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HYDRAULIC CLAMPING FOR MAXPRO H650 IN BHARAT FRITZ WERNER CNC MACHINE

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Abstract

Clamping is the important step to be done before the machining operation. Clamping helps the job to be in position during machining process. In manual clamping system, there is a difficulty involved for operator to clamp the job. It is necessary to get a desired torque while clamping and it's purely dependent on the operator. If desired torque is not achieved it will results in rejection of the component. There is a need to provide a comfortable, safe and effortless means for the operator to get the job fixed. This project demonstrates an effective approach towards better clamping system. This system performs relatively well at both heavy and light work job, offering effortless and accurate job mounting. Thereby introducing this job rejection and non-uniformity of torque during clamping operation is eliminated. This approach is a major advancement over the manual clamping system thereby reducing the operator fatigue and improves the productivity.

Keywords: Hydraulic clamping, MAXPRO H650, Automatic mounting

1. INTRODUCTION

This project is an advanced method of clamping or declamping the job i.e. the differential carrier. The evolution of the CNC machines makes the operator to work safer and efficiently. The hydraulic clamping is designed as the future of clamping or declamping the job to the machine.

Generally, the operator who works in the machine has to clamp and de-clamp the job which is tedious. This happens when he works in manual clamping machine. Whenever the operator wants to mount the job in to the machine, with the help of electric lifter he will keep the job on to the machine and slides the strap clamps to the desired position. With the help of ring end spanner he will screw/unscrew four M24 bolts to the desired torque. Due to this loading effect, on every job

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the operator wants to screw/unscrew 4 times. This action brings adverse effect to the arms of the operator and his safety and it is time consuming. To reduce the operator's effort and increase the safety and production output this project is evolved.

In this present project, HYDRAULIC CLAMPING FOR MAXPRO H650 in Bharat Fritz Werner machine, the effort to the operator is minimized by introducing clamping cylinder along with the clamps. Here the hydraulic system monitors whether the job is clamped or declamped. This system also checks whether there is sufficient operating fluid pressure in the fluid lines. If it is so, the pressure from hydraulic lines will go through solenoid operated direction control valves thereby activating the clamping cylinders and thus clamps the job to the machine. By introduction of hydraulic clamping improves the working ability and safety of the operator. The machining centre here is named as **MAXPRO H650**.

2. Computer Numerical Control

CNC is the automation of machine tools through computers executing pre-programmed sequences of commands which controls machine. In modern CNC systems, end-to-end component design is highly automated using CAD/CAM programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools-drills, saws, etc.-modern machines often combine multiple tools into a single "cell". In other cases, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the complex series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD design.

3. Machine Construction

This project mainly aims at implementing the hydraulic clamps and to compare the performance with the manual clamping. The machine used for this particular project consist of following parts,

3.1 Main Machine

It is the major part of operating system to which hydraulic clamps are going to be implemented. This main machine is composed of following parts

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3.1.1 Machine Bed

This is a sturdy steel fabricated structure, which stress is relieved to maintain the machine accuracy for years. This supports all the three axes drives and the spindle and has been designed keeping in mind the efficient disposal of the chips and collection of lubrication oil from various machine elements like axes drives, LM guides etc. this is supported on anti vibration pads for avoiding disturbances of the machine accuracy due to both active and passive vibration.

3.1.2 Cross slide

This structure is made of Spheroid graphite (SG) iron box type casting for high rigidity and is stress relieved. This unit moves on the LM guides mounted on the main bed and is driven by a servo motor through a high accuracy ball screw (Φ50) constituting the X-axis of the machine. The ball screws are mounted on precision angular contact bearing, which are lubricated for life and are coupled to the servo motor using flexible coupling. The ball nut is oil lubricated. The position sensing is done through the absolute encoder built in to the servomotor and the travel limits are constrained in three stages using limit switches, software limits and mechanical stoppers.

