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Multi Spindle Drilling Spm for G91 Engine Hood

Shreya Gurav*
Mechanical Dept.
shreyagurav10@gmail.com

Shreyas Katti
Mechanical Dept.
shreyask97@gmail.com

Shubham Sanas
Mechanical Dept.
shubham.sanas@gmail.com

Y. G. Nadargi
Mechanical Dept.
yogesh.nadargi@sinhgad.edu

Vitthal Wakchaure
Mechanical Dept.
vitthal.wakchaure@tacogroup.com

Abstract- The use of SPM increases productivity and maintain the accuracy of drilling operation for number of times. This paper gives literature survey about multi-spindle drilling machine and focuses on previous development in Multi-spindle drilling machines. Multi-spindle head machines are used in mechanical industry to increase the productivity of machining systems. The multi spindle drilling machines is production type of machine. It is used to drill two holes in a workpiece simultaneously in one setting. The holes are drilled on number of work pieces with the same accuracy to make them interchangeable. The overall use of drilling SPM increases productivity rate largely as compared to use of conventional drilling machines.

Keywords- SPM (Special Purpose Machine), Multi-spindle drilling machine, Productivity, Accuracy.

I. INTRODUCTION

A. SPM (Special Purpose Machine):

Special purpose machine is new approach to increase the productivity of an organization. Designing of SPM is decided upon the principles of minimization of cost, improved productivity and better safety etc., which posses with high initial investment, higher maintenance cost etc. Special Purpose Machine is a higher degree mechanism in which human participation is replaced by an application of mechanical, electrical, electronics, pneumatic systems.

B. Multi spindle Drilling Machine:

Gang drilling machine is the machine, when a number of single spindle drilling machine columns are placed side by side on a common base and have a common work-table. In this machine, four to six spindles are mounted side by side. This type of machine is specially adapted for production work. A series of operations can be performed on the work by shifting the work from one position to the other on the work-table. Each spindle may be set up properly with different tools for different operations. Multiple-spindle drilling machines are used for mass production, a great time saver where many pieces of jobs having many holes are to be drilled.
Multi-spindle head machines are used in mechanical industry in order to increase the productivity of machining systems. The multi spindle drilling machines is production type of machine. It is used to drill two holes in a workpiece simultaneously in one setting. The holes are drilled on number of work pieces with the same accuracy to make them interchangeable. This machine has two spindles driven by a single motor and all the spindles are fed in to the work piece simultaneously. Feeding motions are obtained either by raising the work table or by lowering the drills head. In mass production work drill jigs are used for guiding the drills in the work piece so as to achieve accurate results. In today's market the customer demands the product of right quality, right quantity, right cost, & at right time. Therefore it is necessary to improve productivity as well as quality. One way to achieve this is by using multi spindle drilling head.

Fig No.1: Multi spindle drilling head

II. LITERATURE REVIEW

1. **S. R. Gawande, S. P. Trikal** studied on "Design ***of Special Purpose Multi Spindle Drilling Machine***". This paper discusses the study of design of multi spindle drilling machine. In case of mass production where variety of jobs is less and quantity to be produced is large, it is very essential to produce the job at a faster rate. This is not possible if we carry out the production by using general purpose machines. The best way to improve the productivity along with quality is by designing special purpose machine. The multiple spindle drilling attachment performs basic drilling operations; there are some specific functions that are performed more accurately. This attachment works mainly on planetary gear system arrangement.

2. B. B. Kuchhadiya, H. G. Chothani, J. R. Solanki studied on "**Selection of Material for bearing using MADM Approach**". This paper discusses about various methods to be used for selection of bearings. The methods used for selection of bearings are The AHP Approach, the simple additive weighting (saw) method, weighted product method (wpm).

III. OBJECTIVES

1) To reduce manpower and time cycle
2) Elimination of inventory and increasing accuracy
3) Automation with use of PLC programming

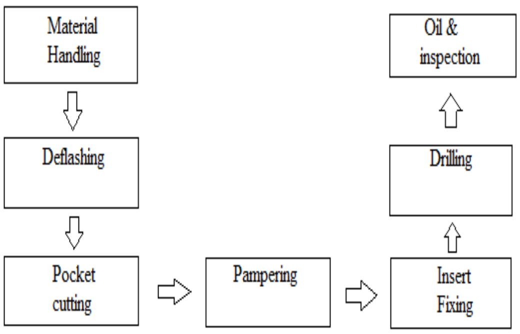


Fig no.2 Old process

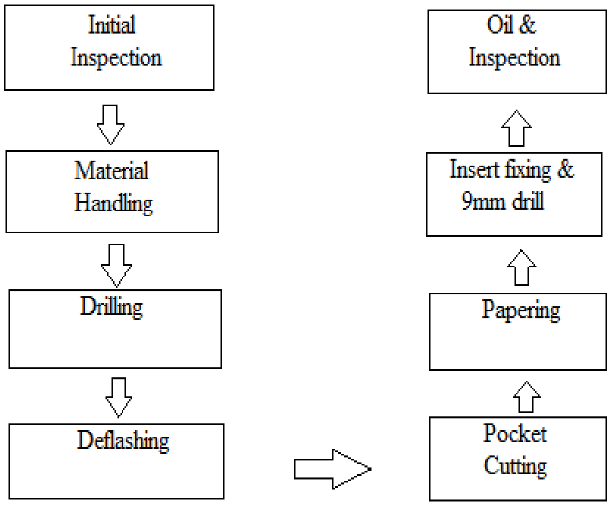


Fig no.3 New process

IV. DESIGN CALCULATIONS

I. Selection of Motor:

The required rpm is 1500rpm and thus a motor of 1500 rpm should be selected with the required power.

