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Design of Hydraulic Power pack for SPM (Multi Spindle Drilling)

KEYWORDS: Multi spindle drill, hydraulic power pack

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ABSTRACT *Advance factory made CNC drilling may fulfill the requirement of industry, but it is not feasible on small scale industry as the installation , cost is much higher. The alternative solution is to install a SPM(Special purpose machine) with required dimensional accuracy and degree of precision with semi or fully automation to overcome this problem.*

1. INTRODUCTION

Now a day's many drilling machine are available for drilling purpose, but that it will not full fill some particular criteria for some kind of special operation which is essential in mass production. Here going to solve problem of one particular industry which face difficulty in large amount of drilling operation (approx 12,000 drill per day) with minimum cycle time.

Problems occurring in current machining method (manual drilling) at industry

- Less Productivity
- Time Consuming
- Costly
- More laborious

For the solution of that manual or convectional drilling machines will modified and equip with PLC controller.

II. BASIC DESCRIPTION

Table 1 Sample calculation to save non productive time

Parameters	In Conventional	In SPM
Loading/Unloading	time =10 sec/piece	5 sec/piece (At a time 2 piece)
Indexing time	2 sec/piece	-
Machining time	45 sec/piece	45sec/2 piece
Total time	57 sec/piece	50 sec/2piece
Total time for 2400 pieces/day	8 hours	3.33 hours

III. REQUIREMENTS OF INDUSTRY

Raw material of Job	:	MS
Tooling material	:	HSS
No. of holes	:	5
Diameter of holes	:	11.5 mm
PCD	:	120 mm
Inner Radius of circular Job	:	90 mm
Outer Radius of circular Job	:	145 mm
Thickness of Job	:	18 mm
Approximate production	:	2400 pieces/day

Figure 1 Initial Job

Figure 2 Final Job

As shown in fig.1 initial job is blank and it need 5 drill at a time on its periphery so after the finish all operation it looks like in fig 2.

IV. FEASIBLE SOLUTION OF PROBLEM

As suggested two solutions for the problem, according to

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

that, SPM is the feasible and optimal solution for the requirements of industry.

V. BASIC DESIGN OF SPM

To design a power pack for this SPM we must go through particular machine design through the calculation of parameters regarding to drilling operation, calculation for dead weight of machine which lifted by hydraulic power, calculation for require clamping force, calculation for require cutting force calculation for power required for drilling.

Dead Load Calculation

- Plate = 16.45 kg
- Cylinder / Work rest = 10 kg
- Supporting pole (4 Nos.)` = 6.62 kg
- Bottom Plate = 67.67 kg
- Tray = 3kg
- Job weight = 1kg
- Fixture = 3.5 kg
- 2 hydraulic cylinders weight = 11.11 kg
- Main hydraulic cylinders weight = 24.8 kg
- Miscellaneous weight = 2 kg
- Clamping force = 30 kg
- Total weight lifted by hydraulic = 176 kg]

Drilling Parameters

Cutting Speed

$$v = \frac{\pi * D * n}{1000}$$

$$n = 665.557 \approx 650\ rpm$$

$$Feed\ Rate = 0.2\ {}^{mm}/_{rev} * 650\ {}^{rev}/_{min}$$

$$= 130\ {}^{mm}/_{min}$$

Material Factor (K)

$$K = 1.22\ (with\ 160\ HB\ \&\ UTS\ 56.7\ {}^{kgf}/_{mm^2})$$

Power at spindle (KW)

$$P = \frac{1.25 * D^2 * K * n * (0.056 + 1.55)}{10^5}$$

$$= 0.426\ KW$$

$$Power\ for\ 5\ Spindles = 5 * 0.426$$

$$= 2.13\ KW \approx 3\ hp$$

$$Assumed\ efficiency\ for\ gear\ drive = 90\%$$
$$Assumed\ efficiency\ for\ belt\ drive = 70\%$$

$$Power\ available\ at\ gear\ shaft = \frac{Power\ required}{Efficiency\ of\ gear\ train}$$

$$= 3.33\ hp$$

$$Power\ available\ at\ belt\ drive = \frac{Power\ at\ gear\ train}{Efficiency\ of\ belt\ drive}$$

