

Design and Development of SPM for Boring and Reaming Operation

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ABSTRACT: This project deals with design, development and fabrication of “Special Purpose Machine”. This machine is designed for the purpose of multi operations i.e. drilling, reaming, boring and clamping and de-clamping. This Machine will perform multipurpose operation at same time with required speed and this is automatic which is controlled or operated by motor which is run with the help of electric power supply. This multi operational machine is used in SAI Industries for drilling and reaming of the RockerArm.

Industries are basically meant for production of useful goods and services at low production cost, machinery cost and low inventory cost. Today in this world every task have been made quicker and fast due to technology advancement but this advancement also demands huge investment and expenditure. Every industry tries to achieve high productivity maintaining the quality and standard of the product at low average cost.

We have develop machine which would be capable of performing different operations simultaneously at high efficiency. This Special Purpose Machine using hydraulic cylinders is used for precise drilling and reaming at a time. The productivity and the quality of the work is increase by this machine. The use of Special Purpose Machine minimizes the possibilities of human errors.

KEYWORDS: Special Purpose Machine, Rocker Arm, Drilling, Boring, Conventional Machining, Automation, Productivity.

I. INTRODUCTION

Special purpose machine are those machine which are not accessible off the shelf. These are not secured in standard manufacturing programs. Therefore they must be designed and tailor made as per the customer’s specific requirement. They are additionally called as ‘Bespoke Machines’. Exceptional reason machine is a piece of multitasking machine. In the event that we think about between common machine and unique reason machine as far as time, costs, number of steps included, and so forth. This is new way to deal with expansion the productivity of association the multitasking machine is favored decision.

Innovation of special purpose machine is settled on the standards of minimization of cost, enhanced efficiency and enhanced security, better wellbeing and so forth. Which gangs with high beginning venture, higher support cost and so on Special purpose machine is higher degree system in which human support is given by mechanical, electrical, liquid force advances fit for doing physical exertion and even mental work as if there should arise an occurrence of CNC machine.

The special purpose machine and automatic machines are intended to operate continuously for 24 hours a day, with minimum supervision. The special purpose machine is generally product specific and they are required to be designed and developed for every specific requirement. At times it may be possible to cater to the jobs having similar features yet differing in dimensions by using change tooling concept.

In case of mass production where variety of jobs is less and quantity to be produced is huge, it is very essential to produce the job at a faster rate. This is not possible if we carry out the production by using general purpose machines. Special purpose machine are not secured in standard manufacturing programs. Therefore they must be designed and tailor made as per the customer’s specific requirement.

II. PROBLEM DEFINITION

By conventional machining methods, only one job can be worked at a time, resulting in lesser production. Today's industrial requirements demand faster production with increased accuracy.

Common problems faced by conventional machining are complicated jig and fixture design to hold component and guide drill bit, controlling drill depth, pressure applied to handle of drilling machine, human error while loading and unloading work piece on fixture, and accommodate change in size of drill hole.

In developing world, performing drilling, reaming and boring operation simultaneously on the same machine was a bigger problem for manufacturing company and workshop holders, individual drilling, boring and reaming machines were exist in the market, but they were not beneficial for workshop holders, small industrialist and entrepreneurs to buy separately due to very highcost.

Current the Sai Industries, Shirolu is using central lathe which machines the Rocker Arm per month as per order. By conventional lathe method for drilling and boring of each rocker arm the time required is 2-2.50 minutes therefore in one shift of 8 hours 240 jobs are completed.

Solution: - By manufacturing SPM the time required for each rocker arm is 40-50 second therefore in one shift of 8 hours 720 jobs are completed. So Sai Industries has been decided to manufacture SPM for drilling & boring.

III. DESIGN SCHEME AND CALCULATION

As shown in figure, there are two spindles one is on the left and one is on the right. These spindles are supported by bed and attached at the bottom side of the machine.

The upper side of the machine consists of spindle assembly, fixture assembly, sliding bed assembly. The spindles are driven by two motors of 1.5 Hp, the belt and pulley drive mechanism is used to transmit motion from motors to spindles. The other end of the spindles are holding tool which is used to bore and ream the workpiece. The sliding bed mechanism consists of bed, sliding mechanism, limit switch, fixture plate, and the bed is connected to the double acting hydraulic cylinder. The bed slides from center position to the right for boring operation and then from right to extreme left for reaming operation with the help of hydraulic cylinder which is controlled and monitored by PLC unit. The fixture assembly is mounted on sliding bed's fixture plate assembly. It consists of vertical column and a small hydraulic double acting cylinder on the top of the column with the v-block attached to its end and another v-block is placed below the hydraulic cylinder to hold the workpiece in proper place while machining. With the help of the PLC unit, before the machining cycle, the cylinder is retracted in upward direction and when the workpiece is placed in proper position while machining. The cylinder is pushed against the workpiece to hold it tight in its position.