$$\text{Cutting speed} = \frac{\pi * D * N}{1000} = 32.96\text{m/min}$$

Feed per revolution for particular material given by the company.

Power

$$P = 1.25 * D^2 * K * N * (0.056 + 1.5s)$$

Material factor K=0.4 , Required feed rate S=0.09377

$$P = 1.25 * D^2 * K * N * (0.056 + 1.5s) * 10^{-5}$$

$$= 1.25 * 7^2 * 0.4 * 1500 * (0.056 + 1.5 * s) * 10^{-5}$$

$$= 1.25 * 49 * 0.4 * 294.9 * 10^{-5} = 0.072275$$

Power required for 2 holes

$$= P * 2 = 0.07227 * 2 = 0.14454\ KW$$

$$= \frac{0.14454}{0.746}$$

$$= 0.193\ HP$$

Considering 80% efficiency of the gearbox

Therefore total power required

$$= \frac{P}{0.8} = \frac{0.14454}{0.8}$$

$$= 0.1806\ KW$$

$$= \frac{0.1806}{0.746} = 0.242\ HP$$

Therefore a motor should be selected with a RPM of 1500 as required and power of 0.18 KW

Therefore a 3 phase 0.18 KW @ 1500 RPM is selected.

II. *Calculation of Gearbox:*

Given-

[1] N_p=1500 (RPM of motor)

[2] N_g=1500 (Required for the drill)

[3] Gear ratio=1:1

Solution-

By selection criteria of material both the gears are manufactured using same material i.e. EN36

S_{ut}=1000MPa=1000N/mm^2

$\sigma_y=\sigma_g$

$$6 = \frac{1000}{3} = 333.33\left(\frac{\mathrm{N}}{\mathrm{mm}^2}\right)$$

Considering minimum number of teeth as 20 on pinion

Lewis form factor = $\mathrm{YG} = \mathrm{Yp} = 0.484 - \frac{2.865}{z}$ …… (For 20^o full depth involute system)

$$= 0.484 - \frac{2.865}{20}$$

$$= 0.34075$$

Gear ratio required is 1:1

Therefore, Zp=Zg=20

Beam strength of spur gear tooth:

$$Fb = 6b * b * m * Yp$$

$$= 333.33 * 10\mathrm{m} * \mathrm{m} * 0.34075$$

$$=1135.82\ \mathrm{m}^2$$

$$Fw = dp * b * q * k$$

Fw-Wear strength, dp=Diameter of pinion, b=Face Width (standard dimensions are from 9m to 10m)…..We selected 10m module, m=module

$$face\ width = dp = m * Zp = 20m$$

For external pair, $Q = 2 * \frac{Zp}{Zg+Zp}$

$$Q = 2 * \frac{Zp}{Zg + Zp} = \frac{2 * 20}{20 + 20} = 1$$

EN36 properties

Hardness= 340BHN, S_{ut}=1000MPa, K=external factor

$$k = 0.16 * \left(\frac{BHN}{100}\right)^2 \text{ For } 20^0 \text{ full depth involute system}$$

$$k = 0.16 * \left(\frac{BHN}{100}\right)^2 = 0.16 * \left(\frac{340}{100}\right)^2 = 1.86\frac{N}{mm^2}$$

Wear strength of spur gear tooth:

$$Fw = dp * b * q * k = 20m * m * 1 * 1.86 = 372m^2$$

Dynamic load $= Feff = \frac{ka*km*ft}{kv}$

Ka=1 ……………Electric motor (uniform driven machine)

Km=1.2 ………..For precision gears up to (50mm face width)

$$Feff = \frac{1*1.2*\left(\frac{119.37}{m}\right)}{\frac{6}{6+1.5079m}} = \left(\frac{1*1.2}{6}\right) * \left(\frac{119.37}{m}\right) * (6 + 1.5079m) = \frac{143.244+35.99m}{m}$$

For finding standard module as Fw<Fb

The gear could fail due to pitting failure therefore $Fw = Feff * FOS$

Considering FOS as 3 we get module as 1.14 which is not a standard.

