AN ADVANCED METHOD FOR THE MANUFACTURE OF GEARS

(REVIEW)

V. A. Krokha and A. M. Bakhovkin

Experimental Scientific-Research Institute of Forging-Machine and Press Construction
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The principal method used in the manufacture of gears, the cutting, has despite its high degree of perfection, many shortcomings. These include: high labor consumption, considerable loss of metal in the form of chips, and finally a relatively low strength of teeth due to the fact that metal "fibers" are cut. As a result new and more advanced methods for the manufacture of gears are now being widely used. Among these methods those taking advantages of powder metallurgy deserve particular attention.

The manufacture of powder-metal gears began in the USSR, England, and the USA about 20 years ago and today the production of gears by this technique occupies an established position in the mechanical engineering industry. Its rapid growth is connected with its great advantages over other methods used in the manufacture of gears.

Powder metallurgy can be used for producing gears of many different shapes and sizes that normally require no further machining or are only partially machined. This method can be used in the manufacture of spur gears (solid or with spokes) with straight or helical teeth, with teeth and teeth spaces of any desired form (e.g., sprockets), bevel gears with straight teeth, gears with teeth on their end faces, quadrants of intricate configuration, cluster gears, and internal gearing (Fig. 1).

Metal powder gears are used in many different branches of industry such as the automobile and tractor industry, the clock and watch industry, armament industry, etc. The accuracy with which metal powder gears are manufactured depends mainly on the precision of the tools used and can be as much as 0.025 mm [1]. A special feature of the manufacture of gears from powder metals is the small number of operations required. The main difference between the various methods used in the production of metal powders gears compared with other methods is the absence of the machining of teeth or other parts of the gear. Usually the teeth of these gears are not machined.

Very accurate gears requiring no machining are usually made in high-precision dies. Such tools are expensive. However, it should be remembered that the high cost of these tools is not a factor which limits the use of powder metallurgy in the production of gears since the tools have a long life which can be as much as million parts (Table 1).

A die used by Ford (USA) in the manufacture of oil pump gears [2] deserves special attention. The dismantled tool is shown in Fig. 2. It consists of two cores, the top core 1 and the bottom core 7, of two punches, the top punch 9 and the bottom punch 6, a guiding body 3, a sizing plate 4, and a die 5. The basic idea is that the gears are pressed and sized in the same tool.

The tool works on the following principle. Double-sided compression is performed in the die. Thereupon the upper punch moves out while the bottom punch forces the gear through the sizing plate. The cores are needed for obtaining a concentric hole. The upper core produces a hole during the compression of the gear while the bottom core remains in the hole during sizing thus preventing the hole from becoming oval. The sizing plate is made of a high-chromium tool steel. The broaching hole is chromium plated in order to reduce wear.

With a die of this type, high-quality gears are obtained with a relatively cheap tool. The use of the sizing plate eliminates the need for making a high-precision die which is a point of great importance for a long die. The sizing plate is relatively low and it is not difficult to make. When worn it can be easily replaced. This tool can be used for producing gears with a length of up to 45 mm.

Helical spur gears present considerable difficulties in manufacturing by powder metallurgical methods. The difficulties consist in forming the tooth, in obtaining the required strength and surface finish of the teeth and the
Fig. 1. Gears made from metal powder.

TABLE 1. Cost of Tools for the Manufacture of Metal Powder Gears

<table>
<thead>
<tr>
<th>Plant and country</th>
<th>Material of the tool</th>
<th>Tool life in thous. parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAS (USSR)</td>
<td>3Kh2V8</td>
<td>80</td>
</tr>
<tr>
<td>Elektrokontakt Plant (USSR)</td>
<td>Kh12F1</td>
<td>50-60</td>
</tr>
<tr>
<td>Engineering Plant in Kovrov (USSR)</td>
<td>KhVG</td>
<td>20-30</td>
</tr>
<tr>
<td>USA</td>
<td>Carbon steel</td>
<td>25</td>
</tr>
<tr>
<td>USA</td>
<td>Hard metal on WC base</td>
<td>1000</td>
</tr>
</tbody>
</table>

ejection of the finished part from the die. Merriman Bros., Inc. (USA) [3] manufacture several types of helical gears.

These gears are made on automatic presses with an output of 28 gears per minute by two-sided compacting. The finished gear is ejected by a synchronized punch and die. This technique can be used for helical gears with a helix angle of 10-27°. The largest gears which can be made by the Merriman method have a diameter of 38 mm.