$$= 4.76\ hp \approx 5\ hp$$

$$Torque\ T_S = \frac{975 * P}{n} = \frac{975 * 3.68}{650}$$

$$= 5.52\ kgf\ m = 54.1512\ Nm$$

$$Thrust\ T_h = 1.16 * K * D * (100 * S)^{0.85}$$

$$= 0.198\ kgf \approx 1.948\ N$$

$$MRR = \frac{(\pi * D^2 * S * n)}{4}$$

$$= 1.35 * 10^{-5}\ {}^{m^3}/_{min}$$

$$= \frac{13500\ {}^{mm^3}/_{min}}{650\ {}^{rev}/_{min}}$$

$$= 20.769\ {}^{mm^3}/_{rev}$$

$$Power\ at\ gear\ shaft = 3\ hp = 2.435\ KW$$

$$P = \frac{2 * \pi * n * T}{60000}$$

$$So, T = 36.0375\ Nm$$

$$T = F * R$$

$$F = \frac{(36.0375 * 1000)}{30}$$

$$= 1201.23\ N$$

$$\sigma = \frac{F}{A}$$

$$A = \frac{\pi}{4} * d^2 = 585.96$$

$$d = 27mm$$

$$\frac{T}{j} = \frac{G * \theta}{l}$$

$$l = 303.2207\ mm$$

VI. DESIGN OF HYDRAULIC POWER PACK

A. Hydraulic parameters

- Cylinder stroke for clamping
- Cylinder stroke for machining
- Dead weight lifted by main cylinder
- Power required for lifting up

Assumption:

Pressure of hydraulic system 30 bar (Design Pressure)

Leakage & Friction losses neglect at initial stage

Standard equipment and component should be selected

B. Technical Data & Specification

- Dead weight of machine : 176 kg
- Clamping Force: 56 kgf/mm2 x 5Tool
- Hydraulic system pressure : 30 bar
- Hydraulic Fluid : SAE 68
- Factor of Safety : 2
- Power at spindle : 4hp
- Feed rate : 2mm/sec
- Cycle time : 50 second
- Assumed efficiency for gear drive : 90%
- Assumed efficiency for belt drive :70%

C. Hydraulic data

To start the design Fluid Pressure – P we can consider according to generalize system of hydraulic is assume as 30 bar.

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

Fluid Flow Rate – Q

$$Liter\ per\ Minutes = \frac{Flow}{Unit\ Time} = 12 \text{ lit/min}$$

Fluid Power in Horsepower – HP

$$Horse\ Power = \frac{Pressure\ (PSI) \times Flow(GPM)}{1714}$$

$$= 0.67 \text{ HP}$$

Cylinder Area – A

$$Sq.In = \pi \times Radius(inch)^2$$

$$= 1.92 \text{ in}^2$$

Cylinder Force – F

$$Pounds = Pressure\ PSI \times Area\ In^2$$

$$= 847 \text{ pound}$$

Cylinder Speed – v

$$Feet\ per\ Sec = \frac{231 \times Flowrate\ GPM}{12 \times 60 \times Area}$$

$$= 0.43 \text{ ft/sec}$$

Cylinder Volume Capacity – V

$$Volume = \frac{231 \times Radius^2 \times stroke}{231}$$

$$= 0.0331 \text{ gallon of fluid}$$

Cylinder Flow Rate – Q

$$Volume = \frac{12 \times 60 \times Velocity \times Area}{231}$$

$$= 2.6 \text{ GPM}$$

Fluid Motor Torque – T

$$Torque = \frac{HP \times 63025}{RPM}$$

$$= 29.32 \text{ pound}$$

Fluid Motor Speed – n

$$Speed = \frac{231 \times GPM}{Disp(in)^3}$$

$$= 1456 \text{ rpm}$$

Fluid Motor Horsepower – HP

$$HP = \frac{Torque \times rpm}{63025}$$

$$= 0.67 \text{ hp}$$

Pump Output Flow

$$GPM = \frac{Speed \times disp.(in)^3}{231}$$

$$= 2.63 \text{ gpm}$$

Pump Torque – T

$$Torque = \frac{HP \times 63025}{RPM}$$

$$= 29.31 \text{ pounds}$$

Pump Efficiency – E = 90 %

Pump Volumetric Efficiency – E = 92 %

Pump Displacement – = 0.42 in^3/rev

D. Selection of standard hydraulic elements according to derived data

- Pump :
  – Vane pump "PV2R" Series Single Pumps
- Direction control valve:
  – 4/3 way solenoid operated DSG01
- Pilot operated check valve :
  – CM0TA-01