The standard module is 1, 1.25, and 1.5

Reducing the FOS to 2

$$372m^3 = (143.244 + 35.99m) * 2$$

$$m = 0.9868$$

By considering FOS as 2.1

$$373m^3 = (143.244 + 35.99m) * 2.1$$

$$m = 1.0002$$

Therefore, selecting the standard module as 1mm$dp = 20mm$, $dg = 20mm$,$b = 10mm$,$Centre\ distance = 20mm$,$addendum = 1mm$,$deddendum = 1.25mm$,$velocity = 1.5079m/s$

Dynamic load, $Fd = \frac{21v(bc+Ftmax)}{21v+sqrt(bc+Ftmax)} = 40\ N$

$$Feff = Fd + Ftmax = 40 + 143.44 = 183.44\ N$$

For checking of pitting failure, $Fw = Feff * FOS$

$$FOS = \frac{Fw}{Feff} = \frac{372}{183} = 2.09$$

Therefore, the design is safe.

V. CAD MODELLING

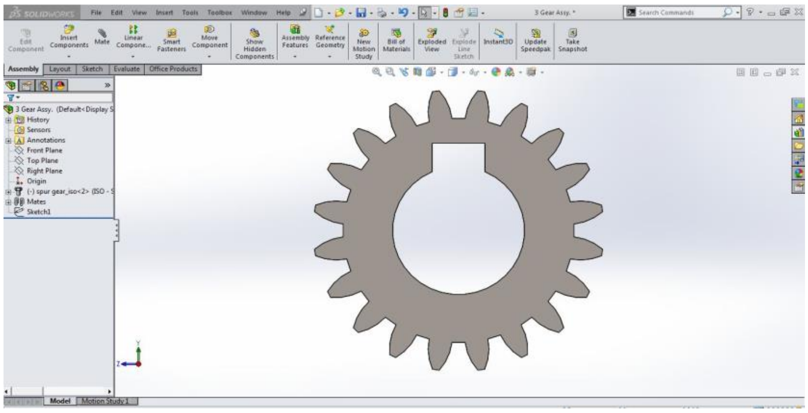


Fig no.2 Cad model of gear on solid works

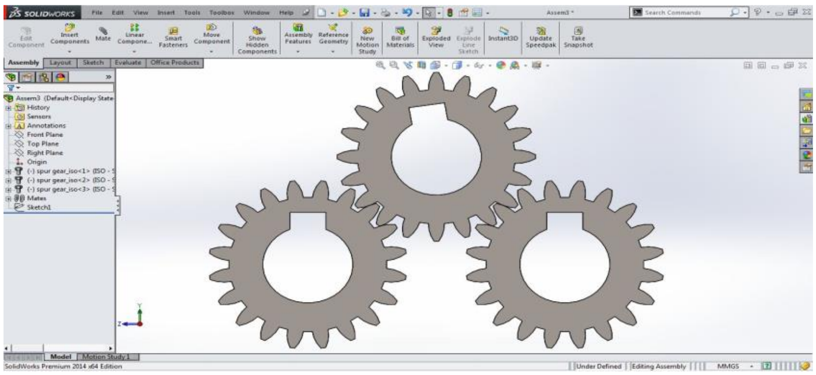
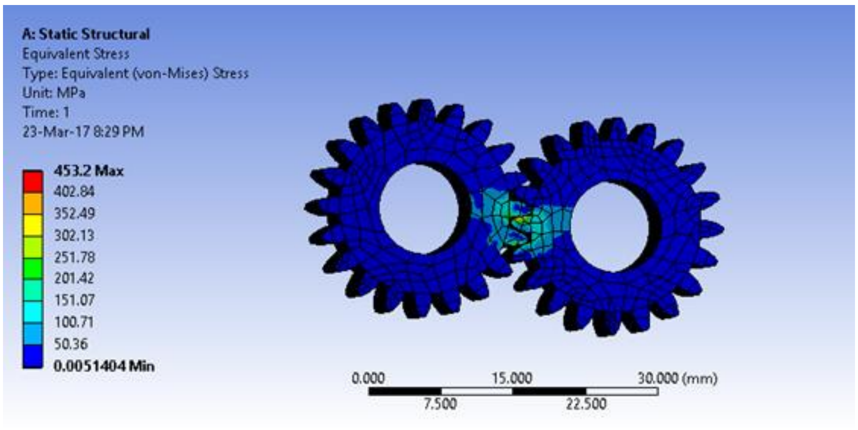


Fig no.3 Cad model of the gear assembly 1

VI. FINITE ELEMENT ANALYSIS



The required image shows that the design is safe according to the analytical software also. Thus the design of gear with a factor of safety of 2 is safe and reliable. The maximum stress the tooth can bear is 453.2MPa, applying the tangential load of 114.5N as per the required power and calculations the design is safe.

CONCLUSION

- Analysis results are reliable as seen in the ANSYS, analytical and actual conditions.
- FEA Validation shows the analytical design calculations we have done are approximately correct and maintaining Factor of Safety 2.

Thus the designed well conceived Special Purpose Machine thus finds a way to utilize the man and machine to the optimum.

The actual time required for drilling manually was 300mins for 100 components while using the SPM it has been reduced to 63 mins for 100 components.

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