

Design, Development and Automation of Hydraulic Broaching Machine

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ABSTRACT: This paper presents the design, modification and automation of hydraulic broaching machine by using simulation and automation tool as automation studio. In automation, Accuracy and Precision are prime requirement for each machine tool. Controller, Solenoid valves, servo control valves are crucial components of any automation. Automation studio can be used for design of automatic hydraulic machines. The automation studio tool helps to simulation, automation and design of hydraulic circuit. Automation studio supports hydraulic, digital electrical and electronic technologies. The automation tool AS 5.7 helped to increase the productivity of broaching machine and to reduce the cycle time of broaching operation. The hydraulic broaching machine circuit has modified with solenoid operated valve and Automated by proximity sensor, proximity switch, electric JIC system. This electro-hydraulic automation results into the reduction of production cycle time and increase in production by 78 jobs/day. In this way, simulation of hydraulic broaching machine on automation studio approaches proved to be in good agreement. This study also helps for working of actual hydraulic system and gives results after simulation on automation studio of hydraulic system.

KEYWORDS: Hydraulic equipment's, Simulation, Computer aided design, Automation etc.

I. INTRODUCTION

In today's fast-moving, highly competitive industrial world, a company must be flexible, cost effective and efficient if it wishes to survive. In the process and manufacturing industries, this has resulted in a great demand for industrial automation in order to streamline operations in terms of speed, reliability and product output. Automation plays an increasingly important role in the world economy and in daily experience. Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well.

Components of hydraulics:

Hydraulic reservoirs: A hydraulic system is closed, and the oil used is in a tank or reservoir to which it is returned after use and also reused by using fixed or variable pump.. The volume of fluid in a tank varies according to temperature and the state of the actuators in the system, being minimum at low temperature with all cylinders extended, and maximum at high temperature with all cylinders retracted. Normally the tank volume is set at the larger of four times the pump draw per minute or twice the external system volume.

Filters: Metal particles, Dirt in a hydraulic system causes blocking of valves, failure of seals and early wear. Even particles of dirt as small as 20/x can cause damage, 1 micron is one millionth of a meter; the naked eye is just able to resolve 40/x). Filters in the hydraulic system are used to prevent metal particles, dirt entering in the parts of the hydraulic system, and are generally specified in microns or meshes per linear inch i.e. sieve number.

Hydraulic Actuators: There are various types of actuators used in hydraulic systems, e.g. hydraulic cylinders, motors, etc. A cylinder is device which transforms fluid power into linear mechanical force and motion. It usually consists of a

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mobile element such as a piston and piston rod, plunger or ram operating within a cylinder bore. Functionally cylinders are classified as: Single acting cylinders and Double acting cylinders.

Proximity Sensor: A proximity sensors are used to detect the presence of nearby objects without any physical contact. The object being sensed is often referred to as the proximity sensor's target. A proximity sensor often emits a beam of electromagnetic radiation or an electromagnetic field, and looks for changes in the field. Different proximity sensor targets demand different sensors. For example, a capacitive photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. Proximity sensors can have a high reliability.

II. EXPERIMENTAL WORK

A) Hydraulic broaching machine



Fig.2.1 Hydraulic Broaching Machine (T-8-24, Mac No. 2229)

Size Of Machine Code Word	T- 8- 24	Broaching of Gear 95T on broaching machine
Capacity normal tons	8	8
Capacity maximum tons	11.8	11.8
Cylinder diameter	4"	4"
Broaching speed down per min.(variable)	7' - 23'	8' 85
Return speed up ft. Per min.	39'	17' 71
Maximum work dia. Pull or push down	10"	10"
Pump cap. Gals. Per min.	28	28
Operating pressure normal	670 lbs	200 lbs
Operating 10 & 950pressure max.	1000 lbs	450 lbs
Motor recommendation normal, hp& rpm	10 & 950	10 & 950
Cubage	150 lit.	150 lit.
Coolant pump cap. G.P.M.	15 G.P.M.	15 G.P.M.
Phase	3	3

Table 2.1 Specification of broaching machine.