Tank	A	B	C	Pump size cc/rev (litre/minute)	Motor size (kW)
16 litre	410 mm	325 mm	310 mm	from 1cc (1.45 lpm) to 9.8cc (14.2 lpm)	from 0.55kW to 1.5kW
30 litre	470 mm	375 mm	340 mm	from 3.15cc (4.5 lpm) To 14cc (20.3 lpm)	from 1.1kW to 4kW
55 litre	600 mm	470 mm	370 mm	from 6.3cc (9.1 lpm) to 22cc (31 lpm)	from 2.2kW to 7.5kW
75 litre	600 mm	470 mm	460 mm	from 12cc (17.4 lpm) to 32cc (46 lpm)	from 4kW to 7.5kW
100 litre	675 mm	520 mm	510 mm	from 12cc (17.4 lpm) to 36cc (52 lpm)	from 4kW to 22kW
180 litre	805 mm	620 mm	560 mm	From 20cc (29 lpm) To 60cc (87 lpm)	from 7.5kW to 30kW

Table 2 Hydraulic Power Pack (specification)

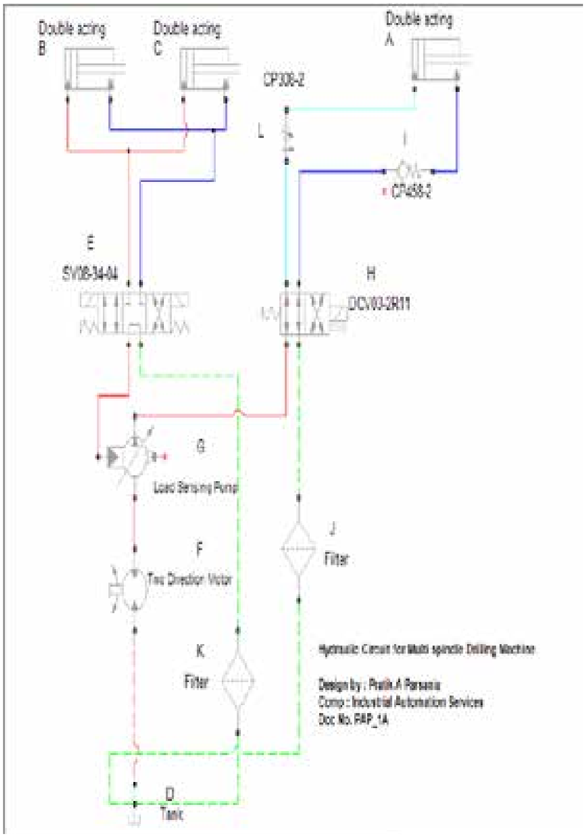

Figure 3 Final Hydraulic Circuit

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

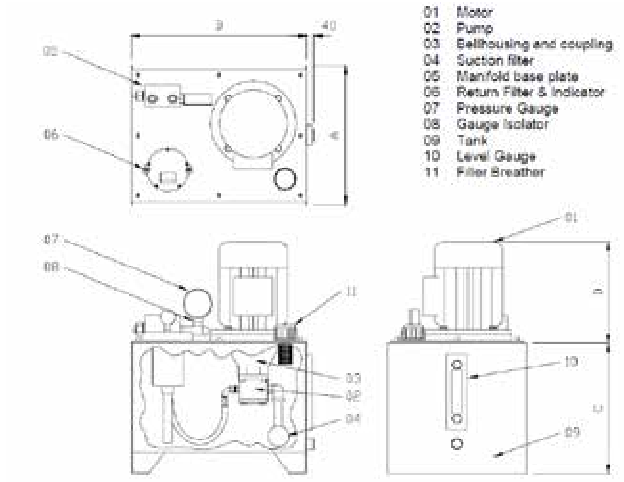

Figure 4 Layout of Power Pack

V. FUTURE SCOP OF WORK

Here is only basic design of hydraulic power pack which used in particular machine. Further may be optimization of cycle time using different types of hydraulic fluid can be done.

VI. CONCLUSION

As the SPM is design for special application it can be so fast in production with minimum cycle time but the main draw-back is that it can be use only for special single kind of machining process for which it was design. If it will used for any other similar that kind of process it need a drastic changes in basic design.

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