conventional lathes in our country, to build a new modern developed Industrialization it is required to convert the old conversional type of machine in to a semiautomated controlled lathe so called Special Purpose Machine by modernizing the old ones.

Now days a product are manufactured by modern technology with high productivity and quality. It is the need of modern Industrialization to use CNC lathe to get more accurate dimension and high productivity.

Modernizing refers to the addition of new technology or features to the existing system, that define what the research works want to refer from the word modernizing.

This paper is related to the Modification of Conventional lathe to a Special Purpose Machine. As we know that SPM itself says that it is for only single purpose, the intention of modifying the convention lathe is to increase the production rate as well as the product with high quality. In this paper, the workpiece which is to be machined is an Aluminum body of Hydraulic pump. As the concepting this machine was inspired by the concept of automation. Previously the process is carried out on Conventional lathe in two setups which is face milling on 1st side of body and the facing the other side. The major disadvantage of this process is perpendicularity of both the face is not achieved because it was carried out in two setups. So, to eliminate such quality related issue and to increase the production rate such SPM is developed for mass production with required quality.

II. LITERATURE SURVEY

A presentation was presented by Mr. J.C.Z Martin in London Graduate Section of the Institution on 18th February 1954 on Special Purpose Machine tools. A visit to the machine shops of an up-to date work engaged with quality products soon highlights the number of machine which are lathes, milling machine, Grinding Machine, drilling machine and boring machine and their well-known performance and all this not new for anyone. But there is some special case, these are special purpose machine or perhaps a better description would be “one Purpose Machine”. This type of machine is not new to the world highly developed by USA in the past couple of years but their large-scale introduction into British and Continental Industry has become marked only during world war. And this introduction of this type

of machine is mainly due to their high productivity because as we said this is for only a single purpose such as milling, drilling, boring and reaming. Maximum benefit can only be obtained from these machines by fully automatic or at least semi-automatic operation and by control system. The design consideration of Special Purpose Machine is a specialized subject and requires not only through knowledge of basic machine tool design, but also and intimate understanding of machine processes and preferably experience in machining the particular component question. Fixture and bed design is frequently a very important factor. The most important overall design considerations are simplicity and reliability in operation. It is fully recognized that the Special Purpose Machine provides much more efficient method of machining rather than conventional type. There is also other economic consideration other than production rate, total output and initial rate of machine, maintenance cost and reliability in operation must also be considered. It is hoped that this survey of special purpose machine has indicated what they are, how that differ from conventional types and what they can do under suitable condition to reduce time and cost.

Knowing about the face milling, the face milling force components, their magnitude and directions are essential for machine tool construction, work piece fixture design and machining face milling is the main processing type of plane molding and is applied widely in some key components great plane machining of weapon and automobile industry such as gear case, engine block, etc. With the current emphasis on achieving higher productivity levels and higher precision, the face milling process has received considerable attention. An effective arithmetic work piece-cutter intersection model is brought forward by representing the cutter feed trajectories and work piece geometry. For studying the behavior of work piece under milling conditions, it is practical to consider the force direction parallel to the machining axis. The cutter feed path is defined parallel to the work piece surface.

Cutting force is one of the most fundamental elements that affect the performance of cutting operation. The cutting force operation improve the production quality and efficiency. The face milling process is one of the most widely used and efficient means of machining at relatively high metal removal rates. In the face milling process, there is a periodically varying chips section during the face milling therefore the cutting force also varies during the process the face milling cutter is to be designed on the primary objective such as cutting force, optimum productivity, life, quality and cost.

Now after all this the question arise that how to control all this system in an automated concept, here comes the idea of Supervisory control. The concept is coordinating equipment operation in a flexible manufacturing system consisting some serval subsystems includes robots, assembling machines, CNC lathes and mills. There are two main problems in such a system, the first one is controlling each individual subsystem considering its own sensors, actuator, proximity and specialized controller to perform a certain sequence of activities. There is a safe and square solution for this is Programmable Logic Controller (PLC). PLC are the primary workhorse of Industrial automation and mass production and are used to simple devices and coordinate robots and manufacturing cells

III. PROPOSED WORK

Fig 1 Dual Spindle Horizontal Face Milling Machine

Dual Spindle Horizontal face milling machine is an ideal solution for modernizing the conventional way of machining to an automation level. The working of the machine is explained in the flow chart, the need of the machine is to upgrade the way of conventional machining to automated level with high productivity and accuracy.