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Fig.2.2 Broaching operation on Gear 95 T



Fig.2.3 Equipment's used to produce keyway

A) Design of existing system on automation studio

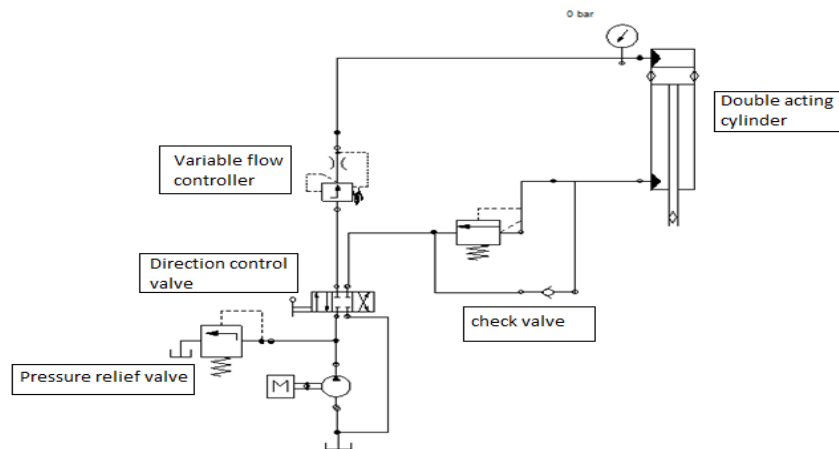


Fig.2.4 Manually operated existing system

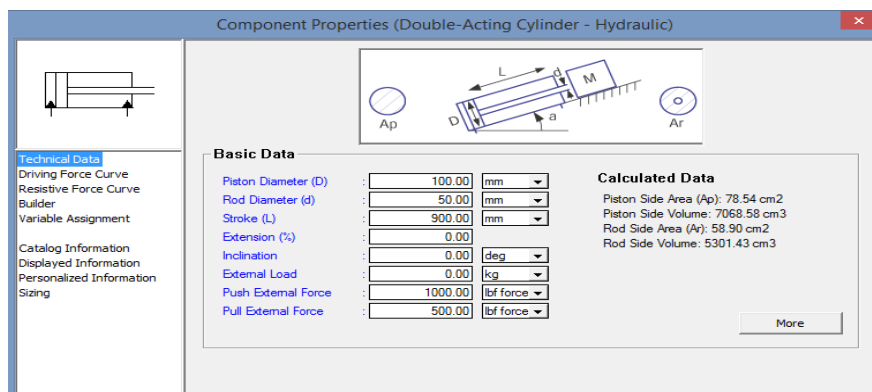


Fig.2.5 Double acting cylinder properties.

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Fig 2.4 shows the entire hydraulic system of broaching machine. This system consists of Double acting cylinder, pressure relief valve, 4/3 way direction control valve, relief valve, variable flow controller valve and check valve etc. The properties of hydraulic components are shown in Fig 2.5 and Fig 2.6 etc. These properties of particular components are designed in automation studio.

