Design and Development of a Special Purpose Machine for Rod End

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Abstract— A special purpose machines are new improvement for manufacturing industry. This is new approach to increase the productivity. These are futures of manufacturing industry lies in reducing production time, improving the performance and consistency in production. There are several types of special purpose machines i.e. semiautomatic and automatic. Compared with general purpose machines, special purpose machine has faster rate of production in less time. Special purpose machines are designed and manufactured as per customer requirements. Special purpose machines have more accuracy and less rejection of job than general purpose machines. These are useful in mass production.

Key words: Special Purpose Machine, Productivity, Mass Production, Accuracy

I. INTRODUCTION

Special purpose machine generally use for increase mass production. Special purpose machine must be design and manufacture as per customer requirement. Due to innovation of special purpose machine minimize cost, enhanced efficiency and enhanced security. The special purpose machine and automatic machines are intended to operate continuously for 24 hours day, with minimum supervision.

In developing world, performing drilling and tapping operations simultaneously on same machine was bigger problem for manufacturing company, workshop holders, individual drilling and tapping machines were exist in market but they were not beneficial for workshop holders and small industrialist due to very high cost. In recent past years more stress was given on design and developing of existing machines. Due to this development drilling and tapping operations perform simultaneously on same machine. In case of drilling operation machine drill two holes at same time. Tapping and chamfering operations at same time. Due to saving of time in two operations, it's possible to increase productivity of machining system.

II. LITERATURE REVIEW

Prof. Dr. V.R.Naik[1], studies different problems that are restricting mass production rate and developed a new special purpose machine that will increase the productivity of machine as compared to the present manually operated band saw machine. Another benefit is that will reduced manufacturing cost per component.

Prof .K.K.Powar[2] states the use and importance of special purpose machine and also their benefits for industry to increase the rate of production along with reducing the machining time and increasing quality of production. Also they perform statistical process control to study the result obtained from special purpose machine and their feasibility and accuracy.

Manish Kale[3], analyses the special purpose machines for drilling, and reaming. Different types of stresses are analyzed. They use Ansys for checking stress analysis. They studied on design, fabrication and analysis of spm. Due to the reduced process time, conclusion is that the special purpose machine is beneficial for mass production.

Yogesh P. Bhalla[4] states that main aim of special purpose machine is to reduce time required to do operation and cost of machining should be less as compare to convectional drilling machine. Both parameters that are cost and machining time have significant to the productivity.

K.M.Mahanvar[5] states that concept of special purpose machine fabricated as an experimental set up can be extended to an industrial application with further modification in the design that is optimization of design process to achieve quality in machine as per the operation requirement.

Prof. D. A. Mahajan[6] found that special purpose machine is beneficial for mechanical workshop, small scale industries where drilling and riveting operations perform on the same job. This machine reduces transportation and operation time and increases the efficiency as well as accuracy of the product.

A.M. Takale[7] was focused on "Design and Manufacturing Of multispindle drilling head for its cycle time optimization."These papers deal with design and development of multispindle drilling head for cycle time optimization of the component. They have design the major components of the multispindle drilling head like main spindle gear and main spindle and calculate stress analysis. By using multispindle drilling head productivity will increases.

Hardik J. Patel[8] : focuses on review on tapping operation and its parametric study carried out by other researchers in same fields. There is scope to work on tapping operation with pneumatic application and can be perform parametric study on it. This study can be helpful for better quality of tapped hole and improvement in productivity as well as to reduce problems concerned with hand tapping and machine tool tapping which can eliminate major problem of tapping tool breakage.

P. R. Sawant[9]; works on Design and development of spm – a case study in multi drilling and tapping machine. Also discuss the case study and comparison of productivity of component using conventional radial drilling machine and spm for drilling and tapping operation.

E. D. Doyle and S. K. Dean[10] ; have designed tapping attachment to reduce the axial forces generated during the tapping operation. A device for reducing the axial force was developed and its use enables the cutting of accurate thread forms.

III. COMPONENT INFORMATION

Name: Rod Eye or Rod end
Material: Stainless Steel
Hardness: 130-275 BHN
Description: The component is a Rod end. This component use in steering knuckle and transmission linkage in automotive industry. Rod end used in applications that accommodate low to moderate shaft misalignment . They are also used in many aerospace, military and automotive applications.