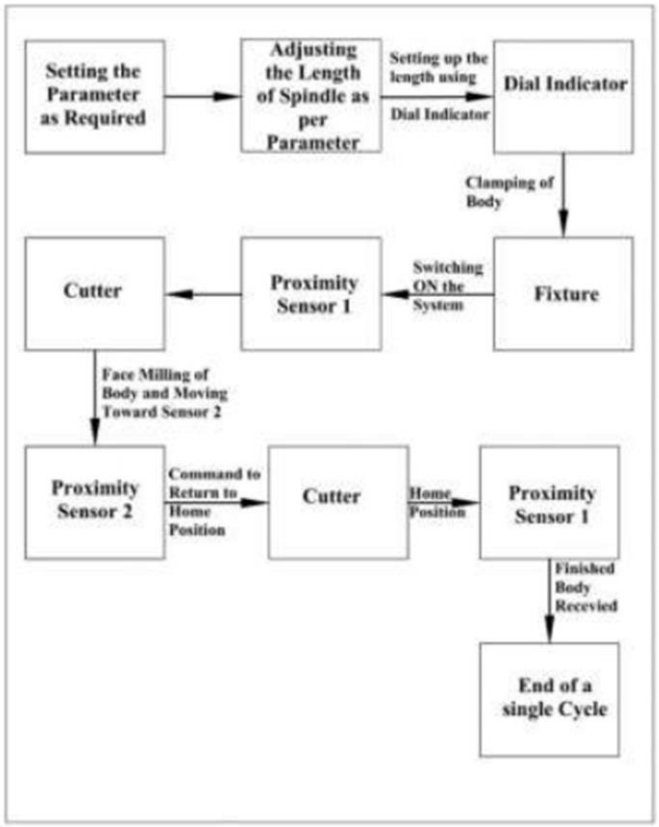


Fig.2 Flow diagram of the whole process

First of all, have to define the need of customer and their parameter and according to that the length is adjusted by moving the spindle TO and FRO to adjust the length as per the parameter for that a dial indicator is used for more accuracy. After setting up the length parameter the raw aluminum body is clamped on the fixture after that switching ON the system. While switching on the system the proximity sensor 1 will sense the fixture position which is already on the home position than the proximity sensor will signals the PLC controller to start the cycle. Now after the command by the PLC the bed on which the fixture is clamped will move towards the cuter with the help of ball screw which is motioned by the servomotor and the face milling of the raw aluminum body take place with the dimensional accuracy as need by the customer parameter. Then the bed reaches the proximity sensor 2 and the sensor signals the arrival of the bed at proximity sensor 2 to the PLC controller and the PLC Controller will command the servomotor to reverse by the bed to its home position. At the end of the cycle a finished body is received as per the customer parameter.