3.1.3 Vertical column

This structure is also a SG iron box type casting and is stress relieved. This moves on the LM guides mounted on the cross slides is driven by servomotor through a high accuracy ball screw (Φ50) constituting the Z-axis of the machine. The ball screws are mounted on precision angular contact bearing, which are lubricated for life and are coupled to the servomotor using flexible coupling. The ball nut is oil lubricated. The position sensing is done through the absolute encoder built in to the servomotor and the travel limits are constrained in three stages using limit switches, software limits and mechanical stoppers. This structure carries the hydraulic counter balancing arrangement for the vertical slides.

3.1.4 Vertical slides

This is a rigid box type stress relieved cast iron structure. This moves on the LM guides mounted on the vertical column and is driven by a servomotor through a high accuracy ball screw (Φ50) constituting the Y-axis of the machine. The ball screws are mounted on precision angular contact bearing, which are lubricated for life and are coupled to the servomotor using flexible coupling. The ball nut is oil lubricated. This arise the spindle cartridge and the spindle drive arrangement. The position sensing is done through the absolute encoder built in to the protected from dirt and coolant by labyrinth seals and air curtain. The tool clamping is done using disc springs and collect

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arrangement and the de-clamping is done by hydraulic from the de-clamp force. The spindle cartridge also houses the coolant nozzles, which can be manually set to direct the coolant to any desired location. The spindle feedback is through an encoder driven through a flexible coupling. The spindle drive powered by a servomotor through a two-speed ZF (1:1 & 1:4) gearbox. This reduction is achieved by helical planetary gear arrangement for compactness and low noise and gearbox is capable of changing the gears in less than two seconds. On the bottom side of the front flange of the spindle cartridge, a hole is provided for coolant drain. If this drain hole is blocked by any dirt or chip particles, coolant may enter & damage the spindle bearings.

3.1.5 Index table

This forms the B axis of the machine and the housing is made of high-grade cast iron and is designed for high rigidity during the machining. This can index the job by 1° or $1/2^{o}$ with a positioning accuracy of ± 3 sec. a servomotor with built-in encoder drives this unit through a reduction unit. The index table carries a pallet of 630*630 or 630*800 size and can handle a job weight of 800 kgs. The pallet clamping / de-clamping is done hydraulically using pull stud / collect arrangement. The indexing accuracy is given by a high precision hirth coupling. A low-pressure air curtain protects the coupling area and the cone seating area. The cone seating area will have a high-pressure air blast at the time of pallet lifting.

3.2 Automatic pallet changer

The pallet changer exchanges the pallet on the index table with finished component and the pallet on the stocker table containing new job. Two independent hydraulic cylinders obtain pallet change motion.

On the pallet stocker table, the pallet can be rotated and clamped at any 90° angle for manual clamping of the fixture. The location of the pallet is by a pneumatic cylinder actuated by a manually operated direction control valve.

3.3 Automatic tool changer

The ATC has a double gripper arrangement for tool holding and a pneumatic cylinder actuated cam locks the tool while indexing. The arm indexing and arm in / out is achieved using hydraulic

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cylinders. The ATC has a provision for slow / fast tool change depending upon the tool weight. The ATC has a servomotor driven ball screw for linear motion (U-axis).

3.4 Tool magazine

The machine has an option of 40 or 60 tools magazine. The tool magazine consists of a chain with tool pots as hinge pin. The tools are held in the tool pot with two spring-loaded balls and are retained positively with a spring-loaded cam. The cam is activated by a pneumatic cylinder, which releases the tool for auto tool change or for manual tool loading. This tool pot arrangement protects the tool taper from dust and chips. A servo driven (through a worm gear-box) sprocket is driving this chain and an encoder achieves the positioning (V-axis). The tensioning is achieved by a floating free-wheel arrangement.

3.5 CNC system and electrical cabinet

A FANUC Oi-M controller controls the machine. The controller and the electrical cabinet are mounted on the rear-right corner of the machine. An operator panel consisting of display panel and controls is provided on the right hand side of the machine. Emergency buttons are provided at various places to stop the machine during an emergency.

3.6 Coolant system with chip conveyor

The machine is provided with a scraper type chip conveyor with coolant tank of sufficient coolant capacity. The coolant system has Hydro cyclone as pre-filter with Duplex Bag type filter which acts as final filter with 25 microns of filtration level. Refer supplier's instruction manuals for the coolant system details.

