Design and Manufacture of the Inner Hole Dresser of Surface Grinder’s Main Shaft Sleeve

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ABSTRACT: While working, the main shaft sleeve would be scratched and wore off easily even out of shape that influence the precision. In order to ensure quality of work pieces, we have to change a new sleeve. But changing the whole set may cost so much that influence economic efficiency badly and is not environment friendly. The dressing methods for chopper inner hole sleeve is backward nowadays. This article is aimed at that status so that to design and manufacture a new inner hole dresser. The dresser is of simple and reasonable structure and the operation is much safer, much more convenient that can cut the maintenance cost while increasing economic efficiency.

KEYWORDS: Copper sleeve of main shaft; Distortion; Dresser; Economic efficiency

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1 INTRODUCTION

Surface grinder is a kind of grinding machine that uses a grinding apparatus. It is widely used in metal processing, parts of automobile and motorcycle, weapon industry, machine tool manufacture, ship building and so on. Even grinding in high-precision and small roughness. So that maintenance is very important. The design and manufacture is aimed at the maintenance and dressing of the sleeve’s inner hole.

2 TECHNICAL BACKGROUND

The traditional way of dressing the inner hole is to use the grinding wheel of grinder’s main shaft, which must have inner hole grinder, special fixture, grinding head and so on. It is dangerous for workers while operating. So, the factories may need a set of maintenance equipment for the sleeve inner hole that is high efficiency, low cost, safe and convenient.

3 DESIGN

This design is about the dresser for inner hole of Surface Grinder’s main shaft sleeve, specifically a dresser for scratch, abrasion and distortion. Including material selection, stress analysis for parts, technical characteristics and principles of operation.

3.1 Material selection

The most important part of the dresser is Grinding Shaft 1. We must legitimately select its material and fully consider if the material properties can fit the best result of process requirements. Grinding Shaft 1 amount to the grinding apparatus of a grinder. So it should be wear-resisting, strength, toughness, high-heat-resisting and in high hardness. While 45 steel can fit all this needs and have good Comprehensive mechanical properties and cutting performance. It is not very sensitive to stress concentration. And it can still have better properties after tempering. Through analysis and researching the requirements of the design, we select 45 steel.
3.2 Strength calculation

Grinding Shaft 1 is such a main part of the whole design that we should evaluate its safety factors precisely. The calculations of safety factors includes checking fatigue strength safety factor and static strength safety factor.

3.2.1 Checking fatigue strength safety factor

This check calculation is for confirming degree of safety of Shaft while the stress is changing. Through analysis, we can confirm one or more dangerous sections (in this case we should not only consider bending stress and torsional shear stress, but effects of stress concentration, absolute size and so on). According to the formula, work out the safety factors and make that slightly greater than design safety factors or at least equal to that[1]. The formula is as follows:

\[
S = \frac{S_{\sigma B} S_{\tau T}}{S_{\sigma B}^2 + S_{\tau T}^2} \geq [S]
\]

In the formula,

- \(S_{\sigma B}\) - safety factor only considering bending moment;
- \(S_{\tau T}\) - safety factor only considering torque;
- \([S]\) - Allowable safety factor that according to calculation of fatigue strength.

3.2.2 Checking static strength safety factor

This check is for evaluating the shaft’s resistance ability for plastic deformation. According to yield strength and the maximum instantaneous load, we can calculate the static strength safety factor of a dangerous section. The formula is as follows:

\[
S_{s} = \frac{S_{\sigma B} S_{\tau T}}{S_{\sigma B}^2 + S_{\tau T}^2} \geq [S_{s}]
\]

In the formula,

- \(S_{\sigma B}\) - safety factor only considering bending nearness;
- \([S_{s}]\) - Allowable static strength safety factor.

3.3 Stiffness calculation

Grinding Shaft will be bent and reversed under the effect of load. During designing, we must test the amount of deformation which can be regarded as rigidity check. But the stiffness should be divided into bending stiffness and torsional stiffness.

3.3.1 Checking bending stiffness

Working out the bending deformation by equivalent diameter analysis, the formula is as follows:

\[
d_m = \sqrt{\sum_{i=1}^{n} \frac{L_i}{\frac{L}{d_i^4}}}
\]

In the formula

- \(L_i\) - length of section i of the multi-diameter shaft;
- \(D_i\) - diameter of section i of the multi-diameter shaft;
- \(L\) - length between two bearings.

