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TAILSTOCK SEMI - AUTOMATION FOR HEAVY DUTY LATHE MACHINE

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ABSTRACT

Today, the production industries are experiencing labour problem, skill problems and delivery problems due to less productivity. For customer satisfaction regarding delivery, the productivity has to be improved with minimum investment. The productivity can be improved by using CNC machines or "SPM"s, but it costs more. On the other hand the traditional machines are being used by semi skilled operators; who are not able to work on "CNC"s. so, the middle way is to rectify the existing machinery and set up. The paper presented here, explains the project work done on the modification of heavy duty lathe machine used for the manufacturing of butterfly valve body. The basic operation in butterfly valve body manufacturing is drilling on heavy duty lathe, which is frustrating for operator. To improve the operators comfort, the toggle clamp is used to fix the position of tailstock on lathe bed instead of locking screw. To move the tailstock over bed, the pneumatic cylinder attachment is used instead of manual pulling or pushing.

Keywords: Automation, Productivity, Heavy duty lathe machine, Toggle clamp, Pneumatic attachment

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I. INTRODUCTION

In the present project work, major part is heavy duty lathe machine over which drilling of butterfly valve body is done. For drilling of Butterfly valve body, it is mounted on face plate with the help of fixture.

Fig.1

Fig. shows heavy duty lathe machine and butterfly valve body is mounted on face plate with the help of fixture. For drilling purpose drill is fed from tailstock. Because of different diameter and lengths of drill bits, operator has to clamp and de-clamp the tailstock up to 25-30 times for a single job.

Fig.2

Fig. shows previous method of tailstock clamping and de-clamping. In this, by using spanner operator has tight or loose the nut according to clamp and de-clamp the tailstock. Which causes fatigue to operator and this affects on the production rate.

Also longitudinal movement of tailstock is done by giving manual effort which causes fatigue to operator. Extra efforts are required because oil is not allowed over the bed as the S.G. cast iron is being machined. Hence, we need automation of tailstock for reducing manual effort to increase productivity.

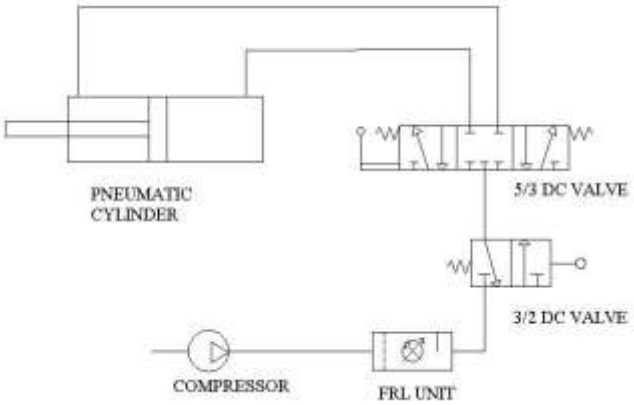


Fig. 3 Circuit Diagram of Pneumatic Arrangement

Pneumatic system is design to handle compressed air/gas through various components and it is used for performing certain assigned task. The fig. shows general layout of pneumatic system in which various components are placed as per their function to form pneumatic system layout.

Working of the system

Fig. shows circuit diagram of pneumatic connection. It consist of compressor, FRL Unit, 3/2 D.C. Valve, 5/3 D.C. Valve & Pneumatic cylinder. This circuit is used to control the motion of pneumatic cylinder. The compressed air from compressor is drawn through FRL unit to the 3/2 Direction Control valve. 3/2 D.C. valve is a push button type & spring loaded so, when this valve is pushed the supply of compressed air is passed through 5/3 D.C. valve to pneumatic cylinder. So, controlling of motion of piston rod is being achieved.

Problem Statement

Butterfly valve body is mounted on the face plate with the help of fixture for drilling purpose. Drill is fed from tailstock. Due to different diameters and lengths of drill bits, operator has to clamp and de-clamp the tailstock up to 25 to 30 times for a single job. The clamping and de-clamping of tailstock is done by tightening and loosening of nut of M25 with the help of spanner. It causes fatigue of operator and reduces productivity. Additionally, the longitudinal movement of tailstock also causes fatigue of operator because the oil over bed is not allowed as the S.G. Cast Iron is being machined. Concluding that, it is necessary to change the method of clamping and de-clamping a tailstock which will save the time and efforts, mean while the semi-automation of tailstock longitudinal movement is important.

