DESIGN IMPLEMENTATION AND ANALYSIS OF AUTOMATIC BURR REMOVAL IN A FIXTURE TOOL

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ABSTRACT:

Grooving operations is necessary for the production of outer race part in drive shaft of automobiles and the burr formation is unavoidable in the existing system. The presence of burr leads to deburring and cleaning operations which make up for a considerable portion of manufacturing costs. Due to burr formation, poor quality of product occurs and results in failure of drive shaft assembly. This research project’s aim is to reduce the burr formed after grooving operations in turret lathe. Thus the quality of component would be improved. The present rejection rates were analyzed and the burr height and thickness were measured using image measuring system. An innovative design was proposed and implemented for the automated deburring set up. The rejection rate after the implementation was analyzed and compared with the present rejection rate. A significant improvement in the quality of the finished product was observed.

Keywords: Grooving; Deburring; Burr reduction.


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1. INTRODUCTION

Grooving is the process of reducing the diameter of a work piece over a very narrow surface length. It is often done at the end of a thread or at adjacent to leave a small margin. The work is revolved at half the speed of turning operation.

A burr is a raised edge or small pieces of material remaining attached to a work piece after a modification process. It is usually an unwanted piece of material and when removed with a
specific tool, this process is called 'deburring'. Burrs are most commonly created after machining operations, such as grinding, drilling, milling, engraving or turning. It may be present in the form of a fine wire on the edge of a freshly sharpened tool or as a raised portion of a surface. This type of burr is commonly formed when a hammer strikes a surface. Deburring accounts for a significant portion of manufacturing costs.

There are three types of burrs that can be formed from machining operations: Plastic deformation of material includes lateral flow (Poisson burr); bending (rollover burr); and tearing of material from the work piece (break down or tear burr). Solidification or redeposition of material results in a recast bead. Incomplete cutoff of material causes a cutoff projection. Burrs can be minimized or prevented by considering materials, function, shape, and processing in the design and manufacturing engineering phases of product development.

Deburring is the process of removing burr, an unwanted piece of material, usually a raised edge or small pieces of material remaining attached to a work piece after a machining process, with a specific tool.

There are many deburring processes, but the most common are mass-finishing, spindle finishing, media blasting, sanding, grinding, wire brushing, abrasive flow machining, electrochemical deburring, electro polishing, thermal energy method, machining, and manual deburring.

1.1. Image Measuring System

The image measuring system is shown in figure 1 and the detail view of burr measuring base is shown in figure 2. The following is the working principle of the image measuring system.

1. Schematic measurement consists of four mirrors.
2. Work piece must be kept in setting base.
3. An Image of the measured burr specimen is taken in CCD camera.
4. A light source was used for uniform illumination on the focused profile of the burr.
5. Once the burr height is visible then snapshot will be taken in camera and stored in computer.
6. The recorded image is accessed through the X-CAP image processing software.
7. Measurement will made in such a way that both maximum and minimum height of burr is measured along other values and average of this will be taken.
2. EXPERIMENTAL SETUP

2.1. Existing Machine Setup
Figure 3 and 4 shows the existing grooving machine set up and a closer view of tool and work piece set up.

2.2. Working Principle
The following is the existing working principle of the grooving machine:
1. The fixture is changed according to the model (Ex. NISSAN).
2. The tool and inserts are changed depending upon the model.
3. The work piece is mounted on the fixture.
4. The appropriate feeding setting is selected in the CNC panel board using pre programmed function.
5. The machine is started to perform its operation.
6. The tool is moved horizontal towards the work piece and the plunging operations is done for required groove.
7. Cutting fluid is applied to point of cutting tool.
8. Machine will stop automatically after grooving is done and the depth of cut is checked with outside calipers or knife-edge verniers.

2.3. Work Component and Tools Used
The figures 5, 6 and 7 shows different work pieces with varying groove length:

Figure 5: Work Component A

Figure 6: Work Component B

Figure 7: Work Component C

The figure 8 shows the work component before machining and after machining and figure 9 shows the tool used for grooving.

Figure 8: Work Component
Figure 9: Tool

2.4. Burr Analysis Using Image Measuring System
The burr analysis was done using the image measuring system. The four types of burr that were identified using image measuring system are shown in figure 10 and the burr nomenclature is shown in figure 11.