A. Example of Setting Parameter

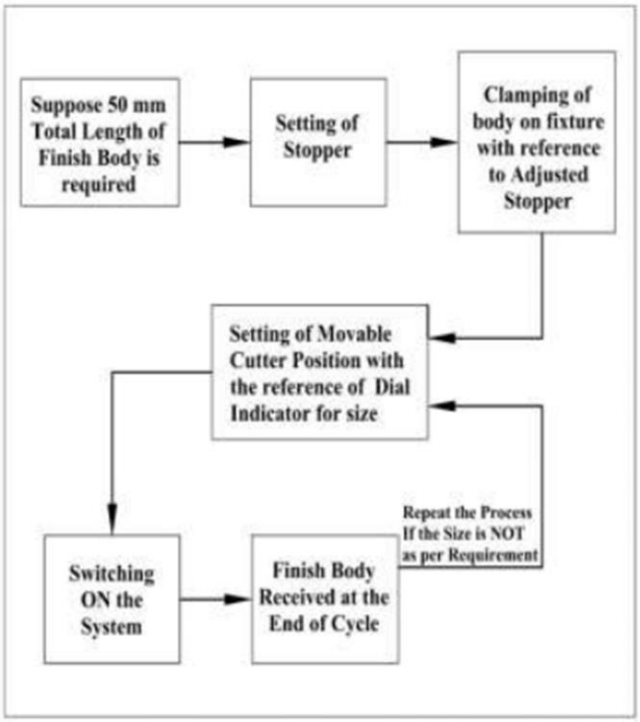


Fig. 3 Flow Diagram of Setting length parameter

Previously we are unable to provide the specified length but can be achieved in this proposed work. Now, the question arise how we set the length of the finish body. Initially the stopper on the side of fixed cutter is adjusted according to the machining material allowance on the fixed cutter. Normally the raw Aluminum body size will be 2.5 mm to 3 mm more than the finish size and on that basis the stopper is adjusted. Now clamping of the raw body on the fixture by taking reference of the stopper. Now the

next parameter is to adjusted the length of the movable cutter according the size of the body and the cutter-spindle setup moves TO and FRO. The movable cutter is moved TO and FRO with the help of a handle. The spindle attachment is attached to a handle and the whole setup is attached to a dial indicator which means the TO and FRO motion of the movable spindle setup is directly controlled by the Dial indictor. The Plunger of the dial is in the contact with a metal thin rod which is flat at the edges and which is also a part of the movable setup so with the motion of the rod the dial shows the reading. After setting up the length parameter switching ON the machine it will procced as explained in the flow chart. At last when we received a final product the size is checked when it is clamped on the fixture if it does not meet the criteria, repetition of the setting of length has to be made again as shown in the flow chart with keeping in mind the size. wheatear it is still undersize or still oversize while comparing with the customer parameter on basis of that the movable cutter is to be adjusted again.

Fig. 4 Shows the Dial and Handel setup for the TO and FRO motion of movable cutter.

B. Working Between the Motion of Fixture to the Cutter

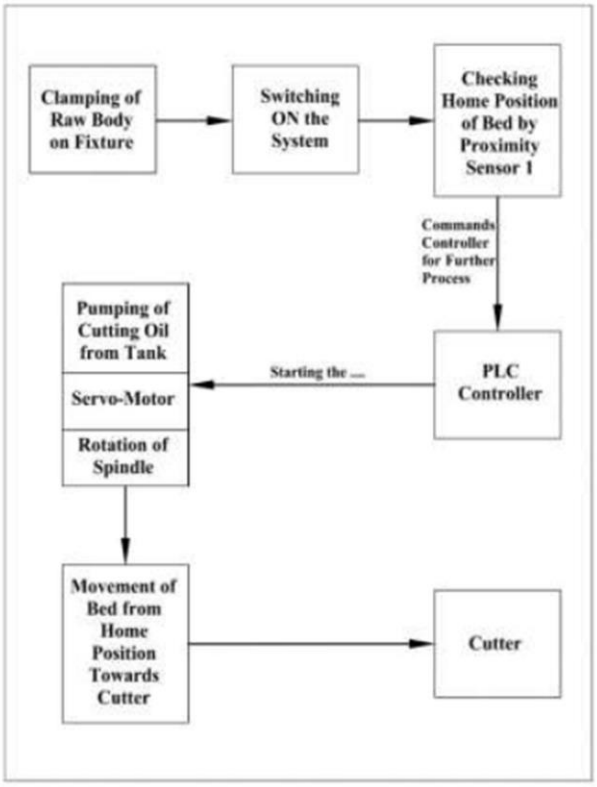


Fig. 5 Flow diagram of working between Motion of fixture to the cutter

After setting up the length parameter as required, The Raw Aluminum body is clamped properly on the fixture and have to Switch ON the system for further process. While Switching ON the system the Proximity sensor 1 which is a NPN-NC type Proximity sensor with a sensing range of 4 mm distance will sense the position of bed by sensing the metal plate of Bed near the Proximity sensor which is on its home position which guides to close the circuit. We can clearly understand the status of circuit, Weather it is closed or not by visually seeing the red light on the Proximity sensor. If, the light is ON then it means the Circuit is Open and if the light is OFF then the Circuit is closed. So, The Closed circuit will switch ON the system which is connected to the PLC Controller and the PLC Controller further commands the Machine System to Start up the following Process: -

1. Starting up the Pumping of cutting oil from the tank through a Pump.
2. Starting the Servomotor which is used for the reciprocating of the bed through ball screw.
3. Starting up the rotation of the both the spindle through their motor.