Objectives

- To understand and study the purpose, machining operations and existing working methodology of butterfly valve body manufacturing.
- To perform the time study and find out the time consuming and fatigue causing operations.
-To attack on the critical issues so as to improve the productivity.

Proposed Work and Methodology

- Study of current manufacturing process.
- Study of process time and delay times.
- Reverse engineering of clamping process – measurements of tailstock, force required to clamp the tailstock, method of clamping and de-clamping.
- Layout design of the system.
- Search out the standard components available in market which can mechanized existing system which can reduce the process time and efforts.
- Design and drafting of assembly and details with CAD.
- Machining, assembling and implementation of improved system.

Idea Formation for Clamping and De-clamping of Tailstock:-

Fig.4 Toggle Clamp

Due to different diameters and lengths of drill bits, operator has to clamp and de-clamp the tailstock up to 25 to 30 times for a single job. The clamping and de-clamping of tailstock is done by tightening and loosening of nut of M25 with the help of spanner. It causes fatigue of operator and reduces productivity.

Toggle clamps are used for temporary clamping that can be employed and released easily via the motion of a handle lever, or pneumatic switch. Different applications for toggle clamps require different configurations, including vertical, push-pull, cam, latch and hook designs. They also require different sizes and clamping pressure. According to present problem we require latch and hook type toggle clamp.

Idea Formation for Longitudinal Movement of Tailstock:

Fig. 5

The longitudinal movement of tailstock also causes fatigue to operator because the oil over bed is not allowed as the S.G. Cast Iron is being machined. Concluding that, it is necessary to convert manual effort required during tailstock to& fro motion into semi automation of tailstock which will save the time and efforts, mean while the semi-automation of tailstock longitudinal movement is important.

So that fig. shows tailstock semi automation, which develop automatic movement of tailstock through pneumatic cylinder by using compressed air. Attachment shows a four plates in which one is used to support a pneumatic cylinder and other three are used to cover the required distance over which tailstock moves. Cylinder piston is attached to tailstock flexibly.

2. LITERATURE REVIEW

H. A. Pagar et al [1] studied, nowadays, products can be produced by modern technology, which uses computer software, hardware and firmware in industry. CNC or semi-automatic control lathe machine used to increase speed at which parts are produced such that these parts are producing the same quality for all work parts at better dimensional accuracy which gives exact and correct dimensions. Therefore, these machines are becoming most important in industrialization . To build a new develop country it is require to convert these conventional lathe machines in to semi-automatic control lathe machine by retrofitting. There are namely three required portions are mechanical, electronics and hydraulic or pneumatic.

Indrajeet Chaudhary et al [2] studied, Various technologies have been developed for automation. In this automation is performed with the help of advanced pneumatic system. There are so many devices used in pneumatic system like compressor, 3/2 way valve pneumatically operated, 5/2 valve pneumatically operated, double acting cylinder, pressure sequence valve, stepper motor. Automation plays important role in industry to increase production, reduce labor costs, reducer cycle time, reduce maintenance cost and improve product quality, reduce possibility of accident etc.

M. Minhat et al [3] studied, this paper discus about an attempt has been made to equip the conventional lathe machine with Digital Intelligence System (DIS) to get more accurate dimensions and precise shape of high end product. The retrofitting process of conventional lathe machine in to semi automatic lathe machine which consist two elements like mechanical and electronics parts.

M. Muthukkaruppan et al [4] studied, the clamping of the drilling machine port transfer and feed of the drilling machine spindle is done using electropneumatics. The total concept of system is based on low cost automation with the micro controllers. The following parts are carried ,

1. Time saved by component handling.
2. Increase in productivity both qualitative and quantitative.
3. Improved repeatability and accuracy.
4. Reduction in operating fatigue.
5. Less rejection due to automatic controls.
6. Minimization of production costs.

Prakash N. Parmar et al [5] studied, Nowaday, in a modern technology, product can be produced by using computer software, hardware and firmware I industry. It is needed to use automatic lathe machine to get more accurate dimensions and irregular shape. There are many conventional lathe machine in our country. To build a new modern developed country, it is required to convert this conventional lathe machine into semiautomatic control lathe machine. There are mainly, three required portions as mechanical, electronics and hydraulic or pneumatic.

Pulkit Barala et al [6] studied, during the past decade number of application have been developed based on pneumatics. With the help of electropneumaticsystem.It is easier to automate various process station know a days, every organization have different needs. This accomplishes the aim to reduce labour cost time of operation better flow of product from one section to other, maintenance cost and simulation. Provide with the feasibility of operation.

