Design of Special Purpose Multi Spindle Drilling Machine

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ABSTRACT:
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.

Keywords: Multi spindle drilling machine, Design, Special purpose machine.

I. INTRODUCTION
Special purpose machine is part of multi-tasking machine. This is new approach to increase the productivity of an organization. If we compare between ordinary machine and special purpose machine in terms of cycle time, number of steps involved, manpower, etc. the special purpose machine is preferred choice. 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 higher degree mechanism in which human participation is replaced by an application of mechanical, electrical, electronics, pneumatic system [1],[2],[3].

II. PROBLEM DEFINITION
In the conventional manner only one hole can be drilled at a time, but with increase in productivity demands a special purpose machine is needed which will increase productivity by performing multiple operations in one cycle. After the survey of complete manufacturing process it is noted that many of the components got rejected because of -
- Non uniform drilling.
- Poor finishing.

A. SOLUTION OF PROBLEM
The special purpose Multi-spindle drilling machine is an ideal solution to the above problem which is used to perform fifteen drilling operations at a time. In the multi-spindle drilling machine fifteen spindles are driven simultaneously which carry fifteen chucks. The chucks can receive twist drills to perform the desired operation.

III. SELECTION OF MATERIAL AND THEIR PROPERTIES

1. EN8 Steel –
EN8 is a medium carbon steel usually supplied untreated.
Properties-
- Good tensile strength.
- Readily machinable in any condition.
- Low wear and tear.

EN8 (080M40) Specification-

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.36-0.44%</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.10-0.40%</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.60-1.00%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.050 Max</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.050 Max</td>
</tr>
</tbody>
</table>
2. Mild Steel (Low Carbon Steel)-
   Properties-
   - Good Modulus of elasticity
   - High yield and tensile strength

3. High Speed Steel-
   Properties-
   I. Hardness: Resistance to penetration by diamond-hard indenter, measured at room temperature.
   II. Hot hardness: The ability to retain high hardness at elevated temperatures.
   III. Wear resistance: Resistance to abrasion, often measured by grind ability, metal-to-metal, or various other types of tests to indicate a relative rating.
   IV. Toughness: Ability to absorb (impact) energy.

V. DESIGN PROCEDURE

To design a special purpose machine we have considered a very careful approach, the total design work has been divided into two parts mainly;
   - System design
   - Mechanical design

System design mainly concerns with the space requirements, arrangement of various components on the main frame of machine, height of machine.

In design, the components are categorized in two parts.
   - Design parts
   - Parts to be purchased.

For design parts, detail design is done and dimensions thus obtained are compared with the parts which are readily available in market, this simplifies the assembly as well as post production servicing work [4].

- Selection of Motor-
  - 3 phase induction motor
  - Power = 2 hp =1492 Watt
  - Speed = 50 rpm

- To calculate Torque on arbor shaft-
  Power = 2\(\pi\)NT/60
  Torque (T) = 285 Nm
  Total number of arbor shaft= 1
  Torque on arbor shaft = T*1*0.75
  = 285*1*0.75
  = 214 Nm

- Check the Safetyness of Shaft-
  Diameter of Shaft = 55 mm
  Torsional Shear =\(\tau\) = 16*214*1000/\(\pi\)*(55)^3
  = 6.55 N/mm^2
  Shear force for standard material is = 56 N/mm^2
  Therefore ,
  \(\tau\) < \(\tau\) for standard material
  Therefore design of shaft is safe.

- Gear box -
  I. Power to be transmitted = 2\(\pi\)NT/60
     = 1492.25 Watt
  II. Gear ratio = 13/10
     = 1.3
  III. Speed of driving gear= 50 RPM
  IV. Centre distance= 43 mm
  V. Material for gear= EN8

- Cutting Speed(S) = \(\pi\)dN/1000
  = \(\pi\)*5*50/1000
  = 0.78 mpm

- Spindle Speed = cutting speed in mpm*1000/\(\pi\)*d
  = 0.78*1000/\(\pi\)*5
  = 50 rpm

- Feed (f) = (Thickness + 0.3d) / RPM
\[
\frac{(2+1.5)}{50} = 0.07 \text{ mm/rev.}
\]

- Depth of cut = \(\frac{d}{2}\) = 2.5
- Machining time \((T) = \frac{L}{N\cdot f}\)  
  Where, \(L = \text{Length of axial travel of drill in mm}=l+a\)  
  \(l = \text{Depth of work piece}\)  
  \(a = \text{Approach of drill} = 0.3d\)  
  \(T = 4/50*0.07\)  
  = 1.14 min.
- Feed rate \((V_f) = \text{feed} * \text{rev.}\)  
  = 3.5 mm/min
- Metal removal rate \((\text{MRR}) = V_f \cdot \pi \cdot \frac{d}{4} \cdot 1000\)  
  = 3.5 * \(\pi \cdot (5\cdot5)/4\cdot1000\)  
  = 0.0687 cm\(^3\)/min. [5],[6],[7].

V. DESIGN AND WORKING OF MACHINE

![Figure 1. Multi Spindle Drilling Machine][8]

![Figure 2. F.V., T.V., L.H.S.V. of machine][8]
The three dimensional model of multi spindle drilling machine is shown in figure 1 which is used to drill stainless steel rod. Operator will manually load the stainless steel rod on fixture and closes the door of machine. Then operator pushes the switch of the machine. Due to this motor starts which rotates the main shaft through chain drive. The main shaft is connected to the gear system which rotates all the spindles attached to it. The gearing arrangement is shown in figure. After this, the pneumatic cylinder pushes the gear box/bearing in the down word direction and fixes the stainless steel rod with fixture cap. Due to this the twist drills are also moved in the down word direction and drilling is done at required position. Fifteen holes can be drilled at a time within seconds. After drilling the component, the pneumatic cylinders pushes back the gear box and also removes the fixture cap for unloading the component.

V. RESULT AND DISCUSSION

After the complete design and manufacturing of the machine, several trials were taken. In these trials it is found that the components are drilled out smoothly without leaving behind the burrs, an accurate and vibration free drilling operation is achieved. In results a drastic change is found in the parameters like cycle time, number of components drilled, number of operators required, finishing of the components. The final results are discussed in following table-

Table 1: Result Table

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Before Automation</th>
<th>After Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cycle Time (Sec)</td>
<td>240</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>No. of Components Finished / month</td>
<td>3900</td>
<td>23400</td>
</tr>
<tr>
<td>3</td>
<td>No. of Operators Required</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Aesthetic Look and Finishing</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>No. of trolley manufacture /month</td>
<td>130</td>
<td>390</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

With the help of this machine we can drill fifteen holes at a time. This study attempted to prioritize critical factors that influence organisation performance. Factors such as business competition and technology are supporting factor that enable organisation to enhance their competitiveness as well. The most critical factor is human resource. The paper describes a special purpose machine which is capable of drilling the respective locations automatically. The paper can be concluded with major points such as the finished component looks aesthetically pleasant. Finally, we concluded that the designed machine is an important step towards fulfilling the need for the company.

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REFERENCES


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