This will now start the movement of bed from Home position towards the Cutter. Initially while switching on the system the movement of bed goes in rapid toward the cutter as it is commanded in the PLC Controller. The Rapid Movement Length is directly propositional to the width of the Aluminum Body and we can change this manually in the display box. And after that a normal feed movement of bed starts towards the cutter while face milling. The Feed Movement is also Manually Controlled and can be changed directly from the Display box.

C. *Working Between the Cutter to Proximity Sensor 2 and Back to Cutter*

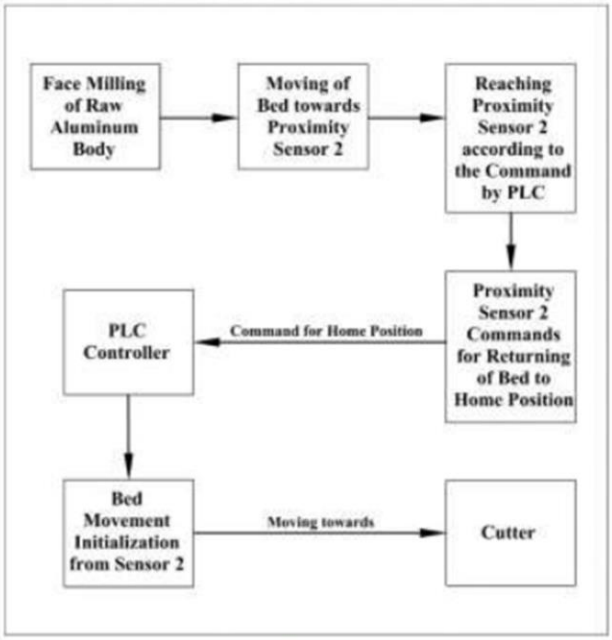


Fig. 6 Flow diagram of working between the cutter to proximity sensor 2 and back to cutter

As per the commands given by the PLC Controller to start the rotation of spindle. The Cutter which is Walter made cutter and the insert is also Walter made for high performance is attached to the spindle for the face milling of the body.

Approach angle	κ	45 °
Cutting edge diameter	D_c	160 mm
Max. cutting edge diameter	D_a	173 mm
Drive size	d_1	40 S
Maximum overhang	l_4	63 mm
Max. depth of cut	L_c	6.5 mm
Peripheral effective cutting edge count	Z	8
Weight		6.34 kg

Fig.7 Specification of Cutter

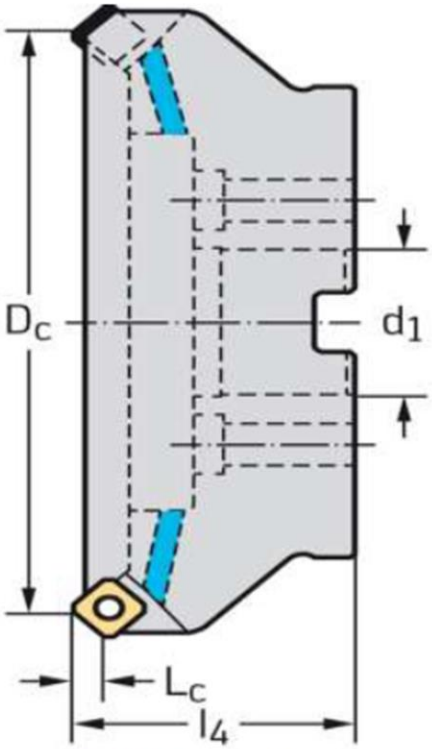


Fig.8 2D view of cutter

Product details

Tolerance class insert		H
Corner count		4
Cutting edge length	l	12.7 mm
Insert thickness	s	6.4 mm
Clearance angle major	α	0 °
Corner radius	r	0.8 mm
Wiper edge length	b	1.5 mm

