Design and Development of Multi-Spindle Drilling Head (MSDH) Machine using ANSYS: A Review

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Abstract— Manufacturing plays vital role in any industry for producing the product. With stiff competition and challenges in the present-day market, manufacturers are compelled to be more responsive to the customer's demands regarding not only quality, but scheduled delivery. Enhancing productivity is a key concern for almost all the mass production industries. In case of mass production where variety of jobs is less and quantity to be produced is huge, it is very essential to produce the job at a faster rate. The best way to improve the production rate along with quality is by use of special purpose machine. This paper discusses the past work done on design, development and analysis of multi-spindle drilling head (MSDH) machine using ANSYS. Our main objective is to study its design procedure along with finite element analysis of its main shaft.

Keywords—*Design, Multi-spindle drilling head (MSDH) machine, ANSYS, Main shaft.*

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I. INTRODUCTION

1.1 Multi-spindle drilling head (MSDH) machine

In the conventional manner, only one job can be worked at a time for various operations such as drilling, tapping, spot facing, reaming, counter sinking, counter boring etc. but with increase in productivity demands a special purpose device or attachment is need which will increase productivity by,

1. Performing operations on more than one job at a time.
2. Performing multiple operations in one cycle.
3. Indexing capability to sequence operations one after another.

The Multi-spindle drilling attachment is an ideal solution to the above problems where in the conventional drilling machine is used to perform these three operations at a time, so also different operations like drilling, reaming, countersinking or spot facing can be done simultaneously.

The most noteworthy aspect when using multi-spindle machines is the cycle time, due to parallel machining the total operating time is dramatically decreased. Added benefits include less chance for error, less accumulated tolerance error, and eliminate tools changes. 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. On the other hand, in order to meet quality requirements of final product

The various methods of multi-spindle drilling head are:-

1 Adjustable multi-spindle drilling head- It can be used in many components, where change the centre distance to some range.

2 Fixed Multi spindle drilling head- It is used where the centre distance cannot change to some range.

Multi-spindle heads can be of fixed centre type construction for mass and large batch production and for batch production, adjustable centre type design is offered.

1.2 Shaft

A shaft of multi spindle machine is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and resultant torque set up within the shaft permits the power to be transferred to various machines linked up to the shaft. In order to transfer the power from one shaft to another, the various members such as pulleys, gears etc. are mounted on it. These members along with the forces exerted upon them causes the shaft to bending.

Shafts are generally manufactured by hot rolling and finished to size by cold drawing or turning and grinding. The material used for the manufacturing of ordinary shafts is carbon steel of grade 40C8. 45C8.50C4 and 50C12. Generally MSDH machine shafts are made by material 40C8 or 45C8. Depending upon the loads, forces these materials are used. There are many possibilities of failure of

these shafts when loads are not stationary or unbalance forces of the various members of the machine.

So in this paper our aim is to design multi-spindle drilling head machine and analyzing its one of the major component i.e. shaft.

II. LITERATURE REVIEW

The exhausted literature study has been carried out on design and development of MSDH machine .The work of various scholars in the field of design, development and analysis of MSDH machine have been presented below:

A. M. Takale et.al [1] was focused on "Design & manufacturing of multi spindle drilling head (msdh) for its cycle time optimization", This paper deals with design and development of multispindle drilling head for cycle time optimization of the component. Their attempts have to improve the productivity by reducing the total machining time and combining the operations. They have design the major components and main spindle and calculate the stress analysis. By using multi-spindle drilling head productivity will increase. Because with the present process one hole produces at a time requires 4 minutes for each component (because tool change takes place for drilling 5mm hole (for M6x1 tap)). i.e. 12-15 parts are produced during one hour, but by using multispindle drilling head cycle time approximately takes place 1 minute.

Prof. P.R.Sawant et.al [2] had been published a paper on "Design and development of SPM-a case study in Multi drilling and tapping machine". This paper discuss the case study and comparison of productivity of component using conventional radial drilling machine and special purpose machine (SPM) for drilling and tapping operation.
In this case study, the SPM used for 8 multi drilling operation (7 of Ø6.75 and Ø12), linear tapping operation of Ø12 and angular tapping operation of Ø5.1 of TATA cylinder block. In this paper the following studies are carried out 1. Time saved by component handling (loading and unloading), using hydraulic clamping, 2. Increase in productivity both qualitative and quantitative, 3. Less human intervention, indirectly reduction in operator fatigue, 4. Less rejection due to automatic controls, and 5. Increase the profit of company.

