TEST METHODS AND PROPERTIES OF MATERIALS

EFFECT OF SURFACE STATE, COMPOSITION, AND STRUCTURE ON THE WEARING-IN OF CERMET MATERIALS

I. M. Fedorchenko and L. V. Zabolotnyi

In our previous report [1] we showed that machining has a marked effect on the way porous iron wears-in with time. It was established that machining lengthens the wearing-in period and during this period we observe a marked reduction (by a factor of 2.2) in linear wear owing to formation of a "pad" of the porous skeleton of the material (compacted to a certain depth) beneath the machined surface.

To study the effect of composition and structure on the wearing-in of materials with different states of the surface layers, experiments like those previously described were performed on ZhGr3 ferrographite and ZhGr15STs4 and ZhGr3STs4 materials. The characteristics of these materials are given in Table 1.

Wear was studied on an MT62-M friction machine [2] with simultaneous automatic recording of the main friction and wear characteristics (linear wear, frictional force, and mean temperature of the specimen at a distance of 0.5 mm from the rubbing surface). Figures 1 and 2 give the results of experiments performed at sliding rate 4 m/sec and load 50 \( \times 10^5 \) N/m² (50 kg/cm²). The points plotted directly on the y axes are the experimental values for unmachined specimens.

It will be seen from Fig. 1 that, other things being equal, ZhGr3 porous ferrographite has a longer wearing-in time (curve 1). The wearing-in times of unmachined specimens of this material are respectively 70 and 30 sec longer than for similar specimens of ZhGr1.5STs4 and ZhGr3STs4.

As in the case of porous iron [1], machining always leads to a lengthening of the wearing-in period. Maximum relative lengthening of this period after machining is observed in the case of ZhGr3 porous ferrographite. The mean wearing-in periods for unmachined specimens of ZhGr1.5STs4 and ZhGr3STs4 are respectively 32 and 33 sec less than for specimens machined at 0.5 m/sec, and 50 sec less than for specimens of ZhGr3 porous ferrographite.

With a reduction in the machining speed from 0.5 to 0.4 m/sec, the wearing-in period of ferrographite specimens (curve 1) falls from 300 to 270 sec. With a further increase in machining speed, little increase in the wearing-in period is observed. In the case of ZhGr3STs4 and ZhGr1.5STs4 specimens, the wearing-in period increases somewhat with the machining speed (curves 2 and 3), but remains smaller than for ZhGr3. With an increase in the machining speed from 0.5 to 10 m/sec, the wearing-in periods of these materials rose by 10%.

**TABLE 1. Characteristic of the Cermet Materials Investigated**

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition of the initial charge, %</th>
<th>Structure</th>
<th>Calculated porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>iron 30 graphite 70 zinc sulfide</td>
<td>Perlite 90%, remainder ferrite</td>
<td>20</td>
</tr>
<tr>
<td>ZhGr3 ferrographite</td>
<td>97 3</td>
<td>Perlite 40-55%, ferrite 50-60%</td>
<td>20</td>
</tr>
<tr>
<td>ZhGr1.5STs4 ferrographite</td>
<td>94.5 1.5 zinc sulfide</td>
<td>Perlite 90%, ferrite and sulfide inclusions</td>
<td>20</td>
</tr>
<tr>
<td>containing zinc sulfide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZhGr3STs4 ferrographite</td>
<td>93 3</td>
<td></td>
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</tr>
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</table>

Fig. 1. Machining speed versus the wearing-in time of cermet materials: 1) ZhGr3 ferrographite; 2) ZhGr1·5STs4 ferrographite containing zinc sulfide; 3) ZhGr3STs4 ferrographite containing zinc sulfide.

Fig. 2. Machining speed versus linear wear during wearing-in period of cermet materials: 1) ZhGr3 ferrographite; 2) ZhGr1·5STs4 ferrographite containing zinc sulfide; 3) ZhGr3STs4 ferrographite containing zinc sulfide.

From a comparison of the wearing-in periods of sintered unmachined specimens of ZhGr3 and ZhGr3STs4, which have similar structures, it will be seen that addition of zinc sulfide reduces the wearing-in period. This may be due to the following reasons. The presence of zinc sulfide inclusions weakens the metal skeleton of the material; this improves the plastic deformation of the surface layers of the material under the effect of frictional forces.

However, the sulfides which reach the surface cannot spread over the rubbing surface during the wearing-in period and therefore a sufficiently compact layer of secondary structures, which would increase the material's durability and thus increase the wearing-in period, does not have time to form. It will be seen from the photomicrograph (Fig. 4), taken with a luminescent microscope, that the zinc sulfide inclusions (light areas of the structure) have not yet formed a continuous surface film on the rubbing surface of the specimen not worn in.

As in the case of porous iron, the linear wear of sintered unmachined ZhGr3, ZhGr1·5STs4, and ZhGr3STs4 specimens during the wearing-in period is usually greater than for machined material; the effect of machining on linear wear increases with the plasticity of the material machined. It will be seen from Fig. 2 that for ZhGr3 and ZhGr3STs4 material with perlite structures (curves 1 and 2) the linear wear of specimens machined at 0.5 m/sec decreases during the wearing-in period by 12 and 10 μ, respectively, and for ZhGr1·5STs4 material with a ferrite-perlite structure by 18 μ (curve 3).

From the leveling of ZhGr3, ZhGr1·5STs4, and ZhGr3STs4 materials it follows that the machining speed greatly influences linear wear only in the case of ZhGr3 (curve 1) and has a much weaker effect on the other two materials (curves 2 and 3). The presence of sulfides in the material reduces the effect of the machining conditions on the state of the surface layers of the material being machined.

In the case of ZhGr3 (curve 1), with an increase in the machining speed from 0.5 to 4 m/sec the linear wear in the initial period decreases by 11 μ, but for ZhGr1·5STs4 and ZhGr3STs4 by only 4 and 3 μ, respectively. A further increase in the machining speed has virtually no effect on linear wear during the wearing-in period.

During the wearing-in period, linear wear is determined by the composition and structure of the material and the initial state of the surface layers. Other conditions being equal, unmachined plastic material undergoes a more marked change in linear dimensions in the initial period than less plastic material, owing to compaction of the surface layers during plastic friction deformation.

The linear wear in the initial period is influenced by the heights of the surface protuberances, which depend in turn on the machining conditions and the material's properties. It will be seen from Table 2, for