3.7 Pneumatic, hydraulic & Lubrication system

The pneumatic system needs 600 lpm pure dry air, and it requires air compressed to 6bar as input and is used for spindle taper cleaning, tool de-clamp on tool magazine, and tool locking on ATC

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etc. The compressed air is connected to the filter regulator which regulates the output to the machine always as a pressure of 6 bars even though the input pressure is higher. It also has a reusable sintered bronze filter of 50µ filtration level and air pressure gauge. The output of the unit is fed to different units through solenoids operated direction control valves and flow control valves. The air purging for linear scale is equipped with an air drier with class l filtration system for pure dry (-40 dew point) air. The desiccate in the air drier unit has to be replaced when the pink coloured desiccate become pale white. Hydraulic system is powered by a 40lpm, 63bar power pack and is used for spindle tool de-clamping. Pallet clamping, ATC & pallet changer operation etc. the centralized lubrication system is of CENLUB make. This system is used to lubricate the axis drive ball nut and LM rails.

3.8 Guards

The machine is provided with a safety guard, which has been designed keeping in view the maintenance with easily removable panels for easy approach and leak proofing of the machine. Guards are the mounting which enables the operator to view the operations taking place inside the machine without coming in contact with chips formed during machining or coolant. It acts as shield between operator and the working centre.

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4. Technical Specification of MAXPRO H650

Table 4.1: Specification of MAXPRO H650 BFW CNC Machine

Particulars	**Units**	
Spindle		
Spindle taper		BT 50
Power (100% / 50% ED)	kW	18.5/22
Speed	Rpm	45-6000
Traverse		
Table (X-axis)	mm	900
Spindle (Y-axis)	Mm	630
Column (Z-axis)	Mm	630
Spindle nose to table centre	Mm	830 max, 200 min
Spindle centre to table top	Mm	780 max, 150 min
Axes drives		
Feed rate	mm/min	1-15000
Rapid traverse	m/min	24
Index table		
Pallet size	Mm	630 × 630(T slots)
Load capacity	Kg	800
Index positions	Deg	360 × 1°
Index accuracy/repeatability	Sec	±3
Pallet change time	Sec	16
Automatic tool changer		
Max tool diameter	Mm	125
Max tool diameter with adjacent pockets empty	Mm	315
Max tool length	Mm	450
Max tool weight	Kg	20(30)
No. of tools		40
Tool change time		
Tool to tool	Sec	6(9.5)
Chip to chip	Sec	12(15.5)
Accuracies-as per JIS		
Positioning	μm	±5
Repeatability	μm	±3
System installation data		FUNAC OiM
Basic weight of machine	Kg	17000
Space (L × W × H)	mm × mm × mm	7200 × 5700 × 3800
Total connected load	Kva	50
Pneumatic supply	bar/lpm	5/600
Power supply		3ph, 415V ±10%, 50HZ ±2%

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5. HYDRAULICS

Hydraulics is a technology using the principles of engineering, chemistry, and other sciences involving the use of liquids. Fluid mechanics provides the theoretical base for hydraulics. Basically, Hydraulic machines are defined as those machines which converts either hydraulic energy into mechanical energy and vice versa.

6. Hydraulic System

It is drive or transmitting system which uses high pressurised fluids for its operations and, consequently the piping must act as a closed loop, with fluid transferred from storage tank to one side of the piston, and returned from the other side of the piston to the tank. *