A. Material composition of the rod end

Most common material is used -304 grade stainless steel
Chromium: 18%
Nickel: 8%

Fig. 1: Actual Component

Fig. 2 : Component After Machining

B. Problem identified by using conventional machine

The drilling is done by conventional drilling machine the following difficulties are going to occur.

1) Manual clamping and de-clamping of component result in excess idle time.
2) Manual radial drilling machine result in more machining time.
3) Component requires more component setting and machining time.
4) Less rate of production.
5) Need of skilled and expertise labor required.
6) More fatigue.
7) More time required for machining.
8) Less accuracy.

Hence for reducing above problems or for overcome the above problems, the special purpose machine will be manufactured. There is lot of advantage of use of a special purpose machine. Main advantage is the increase in productivity. More mass production occurs in a less time and also more accuracy getting by using of a special purpose machine.

C. Solution: Conceptual Model

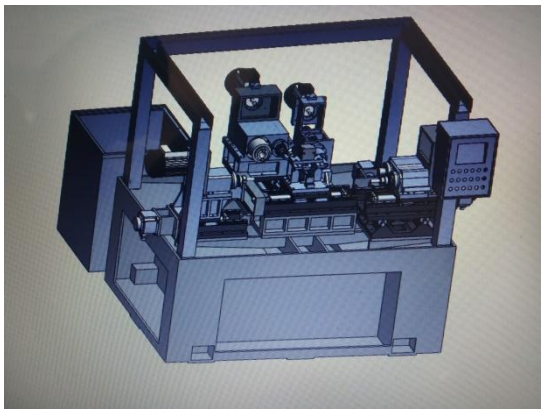

Fig. 3: Conceptual model

This is conceptual model of special purpose machine for rod end. It housed the various mechanisms as work piece carriage, gearbox, servo motors, induction motors, belts, pulleys, PLC unit, fixture, proximity sensors, coolants, hydraulic and pneumatic components, hydraulic power pack etc. Work piece carriage move to and fro on the guide way located at bottom of slide. Hydraulic clamping is used for clamping work piece rigidly to sustain the cutting force. Proximity sensors are to define distance travelled by work piece carriage.

The hydraulic system consists of hydraulic power pack which consists of reservoir tank with fluid stored in it. A FRL unit is used for proper filtration, regulation and lubrication of fluid throughout the system. The fluid is circulated through the system by a pump associated with the motor. Direction control valve is used to direct fluid flow in appropriated direction. The flow rate and pressure of fluid is controlled through the flow and pressure control valve. Actuator is used to achieve the linear motion. Coolant is continuously spread on the tool and work piece interface.

In the operations, first cross drilling is done at same time at station 1 then work piece moves to station 2 for reaming operation. After this operation, slide or work piece moves to station 3 for tapping and chamfering operation done simultaneously. When these operations are done on general purpose machine then there is more time consumes. Hence by using a special purpose machine, total manufacturing cycle time is reduced. This is the benefit of special purpose machine. In this Special purpose machines, all the operations run by PLC (Programmable Logic Controller). With the help of PLC, Rapid forward and backward movement of slider or work piece carriage is possible.It consists of two coolant tanks namely as clean tank and Dirty tank. Dirty tank has two pumps. Mixture of coolant and removed chips are collected in this dirty tank. Coolant is directly sprayed on tool and work piece interface and through another pump called as transfer pump, the coolant from dirty tank transfer to clean tank. The pump 1 supplies the coolant at pressure about 2 bar. Filtration is done in the clean tank to remove the chips from mixture of coolant and chips. The pump of this unit supplies the coolant about 25 bar. This pump supply the coolant through spindle called as CTS.

D. PLC Programmes pictures for operations:

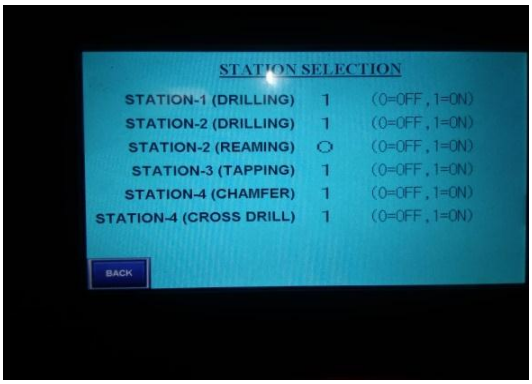

Fig. 4: For selecting a station

In the above figure '0' indicates that there is skipping of reaming operation.