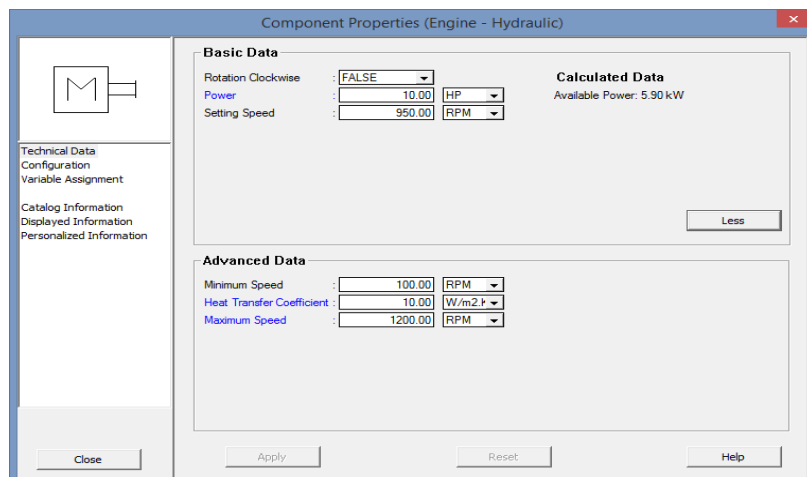


Fig.2.6 Engine properties

C) Simulation of hydraulic broaching machine

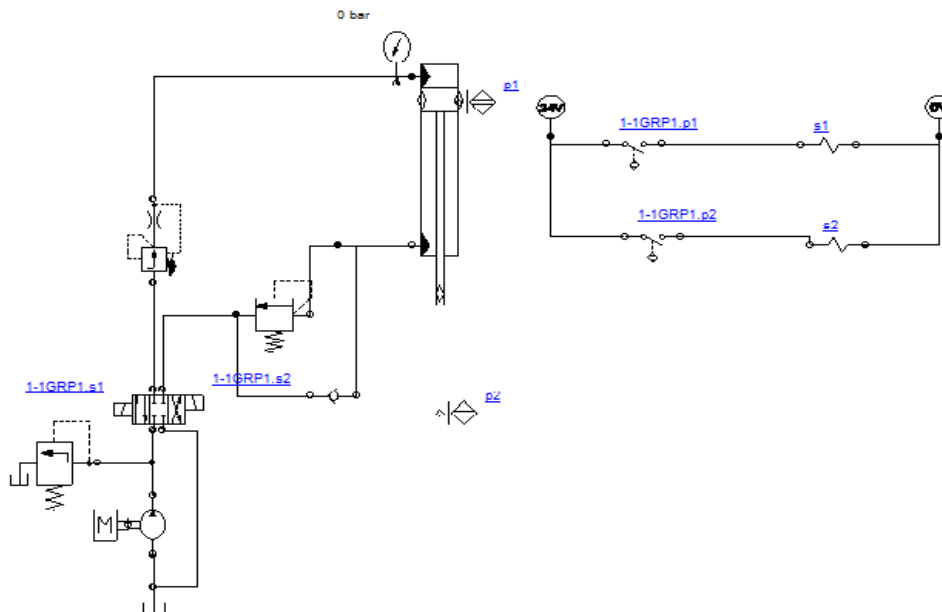


Fig.2.7 Design of electro-hydraulic circuit on AS 5.7

Design and modification of existing hydraulic circuit consists two proximity sensors p1 and p2 connected to the end of cylinder. The Automation software helps to replace 4/3 way DCV with solenoid operated 4/3 DCV. There are two normally closed proximity switches are used in the electric circuit. The electric input given as 24 volt to operate electric

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circuit. A solenoid valve is an electromechanically operated valve and controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off. There are two solenoids used as S1 and S2. The solenoid S1 operated serially with proximity switch 1-GRP1.p1 and solenoid S2 operated serially with proximity switch 1-GRP1.p2. After simulation of this hydraulic circuit, the pressure generated at piston side is 13.19 bar during forward stroke as shown in fig.2.8 and pressure generated during forward stroke is 0.78 bar as shown in fig. 2.10.

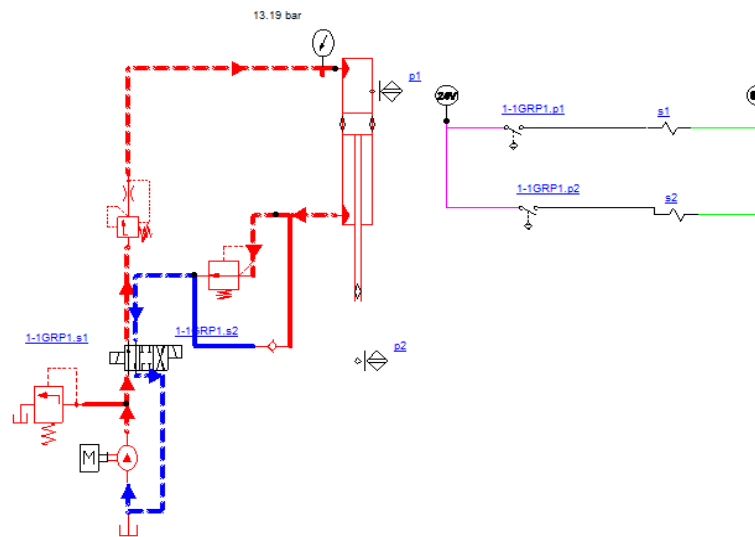


Fig.2.8 Simulation during forward stroke

and it shows the time required for tool travel is 20 seconds. In fig 2.9 Hydraulic system is under simulation mode. The hydraulic system is manually operated system. The operating pressure of broaching machine generated 13.17 bar during forward stroke shown by pressure gauge. After forward stroke the retract stroke generates minimum pressure of 0.96 bar on the system.