Fig.9 Specification of Insert

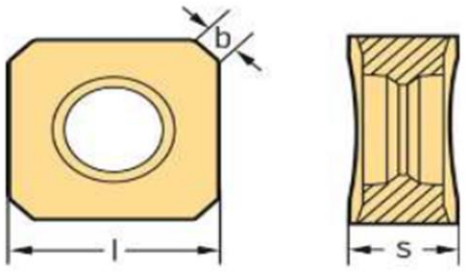


Fig. 10 2D view of insert

Both the spindle is arranged in such a way that, both of them rotates opposite to each other. The purpose of doing this is to neutralize the force of cutting. So, if both rotates at high rpm the cutting force of both cutter on the body get neutralize due to their direction of rotation. Now, the movement of bed, on which the fixture is clamped passes through the cutters. This will start the face milling of the body and due to the continues flow of cutting oil helps to reduce the heat generation due to cutting and helps to improve the finishing on the face of body. And then the bed now reaches the proximity sensor 2. When the metal plate of the bed comes in contact with the sensor 2, the sensor 2 send the commands the controller to starts the reverse jog or movement of bed back to its home position. During the reverse jog, it repasses through both the cutters.

D. Working Between the Cutter to Home Position

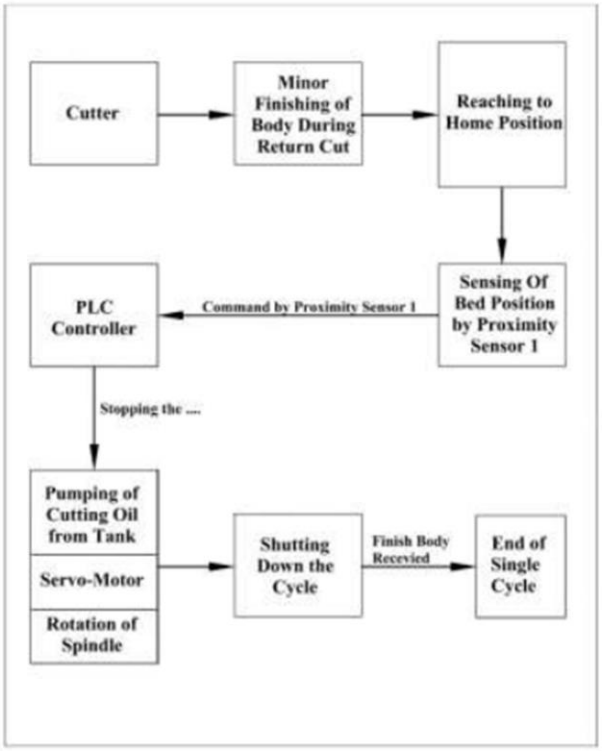


Fig. 11 Flow diagram of working between cutter to home position

As explained in the flow chart, In reverse jog the body repasses through both the cutters. During that minor finishing of the face of the body take place due to the opposite rotation of cutter, So as per the PLC Command the bed reaches the home position and sensing of the bed is done by the proximity sensor 1 and open ups the circuit which is initially closed during the cycle start. Due to the opening up of the circuit by the proximity sensor 1 will stops the following Machine System: -

1. Shutting OFF the Pumping of cutting oil from the tank through a Pump.
2. Shutting OFF the Servomotor which is used for the reciprocating of the bed through ball screw.
3. Shutting OFF the rotation of the both the spindle through their motor.

At the end, of the cycle we receive a finish body. Hence a single cycle is completed.