Rohan Kulkarni et al [7] studied, Industrial automation is broad field in engineering disciplines. The major activities of automation in manufacturing industries and includes cycle time improvement, productivity improvement, cost reduction, efficiency improvement, material handling, analyze and improve the work method, to eliminate waste and proper location and utilization of resources. Productivity improvement is achieved through analyzing the current method by eliminating unnecessary movement reducing cycle time. Providing solution to various problem during the machining of components. In this research paper the use of automation technique namely pneumatics automation technique namely pneumatics automation to increase the productivity and efficiency.

Shivbhadrasinh Jhala et al [8] studied, The paper involves the use of automation solution to reduce operator fatigue and increase efficiency. Recently, industries are concentrating on CNC or semi automatic lathe machines for mass production instead of conventional lathes. To improve productivity, but loading and unloading of job carried over by manual. So machine tool manufacture are coming with solutions improving automatic loading and unloading to reduce fatigue of labor and reduce cycle time and increasing productivity.

Zin Ei Ei Win et al [9] studied, There are many conventional lathe machines in our country. In modern technology it is needed to use CNC lathe machine to get more accurate dimensions. Mechanical, Electronics and Mechatronics are required three portions use for developing semi automatic lathe machine.

Design Calculations:-

1. <u>Selection of Pneumatic Cylinder</u>:-

Step 1:-

- Force required to move the tailstock is 30kg [ergonomically experimental study]But, for safety purpose assuming force required is 40kg. So,

Force = 40kg
= 40 × 9.81
= 392.4 N

Step 2 :-

- Pressure of compressed air available from compressor Assume, Pressure = 2 bar

$= 2 \times 10^5$ N/m^2
= 0.2 N/mm^2

Step 3 :-

- To find out full bore area

As, Force = 392.4 N & Pressure = 0.2 N/mm^2

We know, Force = Pressure × Area

$$\text{Area} = \frac{\text{Force}}{\text{Pressure}} = \frac{392.4}{0.2}$$

Area = 1962 mm^2

Step 4 :-

- To find out piston Diameter As, Area = 1962 mm^2

$$\text{Area} = \frac{\pi \times d^2}{4}$$

$$1962 = \frac{\pi \times d^2}{}$$

$d^2 = 2498.09$

$d = 49.98$ mm $\approx$ 50 mm

So, 50mm bore diameter of pneumatic cylinder is used.

Specifications of Pneumatic System

1.Cylinder :

- Bore diameter :- 50 mm
- Stroke length :- 500mm

2.Tube :

- Pipe / tube diameter :- 6 mm
- Tube length :- 200 mm (minimum)

3.Control Valve:

- D. C. Valve :- 1) 5/3 D.C. Valve, Hand operated, Spring loaded, Normally off.
  2) 3/2 D.C. Valve, Push button type

4.FRL Unit : standard

2.Design of Cylinder mounting Plate:-

Step 1 :-

- We have selected Pneumatic cylinder with Bore diameter 50 mm.

For design of Plate considering, maximum pressure as 5 bar.

We know,

$$\text{Area} = \frac{\pi \times d^2}{4}$$

$$= \frac{\pi \times (50)^2}{4}$$

Area = 1963.49 mm^2

As, Area = 1963.49 mm^2 & Pressure = 0.5 N/mm^2

Force = Pressure × Area
= 0.5 × 1963.49
= 981.74 N

Step 2 :-

- To find maximum bending movement

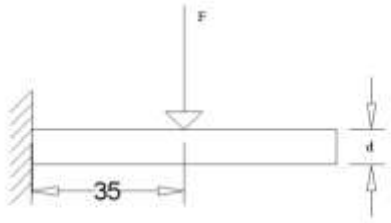


Fig.7

Fig.5 shows plate having one end fixed, another end is movable and vertical load is acting on plate at a 35 mm distance apart from rigid support. So, plate is considered as cantilever beam type.