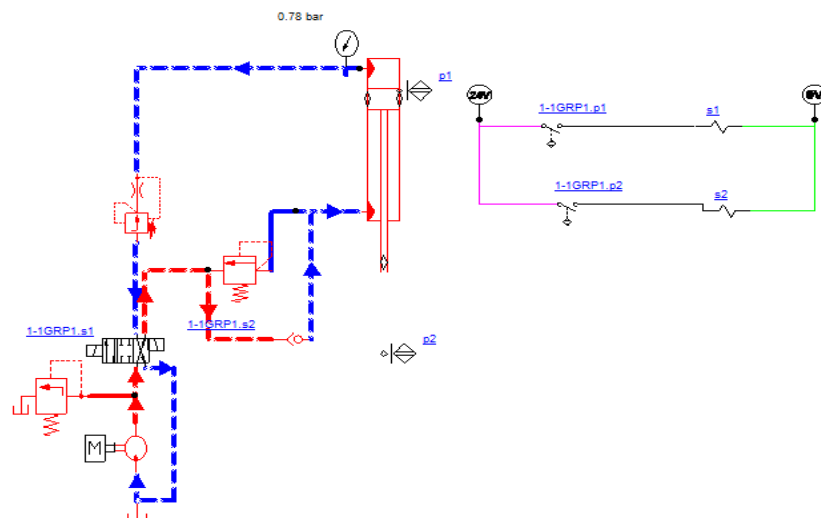


Fig.2.10 Simulation during return stroke

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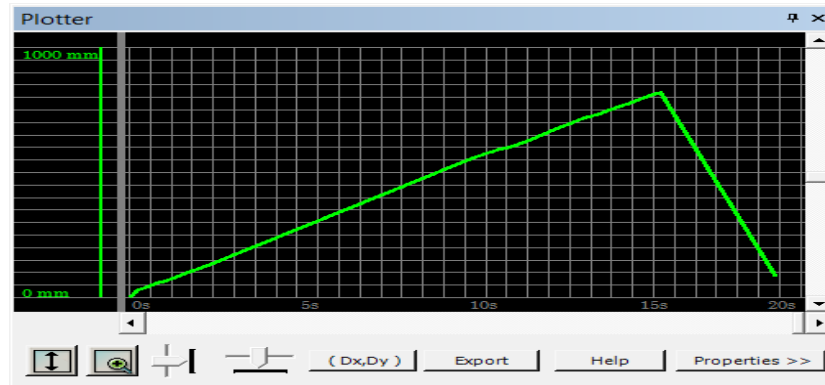


Fig.2.11 Length vs Time graph during forward stroke

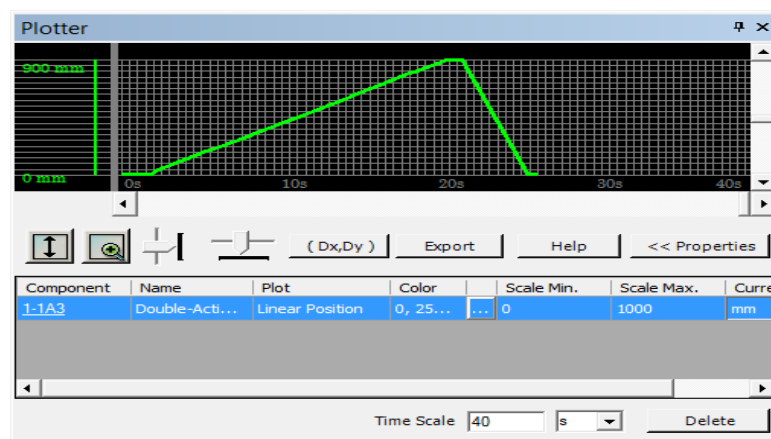


Fig.2.9 Length vs. Time graph during forward stroke

The above graph shows that, the relation between tool travel length in mm and the time required for forward stroke of tool in sec. The tool travel length has length approximately 900 mm. The graphical results drawn on AS 5.7.