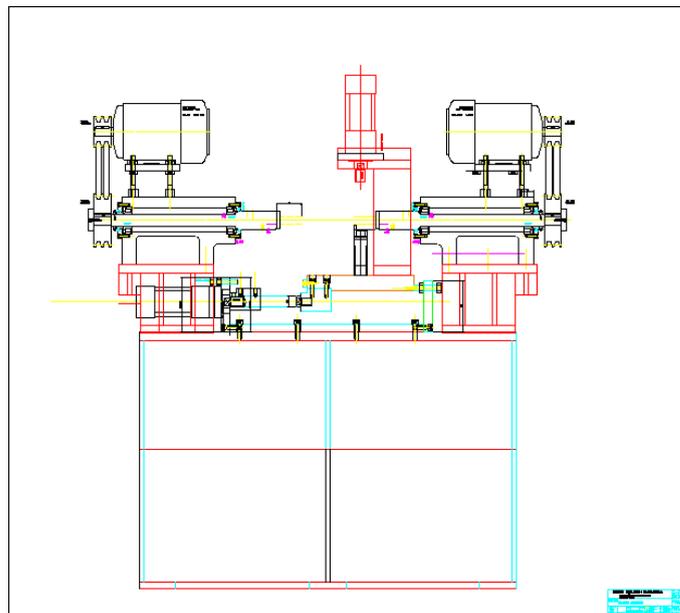


Figure 1: - Layout of Machine



Selection of parameter for proposed machine

1. Cutting tool –U-drill
2. Cutting tool material –HSS
3. Cutting tool specifications –

Cutting speed(V) – 23m/min
 Diameter of cutter(D) – 22.5 mm
 Feed per revolution(S) – 0.28 mm/rev
 By using standard formula,

$$V = \pi Dn$$

$$n = \frac{V}{\pi D}$$

$$= \frac{23}{\pi \times 22.5 \times 10^{-3}}$$

$$n = 325.383 \text{ rpm}$$

Feed rate per revolution = 0.28mm/rev----- CMTI handbook
 Material factor(K)=2.03----- CMTI handbook table 272
 By using standard formula,

$$\text{Power of spindle } N = \frac{1.25 \times D^2 \times K \times n \times (0.056 + 1.5 \times S)}{10^5}$$

$$= \frac{1.25 \times 22.5^2 \times 2.03 \times 325.383 \times (0.056 + 1.5 \times 0.28)}{10^5}$$

$$N = 1.989$$

Now assume, efficiency of Motor $\eta = 0.75$
 By using standard formula,

$$\text{Power of Motor } P = \frac{N}{\eta}$$

$$= \frac{1.989}{0.75}$$

$$P = 1.4922 \text{ kw}$$

Design of Belt-

Given data-

Type of driving unit = 1.5 Hp motor
 Type of driven machine = Spindle
 Operational hour per day = 8 hrs
 Power of be transmitted = 1.49 Kw
 Input Speed = 1440rpm
 Output Speed = 800rpm
 Approximate center distance(C) = 242 mm
 Correction factor (Fa) according to service = 1.1 ----- from Machine Design table no.13.15
 Design power = Fa = 1.1
 Selection of type of cross section of V-belt = A type ----- from Machine Design fig. no. 13.24
 Diameter of smaller pulley (d) = 75 mm, r = 37.5mm
 Diameter of bigger pulley(D) = 135 mm, R = 67.5mm

Length of belt

$$L = 2C + \pi(r+R) + \frac{(R-r)^2}{C}$$

$$L = 2 \times 242 + \pi(37.5 + 67.5) + \frac{(67.5 - 37.5)^2}{242}$$

$$L = 484 + 329.86 + 3.72$$

$$L = 817.58 \text{ mm}$$

By taking L=790mm ----- from Machine Design table no.13.14

Again length of belt ,

$$L = 2C + \pi(r+R) + \frac{(R-r)^2}{C}$$

$$790 = 2 \times C + \pi(37.5 + 67.5) + \frac{(67.5 - 37.5)^2}{C}$$

$$790 = 2 \times C + 329.86 + \frac{900}{C}$$

$$790 - 329.86 - 2 \times C - \frac{900}{C} = 0$$

$$460 - 14 - 2 \times C - \frac{900}{C} = 0$$



Multiplying whole equation by c and dividing by 2,

$$C^2 - 230.07c + 450 = 0$$

By using standard formula,

$$C = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$C = \frac{-(-230.07) + \sqrt{(-230.07)^2 - 4 \times 1 \times 450}}{2 \times 1}$$

$$C = 228.09 \text{ mm}$$

Correction factor (Fc) for belt pitch length

$$F_c = 0.84 \text{ -----from Machine Design table no.13.21}$$

Arc of Contact for smaller pulley (α_s)

$$\alpha_s = 180 - 2 \sin^{-1} \left(\frac{D-d}{2C} \right)$$

$$\alpha_s = 180 - 2 \sin^{-1} \left(\frac{135-75}{2 \times 228} \right)$$

$$\alpha_s = 164.87^\circ \approx 166^\circ$$

Correction Factor (Fd) for Arc of contact

$$F_d = 0.97 \text{ -----from Machine Design table no.13.22}$$

Power Rating (Pr) of Single V-belt

$$P_r = 0.91 \text{ Kw -----from Machine Design table no ... 13.16 –13.20}$$

Number of belts

$$\begin{aligned} \text{Number of belts} &= \frac{P \times F_a}{P_r \times F_c \times F_d} \\ &= \frac{1.49 \times 1.1}{0.91 \times 0.84 \times 0.97} \\ &= 2.2 \approx 2 \end{aligned}$$

