Worn Gear Contact Analysis

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QUESTION

How does one perform a contact analysis for worn gears?

Response provided by Dr. Stefan Beermann:

Wear is an ongoing process that decreases the quality of a gear with increasing number of load cycles. So typical issues addressed by a contact analysis of a worn gear is the transmission error caused by the deviations from the involute, and maybe the effect on the contact stress due to nicks and edges on the theoretically smooth profile. Also, the change in load distribution is of interest.

The information about the wear can come from two sides: it might be from simulation or from a real gear measured on an appropriate measuring machine. In the first case there is usually no problem to get the worn profile into the contact analysis. In the second case you have to be careful in the preparation of the profile data; scan the gear on a measuring machine. Use a high resolution, preferably more than 100 points-per-flank. Then the best next step would be to read the points into a CAD package and convert the points into a curve. For instance—a spline curve or circular arcs. Here you have to pay extra attention, since you might analyze approximation artifacts afterwards instead of the effect of the wear.

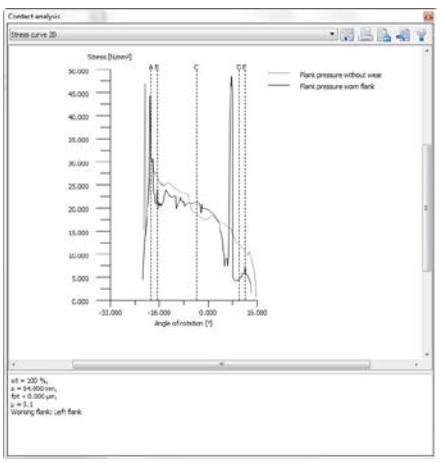

Figure 3 Hertzian pressure with and without wear.

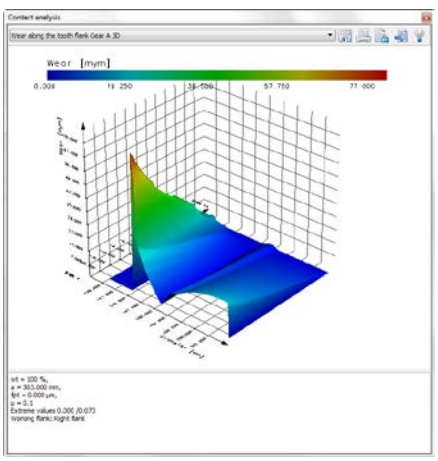

Figure 4 Wear on a gear set with misaligned axes.

The next decision is if you want to look at three-dimensional wear data or two- dimensional in a transverse plane. If the wear is more or less constant over the width, meaning along a constant diameter, the two-dimensional analysis is usually clearer in the results. This would be typical for plastic gears that often show significant wear due to sliding in the profile direction. However, metal gears also can show this type of wear, especially at slow speed or if micropitting occurs.

Should the wear significantly differ over the width—for example, if it is stronger in the middle or on one side of the gear—the three-dimensional approach is necessary. One would expect this if the gears are misaligned due to shaft deformations or tolerances. Sometimes wear can even help in these situations; i.e., an initially high $K_{H\beta}$ could be reduced due to wear in a running-in phase.

For a three-dimensional analysis the easiest way is to read the wear in as topological modifications. This way you can define the wear as a two-dimensional function over the whole flank.

Figure 1 shows the result of a simulated wear inside *KISSsoft* after performing contact analysis. You can see how the path of contact is completely torn apart. The respective transmission error shown in Figure 2 and the Hertzian pressure in Figure 3 show the bad effect of the wear: grey is the curve without wear; blue and black with wear. Of special interest in Figure 3 is the shift of the first contact to a later point in time, and the second peak in pressure towards the end of the contact.

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For the three-dimensional case you find the simulation of the wear over the flank for a gear set with misaligned axis in Figure 4. This would be the topological modifications that one would feed into the contact analysis to determine the transmission error, and so on.

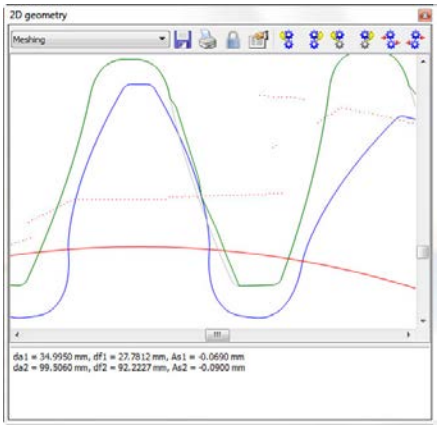

Figure 1 Contact points of a gear meshing with one (plastic) gear showing significant wear.

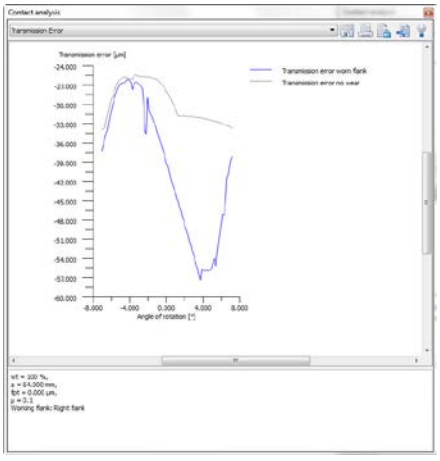

Figure 2 Transmission error with and without wear.

Dr. Stefan Beermann
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