IV. IMPLEMENTATION RESULTS

A. *Example of Setting Parameter*

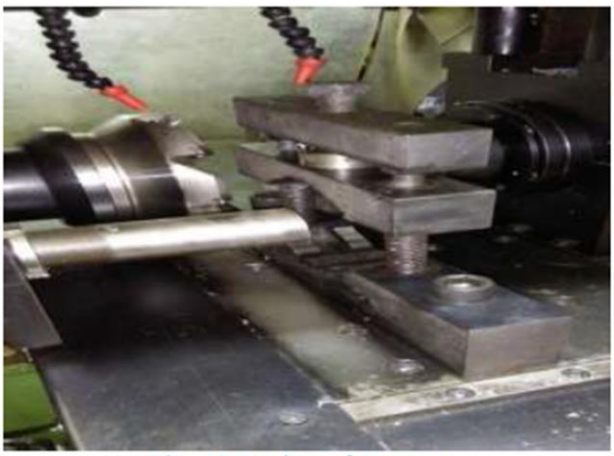


Fig .12 Setting of Stopper

Fig. 13 Clamping of body as per stopper

Fig.14 Forward reverser motion of movable cutter with the help of handle

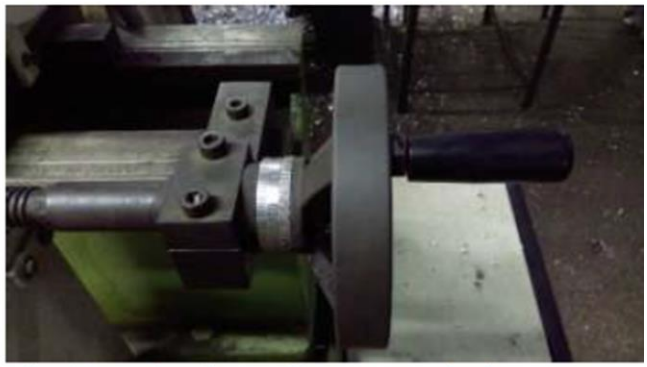


Fig. 15 rotation the handle as per required parameter

Fig.16 Dial indicator for accurate movemet of the movble cutter for acurate results

B. Working Between the Motion of Fixture to the Cutter

Fig. 17 Checking the position of bed at home by proximity sensor 1

Fig 18. Control System Panel

Fig.19 PLC Controller

Fig. 20 Servo Motor Controlling panel

Fig 21. Servo Motor

Fig. 22 Ball Screw connected to servo motor for To and FRO motion of bed

Fig. 23 Face Milling Cutter

Fig. 24 Motion from bed starts from home position to cutter

C. Working Between Proximity Sensor 2 and Back to Home

Fig.25 Motion of bed towards proximity sensor 2 yet to reach Senor 2

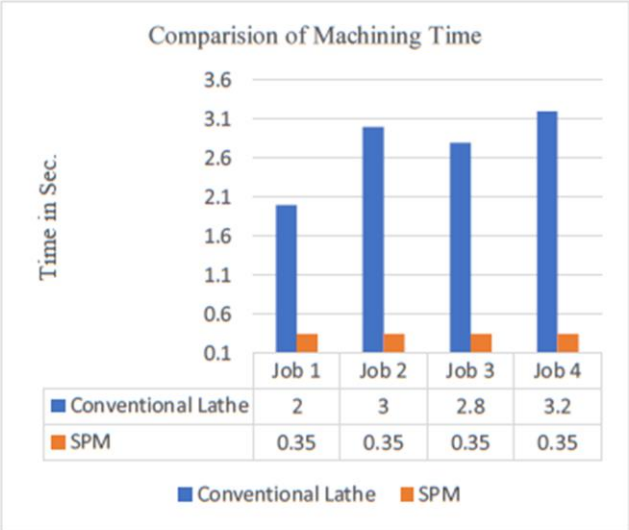
Fig. 26 Bed reached at the Proximity sensor 2

