

Design and analysis of hydraulic fixture for VMC

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Abstract: - Fixtures are very important for manufacturing processes. They locate workpiece with accuracy and precision during manufacturing operations such a way that the part can be manufactured according to design specification Thus they have direct effect on product quality, production cost and overall productivity. This paper represents design and development of hydraulic fixture for industrial manufacturing. The part to be manufactured is clutch housing. In previous time manual fixtures are used for holding workpiece which is time consuming and gives non precise positioning of workpiece because operations are performed manually, Here aim is to replace the existing design with new hydraulic operated design to reduce the required setup time. This design uses hydraulic vertical swing clamp for holding the workpiece driven by hydraulic power pack.

Index terms:-Setup time, Accuracy, positioning, Quality, VMC (Vertical Machining Centre)

Objective: - Our main objective is to increase rate of production that directly increases profit for organization. We focused on various factors that increases productivity i.e. cycle time, sequence of operation, quality, rate of rejection, machine operation, labor etc...

From above given factors we focused on reducing cycle time by designing a new fixture that will actually reduce 60% of loading and unloading(Setup) time in each individual cycle.

This time adds up with further production and at the end of shift we can produce more number of parts in same time compare to before.

One of the major factors is quality which can be affected due to human interruption using hydraulic fixture due to automation human error can be eliminated.

Introduction: - Fixtures plays an important role while machining operations they precisely place the workpiece and constraint the motion and vibration of workpiece. Now in order to get precise work and reduce the setup time and eliminate manual loading efforts Hydraulic fixtures are used in industries vastly. Here we focus on design of hydraulic fixture, the fixture comprises of vertical swing clamp operated using hydraulic pressure which locate the workpiece in a way that clamp will not interfere with the machining operation that are performed by VMC. Function of hydraulic fixture is to apply clamping force on workpiece in a way that it resist all the external forces generated while machining . Proper design is necessary to achieve high precision and accuracy in work and high quality product.

VMC provide work at cheaper rate compare to HMC and other machines so it is economical to use VMC for performing maximum operations. Our goal is to change the manual fixture with hydraulic one to save time without compromising with quality of product. Cast product is placed on fixture and after clamping various operations is performed to achieve final product. Engine side and then transmission side both the sides are machined one by one for achieving final product. In new design mechanical clamps are replaced with hydraulic swing clamps.

Problem identification: - To design & develop hydraulic fixture for machining Clutch housings, Gear box housing, break drum, Motor housing on Vertical Machining center. The operations to be performed are rough & finish milling of flange, drilling, reaming & spot facing. The main problem in such operation is high rejection with low productivity due to manually operated fixture. It is cumbersome process for the workers because present method of machining makes use of Nut-bolts and clamps only which required long processing time. Maximum time of worker is used for setting of work piece on the fixture. Also accuracy is not so precise.

The main task for it is to make the loading and unloading process simple, the time required should be minimized and operation should be easier one. By observing industrial problem and studying previous process there is need of designing new fixture to increase the productivity and reduce the rejection rate with the loading and unloading process simple.

Proposed solution: - After replacing the manual model with hydraulic design the process become more fast and easy. As hydraulic pressure is applied on workpiece it get more stable during machining operation. The number of jobs manufactured in a shift is increased because it saves a lot setup time. It almost saves 60 % of setup time required for each.

Fixture Design:-



New hydraulic fixture design



Old manually operated design

The design of hydraulic fixture is generated on solidworks software made of made of cast stainless steel having properties.

Elastic modulus:	1.9e+011 N/m²
Poisson's ratio:	0.26
Mass density:	7700 kg/m³
Shear modulus:	7.9e+010 N/m²
Thermal expansion coefficient	1.5e-005 /Kelvin

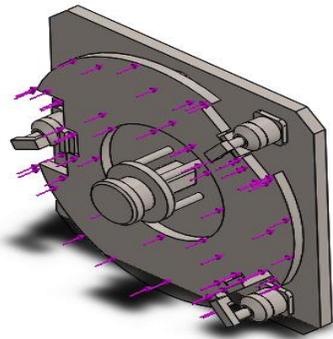
During operations intense forces are generated and upper plate has to withstand all the forces while machining.

The forces generated during operation and clamping force required are:

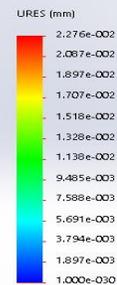
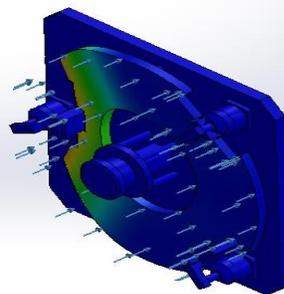
$$P = 8 \text{ bar} = 8 * 10^5 \text{ Pascal} = 0.8 \text{ Mpa}$$

$$A = 30 \text{ mm} * 27 \text{ mm} = 810 \text{ mm}^2$$

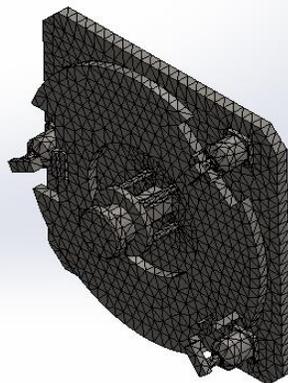
$$\begin{aligned} F &= P * A = 0.8 * 810 \\ &= 648 \text{ N} \\ &= 0.648 \text{ KN} \end{aligned}$$

Fixture analysis:-

Model name: Final.SLD.PRT2
 Study name: Static 2(-Default-)
 Plot type: Static displacement Displacement1
 Deformation scale: 2694.59