Maximum Bending Moment,

M_b = Force × Distance from rigid end
= 981.74 × 35
= 34360.9 Nmm

Step 3 :-

- To find Width of Clamping Plate

By using Flexural formula,

$$\frac{M_b}{I} = \frac{\sigma}{Y}$$

[$I = bd^3/12$ & $Y = d/2$]

$$\therefore \frac{M_b}{bd^3/12} = \frac{\sigma_b}{d/2}$$

$$\therefore \frac{34360.9}{70d^3/12} = \frac{40}{d/2}$$

$$\therefore \frac{34360.9}{5.83d^3} = \frac{80}{d}$$

$\therefore$ d = 8.58 mm $\approx$ 9 mm

3.Clamping Bolt:-

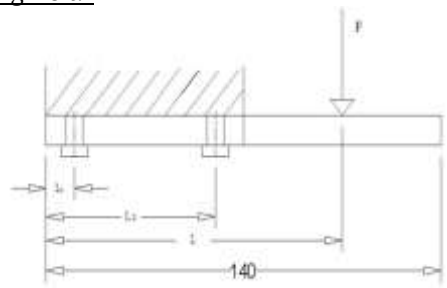


Fig.8

Consider, a plate bolted to a rigid support using four bolts.

Let, P = Load applied = 981.74 N
n = Number of bolts = 4
L = Distance of load from rigid support = 105 mm
L_1&L_2 = Distance of axis of the bolts from eccentric point = 10 mm & 60 mm

Step 1:-

Two types of loads will act on bolt.

1. Direct tensile load (W_{t1})
2. Secondary eccentric tensile load (W_{t2})

Direct tensile load,

$$W_{t1} = \frac{P}{}$$

n

$= \frac{981.74}{4}$

$W_{t1} = 245.43$ N

Secondary eccentric tensile load per unit length,

$$\omega = \frac{P \times L}{2(L_1^2+L_2^2)}$$

$$= \frac{981.74 \times 105}{2(10^2+60^2)}$$

$\omega = 13.93$ N/mm^2

Secondary tensile load,

$W_{t2} = \omega \times L_2$

$= 13.93 \times 60$

$W_{t2} = 835.8$ N

Step 2 :-

Total tensile load,

$W_t = W_{t1} + W_{t2}$

$= 245.44 + 835.8$

$= 1081.24$ N

Step 3 :-

To find core diameter,

Tensile stress,

$$\sigma_t = \frac{4W_t}{\pi d_c^2}$$

$$60 = \frac{4 \times 1081.24}{\pi d_c^2}$$

$d_c = 4.79$ mm

Step 4 :-

To find bolt diameter,

$$d = \frac{d_c}{0.84}$$

$$d = \frac{4.79}{0.84}$$

$d = 5.70$ mm

∴ *Bolt size M6 is used.*

4.Tailstock Clamping & De-Clamping

- Tailstock is clamped with the help of screw. Manual clamping and de-clamping of screw is carried out. So, we have to design this screw for automatic clamping and de- clamping with the help of spanner.

Step 1:-

- Tangential force acting on screw

  Assuming tangential force 20kg to 30kg

  So, Force (F) = 20 × 9.81

  F = 196.2 N

Step 2 :-

- Total Torque acting on screw

  Length of spanner (L) = 200 mm

  ∴ Total Torque $(M_t) = F \times L$

  $= 196.2 \times 200$

  $= 39.24 \times 10^3$Nmm

Step 3:-

- Screw and Collar friction Torques

  We have,

  1. Screw Thread Pitch (p) = 6 mm (V-Thread)
  2. Single Start (l) = p = 6 mm
  3. Inner Diameter of Screw Thread (Di) = 30 mm
  4. Outer Diameter of Screw Thread (Do) = 33.5 mm
  5. Mean Diameter

     $Dm = \frac{Di + Do}{2}$

     $= \frac{30 + 33.5}{2}$

     Dm = 31.75 mm

     $\tan\alpha = \frac{l}{\pi Dm}$

     $= \frac{6}{\pi \times 31.75}$

     $\alpha = 3.44°$

Coefficient of friction at the collar (μ_c) = 0.17

Coefficient of friction at the screw (μ_s) = 0.15

$\tan\varphi = \mu = 0.15$

$\therefore \varphi = 8.53^o$

Torque at the screw, $(M_t)_s = \frac{W \times Dm}{2} \times \tan(\varphi + \alpha)$