Number of belts = 2 belts

Tension in Tight side and Slack side

Given Data-

Motor speed (N_1) = 1440 RPM

Spindle speed (N_2) = 800 RPM

Dia. of motor pulley (D_1) = 75mm

Dia. of spindle pulley (D_2) = 135mm

Center to center distance between pulleys = 242mm

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

Where,

T_1 = Tension on tight side, N

T_2 = Tension on slack side, N

θ = Wrap angle, rad

μ = Coefficient of friction

$$\begin{aligned} \theta &= 180 - 2 \sin^{-1} \left(\frac{D_2 - D_1}{2C} \right) \\ &= 180 - 2 \sin^{-1} \left(\frac{135 - 75}{2 \times 242} \right) \end{aligned}$$

$$\theta = 165.7^\circ$$

$$\theta = 165.7^\circ \times \frac{\pi}{180}$$

$$\theta = 2.89 \text{ rad}$$

Then,

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$\frac{T_1}{T_2} = e^{0.2 \times 2.89}$$

$$\frac{T_1}{T_2} = 1.78$$

Velocity of motor is given by,

$$V = \frac{\pi D_1 N_1}{60 \times 10^3}$$



$$V = \frac{\pi \times 75 \times 1440}{60 \times 10^3}$$

$$V = 5.65 \text{ m/s}$$

Power transmitted by the belt,

$$\text{Power} = (T_1 - T_2) V$$

$$1.49 \times 10^3 = (1.78T_2 - T_2) \times 5.65$$

$$T_2 = 338.09 \text{ N}$$

$$T_1 = 1.78 \times 338.09$$

$$T_1 = 601.80 \text{ N}$$

∴ Tension on slack side (T₂) = 338.09N

And Tension on tight side (T₁) = 601.80N

Selection of Bearing

1- Tapered roller bearing (6306)

Given data:

Inner diameter (d) = 35mm

Outer diameter (D) = 72mm

Width (W) = 24.25mm

N₁ = 1440rpm

N₂ = 800rpm

Load acting on bearing (p) = 3KN

Equivalent Bearing Load

$$p = x \times Fr + y \times fa$$

Where,

P = Equivalent dynamic Load (N)

fr = Radial Load (N)

fa = Axial or thrust load (N)

v = race rotation factor

There is no axial load acting on bearing

$$\therefore p = x \times fr + y \times fa$$

$$p = 1 \times 3000 + y \times 0 \text{ ----- (x=1) from Machine Design table no.15.4}$$

$$p = 3000 \text{ N}$$

Now, bearing life for Industrial application

Machine used for 8hrs of service per day such as electric motor, gear drives.

Rated bearing life (L_{10h}) = 12000-20000h

$$L_{10} = \frac{60 \times N_2 \times L_{10h}}{10^6}$$

$$L_{10} = \frac{60 \times 800 \times 20000}{10^6}$$

$$L_{10} = 960 \text{ million revolution}$$

Load carrying capacity

$$L_{10} = \frac{C^x}{p^x} \text{ ----- for taper rolling bearing (x=3)}$$

$$C^x = L_{10} \times p^x$$

$$C^3 = 960 \times 3000^3$$

$$C = 29594.54 \text{ N}$$

From table for Dynamic Load 28100N.----- from Machine Design table no.15.5

The selected Bearing is 6306.

2- Tapered roller bearing (32207J₂/Q)

$$L_{10} = \frac{60 \times N_2 \times L_{10h}}{10^6}$$

$$L_{10} = \frac{60 \times 1440 \times 20000}{10^6}$$

$$L_{10} = 1036.8 \text{ million revolution}$$

Consider radial load acting on a bearing (fr) = 6000N

Equivalent Dynamic Load

$$p = x \times fr + y \times fa$$

$$p = 1 \times 6000 + y \times 0$$

$$p = 6000 \text{ N}$$



Load carrying capacity

$$L_{10} = \frac{C^x}{p^x} \text{-----for taper rolling bearing}(x=3)$$

$$C^x = L_{10} \times p^x$$

$$C^3 = 1036.8 \times 6000^3$$

$$C = 60627N$$

For Dynamic Load 60629 the standard value in table 61600 ----- from Machine Design table no.15.6

Selected bearing is 32207.

IV.CONCLUSION

From this we have concluded that the use of special purpose machine is beneficial for the manufacturing of rocker arm. It reduces the production time of the rocker arm and at the same time gives better quality with less number of rejection and defects in the rocker arm. Hence special purpose machine is useful for manufacturing of rocker arm.

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