Fig. 27 Motion of bed back to home from proximity sensor 2

V. COMPARISION

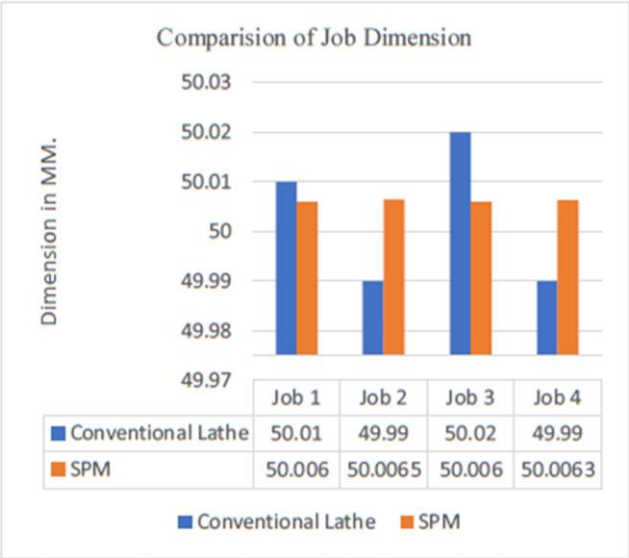
For comparison, the job manufactured on conventional lathe machine and job manufactured on Dual Spindle Horizontal Face Milling Machine.

And the conclusion was that surface roughness, production rate, dimensional accuracy and one time set up cost is high in SPM machine while machining time and machine maintenance is too much low.



	Job 1	Job 2	Job 3	Job 4
Conventional Lathe	2	3	2.8	3.2
SPM	0.35	0.35	0.35	0.35

Chart. 1 Comparison of machining time between job manufactured on proposed and existing



	Job 1	Job 2	Job 3	Job 4
Conventional Lathe	50.01	49.99	50.02	49.99
SPM	50.006	50.0065	50.006	50.0063

Chart. 2 Comparison of job dimension between proposed and existing Lathe

VI. CONCLUSION

By developing automation in conventional lathe machine by modernizing it to a special purpose machine which works as similar to the CNC trainer. Also, the cost of the modernized SPM is 4 times minimum than the CNC.

By using the dual spindle horizontal face milling machine will increase the productivity as compared to the old conventional type of machining. So, it is very much compatible for mass production. This will lead to reduce the cost per piece. Initially it takes 3 setups to finish the body in conventional type but now it takes only a single setup. As the new retrofitted SPM is made by replacing and removing the components from conventional lathe machine, therefore setup cost is high as compare with standard lathe machine but production rat is too high.

The dimensional accuracy of the manufacture job is so accurate as compared to the conventional type machining. The perpendicularity of the both face of the body is so accurate which may not achieve as in conventional type because it is machined in 3 setups. A feistily of cutting oil is also provided which may help to get good finishing on the face. As the feed rate of cutting is programmed in the PLC controller which is constantly similar throughout the machining which will neglect the chance of any kind of lining or vibration on the face. At last the overall performance of the SPM which is Dual Spindle Horizontal Face milling Machine is very high as compared to the Conventional type of machining

VII. REFERENCES

1. Donghong Tang, Guozhi Zhang "A Study on Face Milling Force Model Based on Complex Surface Geometry" 978-1-4244-5268-2/09/$25.00 ©2009 IEEE.
2. Yang Yang, Xinyu Li, Ping Jiang, Long Wen "Cooperative Work in Design Modeling of Cutting Forces in a Face-Milling Operation With Gene Expression Programming" IEEE

16th International Conference on Computer Supported , 978-1-4673-1212-7/12/$31.00 ©2012 IEEE .

3. J. C. Z. MARTIN, D.L.C., Grad.I.Prod.E" special purpose machine tools and unit construction", London Graduate Section of the Institution, 18th February, 1954.
4. Agnelo Denis Vieira, Eduardo Alves Portela Santos, Max Hering de Queiroz, André B. Leal,AmaroDuartedePaulaNeto,andJoséE.R. Cury, "A Method for PLC Implementation of SupervisoryControl of Discrete Event Systems" 1063-6536 © 2016 IEEE.
5. http://www.walter-tools.com/en us/search/pages/products.aspx#k=F4033.B40.160.Z08.06
6. http://www.walter-tools.com/en us/search/pages/products.aspx#k=SNHX1205ANN-K88%20WK10