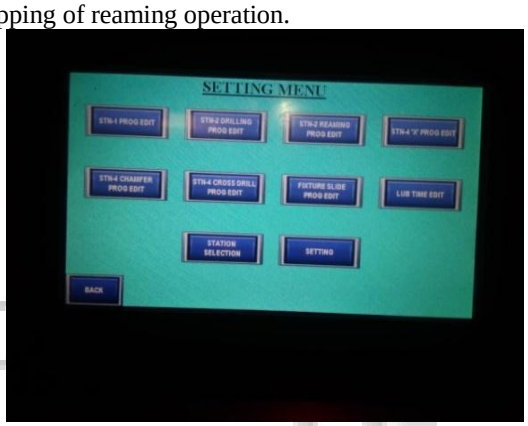

Fig. 5: Setting menu

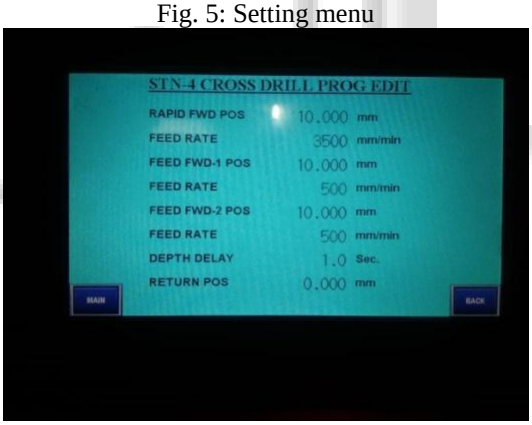

Fig. 6: Cross Drill operation

The following PLC program is done for the cross drill Operation on a special purpose machine. At a time two drilling operations are going to be done i. e (d=11.38mm and d=5.35mm).

E. Cutting Speed for Operations

From CMTI Table,

Operation	Drilling			
Diameter	5.35 mm		11.38 mm	
	Cutting speed	RPM	Cutting speed	RPM
Stainless Steel	13.5	893	13.5	420

For Reaming:

Operation	Reaming	
Stainless Steel	Cutting speed	Feed
	25 m/min	0.16 mm

For Tapping:

operation	Tapping
Stainless steel	Cutting speed
	9m/min

F. Basic calculations

– For Stainless Steel material,

Using CMTI Handbook,

V - Cutting Speed = 13.5 m/min

K – Material Factor = 1.98

S – Feed [mm] [For HSS Tool]

= 0.16

D = Diameter = 11.38 mm

Now finding motor speed,

V = ΠDN/1000

13.5*1000 = 3.14*11.38*N

N =378rpm

– For finding spindle power

P=1.25*D^2*K*N (0.056+1.5S)/10^5

=1.25*(11.38^2)*1.98*378(0.056+1.5(0.16))/10^5

=0.353 KW

Then find power of motor =0.353/0.9

=0.392 kW

(90% efficiency is considered)

Find the Torque,

Ts = 975N/n

=975*0.353/378

=8.92 Nm

Find axial thrust force,

Th = 1.16K*D*(100S) ^0.85

=1.16*1.98*11.38(100*0.16) ^0.85

=275.90 N

Now Finding a Machining time,

Drill diameter = d= 11.38mm

Feed = f = 0.16mm/revolution

Thickness = 5.6mm

Cutting Speed = V = 13.5 mm/min

V = ΠDN/1000

13.5*1000 = 3.14*11.38*N

N =378rpm

Time required for drilling a hole:

T = L/Nf = [thickness + (0.3*d)]/ fN

= [5.6 + (0.3*11.38)}/ 378*0.16

= 0.15 min

= 9 sec.

Similarly, calculated machining times for drilling (d = 5.35mm) tapping, reaming operations are as bellows:

Sr no.	Operations	Machining time
1	Drill (d = 5.35mm)	11 sec
2	tapping	12 sec
3	reaming	4 sec

Above are the only machining time calculated for operations.

Hence For calculating Total time or Cycle time, there is also addition of cut in time, cut out time, stand-by time (when operation is competed then there is stop of 1 sec of tool.).

Hence the total cycle optimize for doing all the operations is 54 sec.

IV. CONCLUSION

According to conceptual model, the special purpose machine Is to be designed and developed. This will result in increase in productivity in less time and also increase in productivity in as compared to present general purpose machine. Another advantage of this special purpose machine is to be reduced manufacturing cost per component.

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