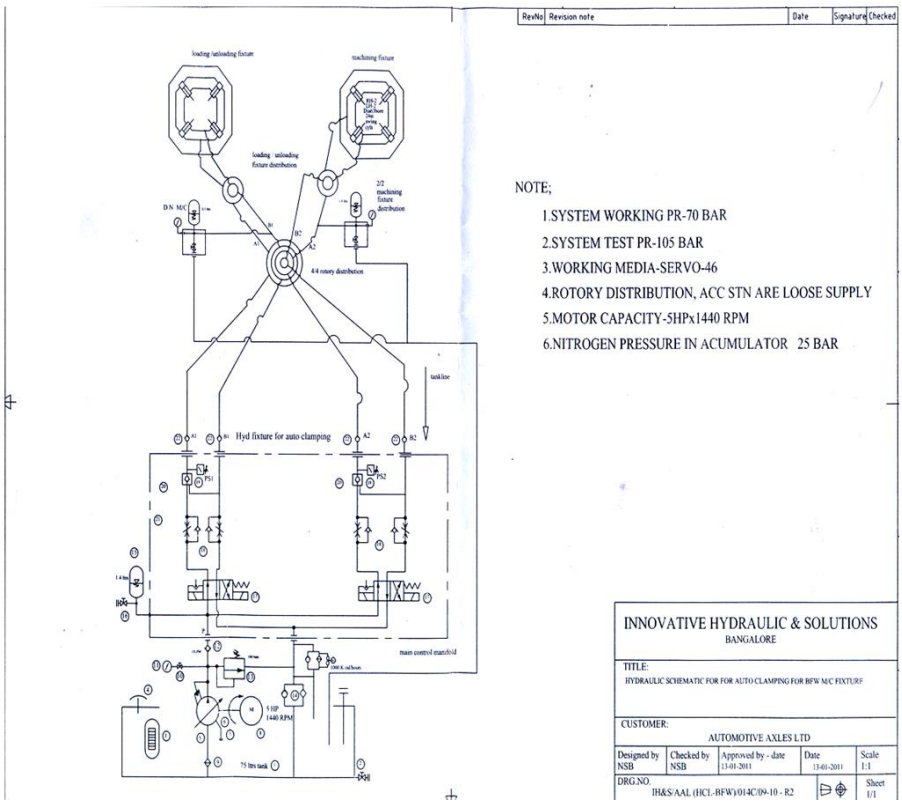

Fig 6.1: Layout of Hydraulic system for MAXPRO H650

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7. Hydraulic power pack

Hydraulic power packs integrate all the required elements to supply a flow of hydraulic fluid under pressure to the system or directly to the actuators. The hydraulic power pack output pressure is set to 63 bars and flow of 40 lpm. It has a variable displacement vane pump with built in pressure control valve, powered by a 7.5HP AC motor. It also has a 100µ strainer, return line filter of 25µ filtration level and a pressure line filter of 10µ and an oil chillers (6000kcal/hr) for dissipating the heat generated. A 1-litre accumulator has been provided to maintain the line pressure. A pressure gauge with gauge isolator is provided to verify the output pressure. Pressure and flow required for different operations is varied by suitable pressure reducing valves and flow control valves. To confirm the pressure at critical points modular type of pressure switches are used.

8. Hydraulic counter balance

This consists of a BOSCH make bladder type accumulator of 10-litre capacity charged with nitrogen gas. This is connected to the vertical slide counter balancing cylinder (Ø50). A pressure gauge through a gauge isolator is provided for checking the set pressure. The leakage of oil from the cylinder is collected in a collection tank, which has to be emptied as and when it gets filled up.

9. Hydraulic Clamping

Clamping is a means of attaching the work piece component to the machine fixture securely so that it will be constrained to motion when the machining process is carried out. Hydraulic clamping involves the use of hydraulics to fix the job into the machining centre of CNC machine.

9.1 Need for hydraulic clamping

- Considering the fatigue factor of the operator hydraulic clamping will reduce to some extent.
- To provide uniform tightening torque at each clamping point on the job.
- To reduce the time carried by the operator for sliding of four strap clamps and screw/unscrew the M24 bolts for clamping/declamping.
- One operator can work in two machines with less time

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Fig 9.1: Job Mounting through Hydraulic Clamping

10. Working principle

The hydraulic system consists of a hydraulic power pack which caters all the hydraulic function of the machine. One of the hydraulic lines taken from the power pack will helps the functioning of hydraulic clamping mechanism. The hydraulic power pack consists of a hydraulic tank which is having a capacity of 200 ltrs. The fluid temperature range in the system should be in the range of 10-60deg C. Hydraulic power pack consists of a hydraulic pump of vane type with 40LPM @ 63 bar is coupled to a 7.5 HP 415v 3Ph 50Hz 1440 induction motor which together will pump the fluid.