![Types of burr](image)

**Figure 10: Types of burr**

1. Type 1 is a uniform burr; this type has a consistent height and thickness around the edge of the groove and is effortless to deburr after grooving.
2. Type 2 looks similar to type 1, but has leaned – back shape.
3. Type 3 burr has a severe rolled back shape.
4. Type 4 is similar to type 3 but has a comparatively small height and broadened exit.

![Burr Nomenclature](image)

**Figure 11: Burr Nomenclature**

3. CAUSE AND EFFECT ANALYSIS
As the main aim of the project is to reduce and remove the burr formations for Nissan model, the root cause for the formation of burr was identified using cause and effect diagram. The cause and effect analysis result is shown below in figure 12.
The cause and effect diagram shows us various factors which are influencing the burr formation. The major causes such as tool failure, burr formation, tool material, operator error and loading conditions are chosen for rectification.

4. PROPOSED DESIGN FOR FIXTURE TOOL
The new fixture tool is designed and is shown in figure 13 & figure 14. It is designed to reduce the burr formation in the work piece. The fixture set up consists of the following parts:
1. Linear motion bearing
2. Pneumatic cylinder
3. Tool
4. Adjustable bed
5. EXPERIMENTAL DATA COLLECTION AND ANALYSIS

5.1. Cycle Time and Tool Life Analysis

Table 1 shows the average cycle time and tool life for existing setup. The average tool life is 302 but the expected tool life is about 450 work pieces. The current rejection due to burr is 3.94 % in the total production rate. To increase the tool life and reduce the percentage of rejection due to burr, a new fixture tool is design to remove the burr in the component without affecting the cycle time.

![Figure 14: Fixture Tool in the Machine Set Up](image)

Table 1: Cycle Time and Tool Life

<table>
<thead>
<tr>
<th>Time/Trials</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool Life (Nos)</td>
<td>Before</td>
<td>298</td>
<td>303</td>
<td>306</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>450</td>
<td>456</td>
<td>453</td>
</tr>
<tr>
<td>Cycle Time (Sec)</td>
<td>Before</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Time Taken For</td>
<td>Before</td>
<td>5</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Deburring (Sec)</td>
<td>After</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The cost of tool was Rs 1200/piece, after implementing the fixture tool, tool life was increased, the overall cost for tool was reduced around 35%, and this increased the overall profit.

The cycle time for each work-piece will remain same due to the working process programmed in the machine.

5.2. Dimensional Analysis of Burr

One of the main challenges in burr research is burr measurement owing to their complex and irregular shape and size. It is usually very difficult to measure burr accurately. Therefore, burr values are collected from the edge surface of a work piece for burr height and burr thickness by diving the parts into several parts.
Table 2: Burr Height and Thickness

<table>
<thead>
<tr>
<th>Trial No</th>
<th>Burr Height (mm) Before</th>
<th>Burr Height (mm) After</th>
<th>Burr Thickness (mm) Before</th>
<th>Burr Thickness (mm) After</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.103</td>
<td>0.011</td>
<td>0.021</td>
<td>0.012</td>
</tr>
<tr>
<td>2</td>
<td>0.121</td>
<td>0.019</td>
<td>0.016</td>
<td>0.011</td>
</tr>
<tr>
<td>3</td>
<td>0.129</td>
<td>0.018</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>4</td>
<td>0.183</td>
<td>0.009</td>
<td>0.017</td>
<td>0.007</td>
</tr>
<tr>
<td>5</td>
<td>0.116</td>
<td>0.008</td>
<td>0.017</td>
<td>0.007</td>
</tr>
<tr>
<td>6</td>
<td>0.155</td>
<td>0.006</td>
<td>0.026</td>
<td>0.009</td>
</tr>
<tr>
<td>7</td>
<td>0.191</td>
<td>0.006</td>
<td>0.028</td>
<td>0.010</td>
</tr>
<tr>
<td>8</td>
<td>0.129</td>
<td>0.009</td>
<td>0.039</td>
<td>0.012</td>
</tr>
<tr>
<td>9</td>
<td>0.107</td>
<td>0.011</td>
<td>0.073</td>
<td>0.015</td>
</tr>
<tr>
<td>10</td>
<td>0.117</td>
<td>0.012</td>
<td>0.051</td>
<td>0.009</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.191</td>
<td>0.019</td>
<td>0.073</td>
<td>0.015</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.103</td>
<td>0.006</td>
<td>0.015</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Table 2 shows the burr height and thickness data collected for a set of trial. The distance of the highest peak to deepest valley is measured. Then the average of these values is taken. This gives a good picture of the achieved edge quality in the direction of the burr height and burr thickness.