$= \frac{W \times 31.75}{2} \times \tan(8.53+3.44)$

$(M_t)_s = 3.36W$

Torque at the collar, $(M_t)_c = \frac{\mu_c \times W}{4} \times (Do+Di)$

$= \frac{0.17 \times W(30+33.5)}{4}$

$(M_t)_c = 2.698$ W Nmm

Total torque $M_t = 39.24 \times 10^3$Nmm

$M_t = (M_t)_s + (M_t)_c$

$39.24 \times 10^3 = 3.36W + 2.698W$

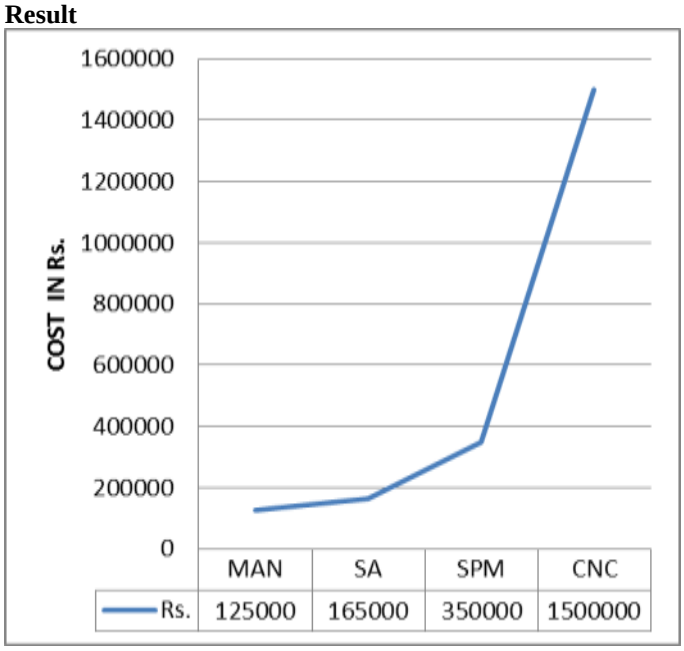
$39.24 \times 10^3 = 6.058W$

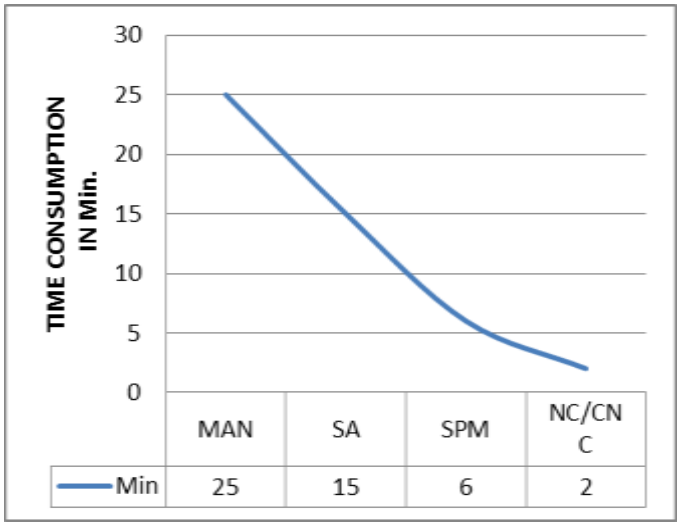
$W = 6.477 \times 10^3$ N

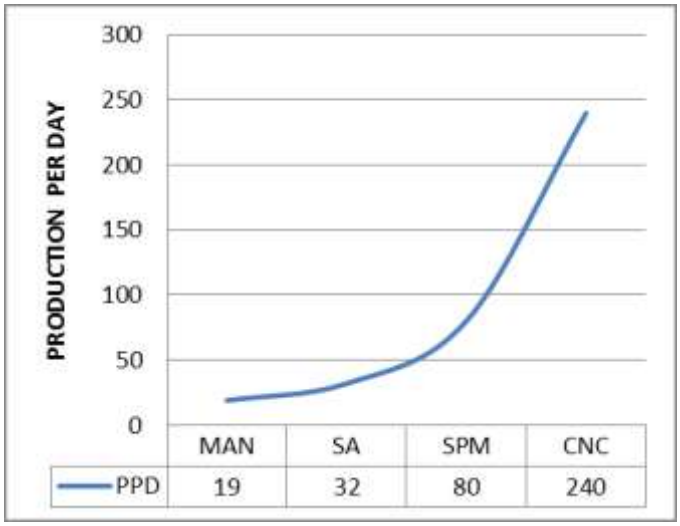
Axial Force $W = 6.477 \times 10^3$ N

$W \approx 660.24$ kg

Result







Conclusion

In this way, by adopting this type semi automation, we improved the productivity as compared to manual handling. On the other hand, the semi automation is less expensive as compare existing CNC or NC machines.

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