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The hydraulic clamping consists of the following main parts such as a Direction control solenoid valve, Pressure switches, Clamping/declamping cylinders, Clamps, Check valve and Gauges.

Direction control solenoid valve is for controlling the flow of fluid for the movement of piston in the clamping cylinder according to the required condition that is clamping or declamping.

Variable pressure switches that are used in the hydraulic circuit are for the confirmation of hydraulic clamping/declamping for the work set pressure.

Pressure switches are used to set the variable pressure and to get necessary feed back to the PLC. The clamping pressure switch is set for max. of 60 bars and a min. of 50 bars. If there is a drop in set values and after clamping and declamping and the pressure generated is not sufficient enough the system will shows a warning and stops.

Whenever the operator wants to clamp or de-clamp the job the operator will push a button which is in the control panel. When the button gets operated it will actuate the solenoid in the solenoid direction control valve. The piston inside the direction control valve will move to the desired position whether the clamping or declamping has to be done. The fluid will goes to the clamping cylinder and it will activate the cylinder which will clamp or de-clamp the job. The pressure switches which are attached to the hydraulic line will act as a safety device. If the working conditions are normal the clamping cylinder will put the clamps in desired position.

The clamping torque acting will be uniform throughout. The clamping force acting on the different cylinders are calculated.

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11. Calculations

11.1 To calculate clamping force of the cylinder under different pressure

Diameter of rod, d= ϕ35mm
Diameter of piston, D = ϕ63mm

1. Effective area = $\frac{\Pi (D^2 - d^2)}{4}$ (1)

$= \frac{\Pi (63^2 - 35^2)}{4}$

Effective area = 2155.132mm^2

2. Pressure = Load/area

Load = pressure * area (2)

1bar = 105 $\frac{N}{m}$ 1kg-f = 9.81N

- When pressure at 60 bar

Load=

$\text{Load} = (60 \times 105 \times 2.1555 \times 10^{-3} \times 9.81)$

L= 1317kgf-m

- When pressure at 80 bar

Load= $(80 \times 105 \times 2.1555 \times 10^{-3} \times 9.81)$

L= 1757.4kgf-m

- When pressure at 100 bar

Load= $(100 \times 105 \times 2.1555 \times 10^{-3} \times 9.81)$

L= 2196kgf-m

- When pressure at 120 bar

Load=$(120 \times 105 \times 2.1555 \times 10^{-3} \times 9.81)$

L= 2636kgf-m

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3. Torque used to tightening M24 screw is 120 N-m

For M24 max tightening torque is 32.8kgf-m which is having a load carrying Capacity of,
Static load = 7060 kg-f
Varying load = 4750 kg-f
For 32.8kgf-m = 4750 kg-f
(120 N-m) 12.232kgf-m = $\frac{12.232 \times 4750}{32.8}$ = 1771 kg-f

12. CONCLUSION

After the innovation of hydraulic technology, it has totally changed the face of machines. Hydraulics makes the machine to work efficiently with less error for both man and the machine and operator morale. Hydraulic clamping has many advantages over manual clamping. Most of work involved in the machine has greatly reduced. It also reduces the time involved to finish a job. With this innovation he can be also assigned for multi machine manning.

Most important factor that affects the operator is the safety and the operating condition. By implementing hydraulic clamping, the operator is more secure against the fatigue thereby his personal safety. The operator will get a good operating condition and it helps in the improvement of production output and at the same time the job rejection will be less in this case.

In the present study of CNC, there are 7 horizontal boring machines and 7 operators, which mean one operator per machine. By implementing hydraulic clamping for the 7 machines, we can reduce 7 operators to 3 operators for 7 machines. There by multi manning can be applied.

Another improvement in this mechanism is the ease of clamping and the job stability. This reduces the errors caused during machining and hence the machining will be précised.

Thus, the CNC machines with Hydraulic clamping are far better than any other clamping.

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