5.3. Distribution of Burr Height and Burr Thickness

The burrs from the grooving experiment varied in shape from one groove to another work-piece but, generally have a similar pattern for the various burrs observed in previous studies on burr formation.

**Figure 15**: Distribution of Burr Height

**Figure 16**: Distribution of Burr Thickness
5.4. Month-wise Burr Rejection Rate before Implementation of Fixture Tool

The observations were made on standard operating condition followed in the machine and recorded in table A.1, A.2, and A.3 in Appendix. Table 3 shows monthly rejection rate of work piece. The month wise data help us to visualize the percentage of rejection of work piece in numbers.

Table 3: Month-Wise Burr Rejection Rate before Implementation of Fixture Tool

<table>
<thead>
<tr>
<th>Month</th>
<th>Production (Nos)</th>
<th>Rejection (Nos)</th>
<th>Rejection Due to Burr</th>
<th>% of Rejection</th>
<th>% of Rejection Due to Burr</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>13375</td>
<td>319</td>
<td>207</td>
<td>14.88</td>
<td>1.54</td>
</tr>
<tr>
<td>September</td>
<td>17826</td>
<td>415</td>
<td>221</td>
<td>18.6</td>
<td>1.23</td>
</tr>
<tr>
<td>October</td>
<td>17840</td>
<td>431</td>
<td>209</td>
<td>21.09</td>
<td>1.17</td>
</tr>
<tr>
<td>Total</td>
<td>49041</td>
<td>1165</td>
<td>637</td>
<td>51.57</td>
<td>3.94</td>
</tr>
</tbody>
</table>

5.5. Month-wise Burr Rejection Rate after Implementation of Fixture Tool

The observations were made on standard operating condition followed in the machine and recorded in table A.4, A.5, and A.6 in Appendix. Table 4 shows monthly rejection rate of work piece. The month wise data help us to visualize the reduced percentage of rejection of work piece.

Table 4: Month-Wise Burr Rejection Rate after Implementation of Fixture Tool

<table>
<thead>
<tr>
<th>Month</th>
<th>Production (Nos)</th>
<th>Rejection (Nos)</th>
<th>Rejection Due to Burr</th>
<th>% of Rejection</th>
<th>% of Rejection Due to Burr</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>13421</td>
<td>70</td>
<td>8</td>
<td>3.11</td>
<td>0.15</td>
</tr>
<tr>
<td>December</td>
<td>13382</td>
<td>73</td>
<td>9</td>
<td>3.24</td>
<td>0.06</td>
</tr>
<tr>
<td>January</td>
<td>15618</td>
<td>74</td>
<td>11</td>
<td>2.66</td>
<td>0.07</td>
</tr>
<tr>
<td>Total</td>
<td>42421</td>
<td>217</td>
<td>28</td>
<td>9.01</td>
<td>0.18</td>
</tr>
</tbody>
</table>

6. CONCLUSION

The presence of burr leads to deburring and cleaning operations which make up for a considerable portion of manufacturing costs. The discussed results clearly show that the rejection of part /component is mainly due to the burr formation. The only way to reduce the rejection of component without affecting the cycle time of grooving operations is by removing the burr formation by designing the fixture tool for automating deburring operation. The fixture tool was designed and implemented for the automated deburring set up for reducing the burr. Due to that:

1. Tool life was increased from 302 to 403 work-pieces.
2. Productivity increased due to eliminating deburring operations from the cycle time.
3. The overall cost for tool was reduced around 35%, and this increased the overall profit.
4. The rejection rate was reduced from 54.57% to 9.01 % that reduced the scrap and increased the productivity.
7. REFERENCES


