NUMERICAL ANALYSIS ON FATIGUE FAILURE OF SLEEVE IN OIL-FILM BEARING

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ABSTRACT

Due to the three-segment loop-like damage axially along inner surface of bearing sleeve under rolling loadcases, to quantitatively analyze damage mechanism, a mathematical model of oil-film bearing in the process of roll was developed by 3-D elastic contact boundary element method. A program of automatically creating 3-D surface grid model has been developed to check data and display deformation, the properties of stress and deformation fields have been analyzed, the rules of 3D contact pressure distribution among contact areas have been quantitatively described, which provided an effective way to decrease wear and adhesive damage of sleeve, and to increase load capacity of oil-film bearing and its service life as well.

Keywords: oil-film bearing; fatigue failure analysis; contact problems; boundary element method

1. CALCULATION MODELS AND PARAMETERS

The mechanism model was properly simplified because of symmetrical force. Considering dynamic effects in load zones, and taking the contact behaviors between sleeve and roll neck into account, the internal end section of roll was fixed and its external one was free, whereas the displacement of the external end section of sleeve was axially constrained and the internal end section was free.

The sleeve was divided into 1874 nodes, 1868 elements by BEM, whereas the roll neck was divided into 996 nodes and 986 elements, there was 349 pairs of contact points in both bodies. The contact model was shown in Fig. 1.

2. NUMERICAL CALCULATING ALGORITHM

Based on the visualization flat of FPS and FORTRAN 90 programming language, some BEM programs have been developed to solve 3D elastic contact problems. Such special programs are used to calculate the contact pressure distribution of oil-film bearing in rolling mill. Moreover, programs to produce drawings automatically through Mechanical Desktop have also been developed. During the process of programming, the main program controls the subroutines that are used for various calculation and judgment. When solving the problems about two contact bodies [1-6], such information as pressure of contact regions, displacement and pressure of each node, as well as the deformed model could be got. The program could automatically distinguish the configurations of contact region, then automatically adjust its dimensions. (The program flow chart, symbols and algorithms descriptions are omitted.)

Table 1 Parameters for calculating load properties of oil film bearing

<table>
<thead>
<tr>
<th>Roll diameter d/mm</th>
<th>Roll length L/mm</th>
<th>Elastic modulus E/Mpa</th>
<th>Possion ratio</th>
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<tbody>
<tr>
<td>1550</td>
<td>2050</td>
<td>210000</td>
<td>0.3</td>
</tr>
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</table>

3. CALCULATING RESULTS AND DISCUSSION

According to the above models and parameters, load distribution of F3 stand mill in some mill group has been successfully calculated by BEM. The different contact pressure distributions under the loadcases with different rolling velocity are respectively shown in Fig. 2.
As is shown in Fig. 2 that pressure load of oil film under lower rotating velocity is obviously smaller than that under higher rotating velocity. Therefore, the contact pressure would be unevenly distributed in the contact surfaces between sleeve and roll neck, the contact pressure under low speed loadcase is evidently smaller than that under high speed loadcase. Moreover, the contact pressure in the groove is found to be the largest. The reason is that torque transmission during the rolling process is sure to produce stress concentration in the groove area and much less friction force in middle section than in the other two non-rolling sections. Such data is from on-spot inspection. Therefore, there are less linear contact area and much less friction force in middle section than in the other zones, while there is more wear in the both end sections of sleeve. (The corresponding friction force distribution under such loadcase is shown in Fig. 4(b)). Such result is consistent with sleeve wear of on-spot inspection.

Figure 3(a). Contact pressure distribution in axial section of sleeve under 4500t rolling force.
Figure 3(b). Friction force distribution in axial section of sleeve under 4500t rolling force.

Figure 4(a). Relative displacement distribution in axial section of sleeve under 4500t rolling force.
Figure 4(b). Friction force distribution in axial section of sleeve under 4500t rolling force.

As can be seen from Fig. 3(a), the contact pressure in the axial load zones in the inner surface of sleeve displays a distribution law of segmented feature. During the first third segment, the contact pressure shows the tendency of slow rise, while the contact pressure gradually decreases in the last third segment. Therefore, when expanding around sleeve circumference, the contact pressure in the axial direction of sleeve displays an distribution belt with three loop-like features. During the rolling process, great symplectic torque will be produced when the rolling force on roll is balanced by oil film pressure exerted between sleeve and bush. Because torque is transmitted through the coupled double keys, which connect sleeve and roll neck together, with the great deformation in the groove, relative tiny slide will consequently be produced in the contact load zones between sleeve and roll neck. Fig. 4(a) shows the tangential displacement of the deformed nodes in contact zones. Such tiny displacement in the tangential direction of each contact node is in accordance with fatigue mechanism of jiggle wear. i.e. friction force is accompanied with tiny slide.

It is just friction that causes wear in the contact section between sleeve and roll neck. During the continuously rotating process, pressure in load zones of oil film bearing is alternatively acted on the outer surface of sleeve without interruption, which results in the alternative function of contact pressure on different contact zones. The continuous expansion of contact wear is sure to produce uninterruptedly circumferential wear belt. Meanwhile, according to the parabolic contact pressure in the axial direction of sleeve and roll neck, the wear belt between sleeve and roll neck could not but display disciplinary distribution law of three loop-like features. With its continuous rotation on the supporting wheel, when the middle zone of roll neck wears under the rolling pressure, its outer surface is found to be lower 0.3 ~ 0.6 mm than that of the other two non-rolling sections. Such data is from on-spot inspection. Therefore, there are less linear contact area and much less friction force in middle section than in the other zones, while there is more wear in the both end sections of sleeve. (The corresponding friction force distribution under such loadcase is shown in Fig. 4(b).) Such result is consistent with sleeve wear of on-spot inspection.

REFERENCES