III. RESULTS AND DISCUSION

A) Time calculation of existing hydraulic broach machine

Table 3.1 Readings of forward stroke and retract stroke of broach tool

Readings of broach machine	Forward stroke	Retract Stroke
Stroke length	900 mm	900 mm
Time required for forward stroke of 900 mm length	20 sec	10 sec
Linear distance covered by piston in 1 sec.	45 mm	90 mm
Linear speed of cylinder per min. (variable)	8.85 ft/min.	17.71 ft/min

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B) Time required for broaching of GEAR 95T

Table 3.2 Time required for broaching of GEAR 95T

Readings taken during broaching of GEAR 95T	Time
Time required for broaching operation of 900 mm length	20 sec.
Loading and Unloading of tool	30 sec.
Broaching tool finishing time	10 sec.
Total time used for single pass	1 min.
Number of operations required to produce single keyway	3
Time required to produce complete keyway	3 min.

Total production per day = 155 jobs per day.

Total production per month = 4030 jobs per month.

C) Readings taken during forward stroke and retract stroke of length 700 mm due to proximity sensor

Table 3.3 Calculation for forward stroke and retract stroke

Readings by using proximity sensor	Forward stroke	Retract stroke
Stroke length due to proximity sensor	700 mm	700 mm
Time required for forward stroke of 700 mm	15.55 sec	7.77 sec
Linear distance covered by piston in 1 sec.	45 mm	90 mm
Linear speed of cylinder per min. (variable)	8.85 ft/min.	17.71 ft/min

D) Time required to produce keyway of GEAR 95T by setting stroke length using proximity sensor

Table 3.4 Time required to produce keyway of GEAR 95T

Time required for broach tool travel of length 700 mm in single pass (proximity sensor used to set the stroke length)	15.55 sec.
Loading and Unloading of tool (time reduced due to tool holder)	15 sec.
Broaching tool finishing time	8 sec.
Total time used for single pass	38.55 sec.
Number of passes required to produce complete keyway	3
Time required to produce complete keyway	2 min.

Total production = 233 jobs /day

a) Cost of production of hydraulic broaching machine:

- Cost of broaching of one keyway on hydraulic broaching machine = Rs.7.50.
- Production cost or broaching cost on hydraulic broaching machine/day = (No of jobs produced) × (cost of unit product required for broaching operation)
=Rs.1162.50-/day.

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- Production cost or broaching cost on hydraulic broaching machine/month = Rs.30, 225 /month.
- b) Cost of production of hydraulic broaching machine after simulation:
 - Production cost or broaching cost on hydraulic broaching machine/day =(No of jobs produced) ×(cost of unit product required for broaching operation)

= Rs.1747.50-/day.

- Production cost or broaching cost on hydraulic broaching machine per month = Rs.45435- /month.
- Daily increased production = (Final production/day) - (Initial production/day)

Daily increased production = 78 jobs / day

- c) Profit/day = (Increased production/day) × (cost of unit product required for broaching operation)
= 585 Rs.

Profit/month = (Increased production/month) × (cost of unit product required for broaching operation)
= 15,210 Rs.

IV. CONCLUSION

The main results of this experimental study can be summarized to following points.

- a) Developed new correlation for simulation of hydraulic circuit with better accurate performances with wide range of experimental database.
- b) The simulation is performed on Automation Studio of version 5.7. The cycle time of operation can be reduced with modification of components like solenoid operated direction control valve, proximity sensor, proximity sensor etc. The time can be plotted by using automation plotter to represent the cycle time of operation to produce keyway.
- c) The results obtained by design of tool holder and automation are more effective than manual operation and also reduce the work force in the industry.
- d) Time to produce single keyway with manual operation is 3 min which is reduced up to 2 min by simulating the hydraulic circuit. This results in increase in production 78 jobs per day and Profit Rs.15210/- per month.

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