M. Narasimha et.al [3] published a paper on Design of adjustable multi-spindle attachment. This paper focuses upon the design of an adjustable multi-spindle attachment for machining three T-slots together in a single pass thus augmenting the productivity thrice The design includes provision for changing the spacing between the T-slots in the range of 40 mm to 320 mm.

Bajirao H. Nangar e Patil [4] emphasized on modeling and developing of gearbox which operate the multi-spindle drilling machine for drilling operation of counter bore of ø5 mm, ø6.8 mm and ø14.4 mm for a cylinder block.

From this review it was found that no analysis work of shaft is carried out for the given subject. So we decided to design and develop the multi-spindle drilling head machine and analyzing its shaft by using ANSYS.

III. LAYOUT OF MACHINE

For our project we review one of the multi-spindle drilling machine used in ABC Company and its multi-spindle layout.

Fig. 1 Multi-spindle drilling head machine

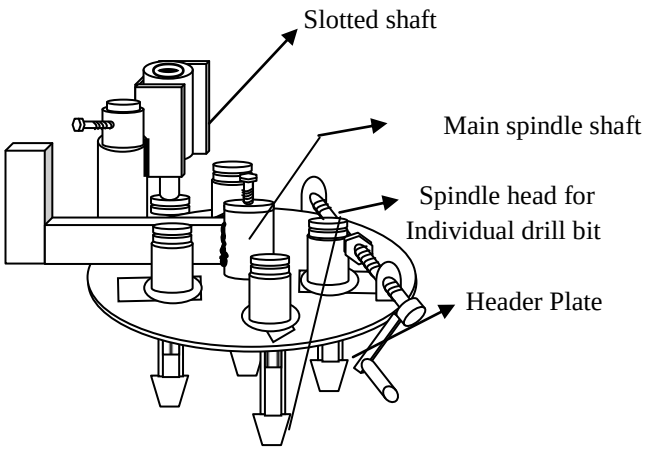

Fig. 2 Layout of Multi-spindle

IV. DESIGN PROCEDURE

For the above selected machine following design procedure is carried out.

4.1. Motor selection

For the above machine a motor of the following specifications is used.
3 phase induction motor
Power = O.5 hp= 375 watt

Speed= 1440 rpm.

Motor is 375 watt power, run at 1440rpm, connected to drilling machine spindle by belt pulley arrangement of 2.88:1 ratio, considering 65% efficiency of belt drive.

Assume for pulleys, $D_{arbour} = D_{motor} = 50$ mm.

So, $N_{arbour\ pulley} = 1440$ rpm.

4.2 Shaft Design

For the above machine, shaft is made up of material 40C8 having Ultimate tensile strength=560 N/mm^2, Yield strength=320 N/mm^2.

Following stresses are normally adopted in shaft design,

Taking factor of safety = 2.5

Max^m tensile stress = yield strength / FOS = 320/ 2.5

=128 N/mm^2

Max^m shear stress =0.5 x ft = 0.5 x 128 = 64 N/mm^2

Shaft design on basic of study

P = 0. 5 hp = 0. 5 x 746 = 373 watt

Power = 2 Π (1440) T/ 60

373 = 2 x 3.14 x 1440 x T / 60

T = 2.48 N m = 2480 Nmm

The transmission ratio of gearing is 2.88

So actual torque applied on shaft is

T final = 2480 x 2.88 = 7142 N mm

We know

The standard dia. used in machine is 8 mm

T= 3.14/16 x $fs_{induced}$ x 8^3

7142 = 3.14/16 x $fs_{induced}$ x 8^3

$fs_{induced}$ =71 N/mm^2.

During practical operation this shaft is safe for limited load condition after that it will fail due to torsional movement.

4.3 Other Components Design

Similarly safe design is made for the other components of machine such as gears, bearing, welded joints, and pulleys etc.as per standard design procedure by using design data book.

V. DESIGN ANALYSIS

FEA is a computer based analysis technique for calculating the strength and behavior of structures. These elements are joined at particular points which are called as nodes. The FEA is used to calculate the deflection, stress, strains, temperature, buckling behavior of the member. In our study FEA is carried out by using the ANYSIS. Initially we don't know the displacement and other quantities like strains, stresses, which are then calculated from nodal displacement.

VI. CONCLUSIONS

The wide research has been carried out in the field of design of Multi-spindle drilling head (MSDH) machine. The main objective of this work is studied and to take an account of previous work carried out by researcher on MSDH Machine. From the review it can be noted that there are various forces, torque, material affects on design of MSDH machine specially its shaft, so we try to make it better and making it more safe for torsional movement by changing some parameters or replacing material to highly strength material and test the same.

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