3.3.2 Checking torsional stiffness

It is to calculate the torsional deformation amount when working, the formula is as follows:

\[
\varphi = \frac{584}{G} \sum_{i=1}^{n} \frac{T_i l_i}{d_i^4}
\]

In the formula

- \(G\) - Shear modulus (MPa) for steel \(G=8.1 \times 108\)MPa
- \(T_i, l_i, d_i\) - represent torque, length, in and out diameter of the section i of the multi-diameter shaft, respectively [2].

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**Table 1. Mechanical properties of 45 steel.**

<table>
<thead>
<tr>
<th>heat treatment</th>
<th>tempering</th>
</tr>
</thead>
<tbody>
<tr>
<td>blank diameter/mm</td>
<td>≤200</td>
</tr>
<tr>
<td>Hardness HBW</td>
<td>217–255</td>
</tr>
<tr>
<td>tensile strength σb</td>
<td>650</td>
</tr>
<tr>
<td>yield strength σs</td>
<td>360</td>
</tr>
<tr>
<td>bending fatigue limit σ-1</td>
<td>270</td>
</tr>
<tr>
<td>Torsional fatigue limit τ-1</td>
<td>155</td>
</tr>
<tr>
<td>Allowable stress ([\sigma+1])</td>
<td>260</td>
</tr>
<tr>
<td>Allowable fatigue stress ([\sigma-1])</td>
<td>180–270</td>
</tr>
</tbody>
</table>

**Table 2. Allowable safety factor[S].**

<table>
<thead>
<tr>
<th>Selection condition</th>
<th>1.3~1.5</th>
<th>1.5~1.8</th>
<th>1.8~2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load can be precisely confirmed, properties of materials are homogeneous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load determination is not that precise, properties of materials are not very homogeneous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load determination is not precise, properties of materials are not homogeneous</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3. Allowable static strength safety factor.**

<table>
<thead>
<tr>
<th>Ss/σb</th>
<th>0.45~0.55</th>
<th>0.55~0.7</th>
<th>0.7~0.9</th>
<th>casting</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Ss]</td>
<td>1.2~1.5</td>
<td>1.4~1.8</td>
<td>1.7~2.2</td>
<td>1.6~2.5</td>
</tr>
</tbody>
</table>
3.4 Technical features

According to the Figure 1 and Figure 2, the whole dresser is based on Fixture Body 7, Support Base 4, Pull Rod 5. The characteristics are Grinding Shaft 1, Spacing Nut 3, Positioning Screw 6. Both heads of Grinding Shaft 1 have center holes; middle segment of that is evenly covered with reservoir grooves which are full of abrasive material and sealed both sides.

Copper Sleeve 2 is plugged into the inner cavity of Fixture Body 7, there are two Positioning Screws 6 at the top of Fixture Body 7 and through out Copper Sleeve 2 inside fixture body. Then the Grinding Shaft 1 is plugged into the inner cavity of Copper Sleeve 2.

Finally, Spacing Nut 3 is tightened by screws at one end of Grinding Shaft 1 so that can limit the depth of Grinding Shaft 1 inserting Copper Sleeve 2. Abrasive material is grinding wheel grit in CF320. Diameter of the inner cavity of Fixture Body 7 is larger than the external diameter of Copper Sleeve 2 from 0.1mm to 0.3mm. While the external diameter of Grinding Shaft 1 is smaller than the internal diameter of Copper Sleeve 2 from 0.01mm to 0.02mm.

3.5 Working principle

This design is taking the advantages of grinding principle, setting the center holes at both sides of the grinding shaft, middle section is covered by reservoir grooves which is sealed at both two ends. Plug the grinding shaft into copper sleeve then bung up the grooves with CF320 grinding wheel grit. Tighten the nut on the side that has screws of shaft, not too tight but able to roll. Put the copper sleeve into the fixture body, the hole of fixture body is larger but at the same shape of copper sleeve. Then fix the fixture on the copper sleeve’s outer cone by screws. Clip one end of the grinding shaft on the cam-ring chuck of lathe C6132 while the other end is tightened by the end of the lathe. The supporting base is fixed on the blade adapter by screws. The center line of the base coincides with the center line of the screws approximately then connect the upper hole of the base and screws. Start the lathe at 45r/min, grinding 5 to 10 minutes. That can eliminate ellipticity, abrasion and scratch of the inner hole of copper sleeve. Then the sleeve can be used again.

4 CONCLUSION

This design has a very simple and very reasonable structure, long service life and its operation is safe and convenient. All these advantages much lower the maintenance cost and finally increase the economic benefits which adapts to the green modern industry.

REFERENCES