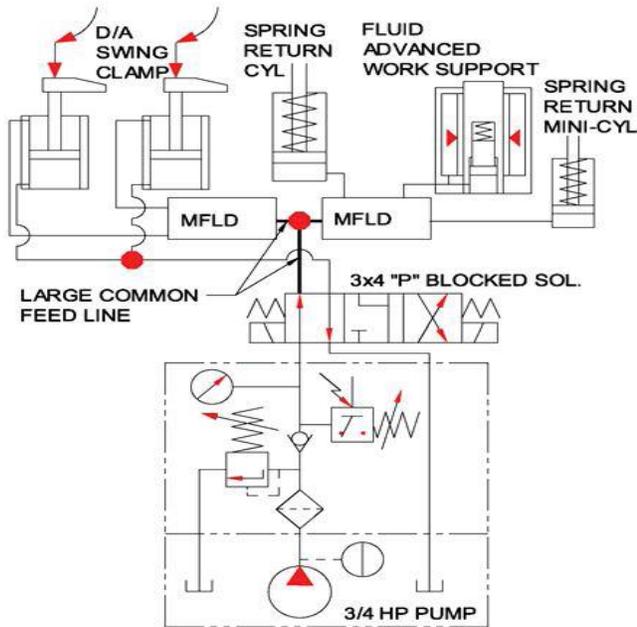
Model name: Final.SLD.PRT2
 Study name: Static 2(-Default-)
 Mesh type: Solid Mesh



Hydraulic Circuit diagram:-A hydraulic circuit diagram contains an interconnected set of various components that transport hydraulic fluid. Circuit provide route to hydraulic fluid in proper manner and require forces are achieved and this power is used to achieve specific function resulting in work.

Before designing hydraulic circuit following must be considered

- The type of hydraulic actuator used.
- The operating pressure required
- Time required for setup
- Type of control required



The circuit contain following components

1. Active component:- Hydraulic power pack
2. Transmission lines:- Hydraulic pipes
3. Passive components:-Hydraulic cylinders

Sequence of operation in manufacturing a part is as below

- **VMC**
 1. Transmission Side
 - Surface finishing
 - Drill $\text{\O} 12.5 \text{ mm}$
 - Reaming
 - Boring
 - Drill $\text{\O} 15 \text{ mm}$
 - Drill $\text{\O} 8.5 \text{ mm}$
 - Chamfer ($1 \times 45^\circ$)
 - Reaming $\text{\O} 16.13 \text{ mm}$ Tapping $M10 \times 1.5$
 - Groove 0.5 mm
 2. Engine side
 - Finishing
 - Rough rim ($449 \pm 0.2 \text{ mm}$)
 - Drilling ($\text{\O} 11 \pm 0.2 \text{ mm}$)
 - Drilling $\text{\O} 6.6 \text{ mm}$ d 14 mm
 - Chamfer $1 \times 45^\circ$
 - Tapping $M8 \times 1.25 \text{ mm}$



Time require for performing all the operations in VMC are given and compared with standards.

$$\begin{aligned} \text{Standard cycle time} &= \text{setup time} + \text{operation time} \\ &= 19 \text{ min} + 4 \text{ min} \\ &= 23 \text{ min} \end{aligned}$$

Standard cycle time = 1380 sec

- **Using manual fixture**

$$\text{Total cycle time} = \text{setup time} + \text{operation time}$$

$$= 30\text{min } 15\text{sec} + 5\text{min } 35\text{sec}$$

$$= 35\text{min } 50\text{sec}$$

$$\text{Total cycle time} = 2150 \text{ sec}$$

$$\text{Work efficiency using manual model} = 1380/2150$$

$$= 64.18 \%$$

Work efficiency using manual model = 64.18 %

➤ **Using hydraulic fixture**

Total cycle time = setup time + operation time

$$= 30\text{min } 15\text{sec} + 1\text{min } 15 \text{ sec}$$

$$= 31\text{min } 10\text{sec}$$

$$\text{Total cycle time} = 1870\text{sec}$$

$$\text{Work efficiency using hydraulic fixture} = 1380/1870$$

$$= 74 \%$$

Work efficiency using hydraulic fixture = 74%

Result and Discussion:-Results of using hydraulic fixture instead of manual fixture is shown in table given below.

Results:-

NO..	Parameter	Manual fixture	Hydraulic fixture	Standard time
1	Loading/unloading time	5min 35 sec	1 min	4 min
2	Cycle time/job	35min50 sec	31min10sec	23min
3	Jobs/shift	12 jobs	15 jobs	18 jobs
4	Productivity	64.18%	73%	-----

Discussion:-Using hydraulic model almost all the drawbacks of manual model can be eliminated. The drawbacks such as more setup time, High rejection, More manpower, Extra forces on part are eliminated upto certain extent. The maximum effect is on setup time required more the setup time less the productivity, Here we have reduce the setup time from 5min 35 sec to 1min that directly increases the productivity for organization. Jobs manufactured per shift increases from 12jobs/shift to 15 jobs/shift that leads to higher production rate.

Another important aspect is Rate of rejection due to extra forces generated using manual operation. Our new model is provided with position sensors as well as position time sensors that ensure that part is gripped not so tight and not so loose and applies only required gripping force which reduces damage of parts and improve product quality.

Conclusion: - Implementation of this project eliminates the need of human operator for clamping of clutch housing. It reduces the setup time and increase the rate of production achieved per shift. It gives economically feasible design and also ensures accurate and efficient clamping of parts. The model helps in achieving precise, reliable, safe as well as accurate production method. this model is designed in such a way that it can withstand huge retention forces applied during machining operation. Using manual fixture is insufficient for industries hence hydraulic fixture is good option to increase the production.

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