Correlation of wear rate, hardness, and density for a dry clutch friction material

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The paper presents the results of experimentally established correlations between dry clutch friction material wear rate and hardness and density, obtained for a substantial number of friction plates from different production batches. The wear rate was reconstructed by using a custom-designed disc-on-disc-type tribometer and mass difference method. A strong positive correlation is observed between stabilized wear rate and hardness for the particular composite-made friction material. Similarly, a positive, although significantly weaker, wear rate vs. density correlation is demonstrated. Using the established correlations may facilitate friction material and clutch production and application quality-check processes.

Keywords: dry clutch, friction material, wear rate, hardness, density

1. Introduction

Dry clutch friction lining wear rate characterization with respect to temperature, slip speed, torque, and closing time inputs has been carried out in [1] by using a custom made dis-on-disc-type tribometer. The results recorded after the wear rate characterization experiments show a significant variation in stabilized wear rate between individual friction plates for the same operating conditions. Wear is typically described by the Archard's law [2] which states that wear decreases with increase of friction material hardness. However, for the considered case of composite materials, opposite influence of hardness on wear may occur [3]. Thus, relations between the wear rate, hardness, and also density is analyzed.

2. Test procedures

2.1. Wear rate
The wear rate is reconstructed in run-out phase (fully stabilized wear), based on clutch closing cycle tests and sensing difference in friction plate mass [1].

2.2. Hardness
The hardness was measured in accordance with the BS EN ISO 2039-1:2003 standard using a Zwick 3106 hardness tester. The measured values for three samples of each friction plate are averaged to get final hardness.

2.3. Density
The density was measured based on Archimedes law and by using the Ohaus PA64 precision scale. Again, the measurements over three samples are averaged.

3. Correlation results

Correlation between the stabilized wear rate and the hardness is positive (Fig. 1), where the overall correlation factor is 0.613 (Excel function *Correl*). A certain positive correlation (the correlation factor of 0.231, Fig. 2) is also found for stabilized wear rate vs. density dependence. Different friction material plate batches can have characteristic differences in wear rate, hardness, and density values, which is explained by production deviations. Certain outliers are contributed to measurement inaccuracies and throughput variations. The full paper will show that using the established correlations improves the wear rate modeling accuracy.

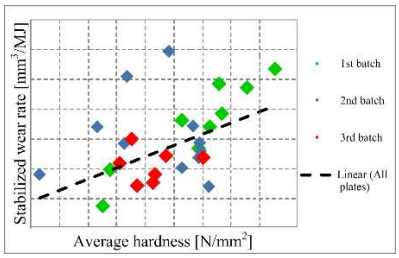

Figure 1: Correlation between wear rate and hardness.

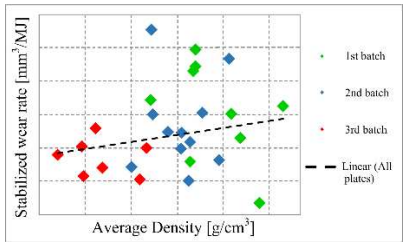

Figure 2: Correlation between wear rate and density.

4. Conclusion

A strong positive correlation between stabilized wear rate and hardness for dry clutch friction material has been evidenced, meaning that harder material exhibits higher wear in the particular case of composite-made friction plate. Similar, albeit weaker correlation has been observed for stabilized wear rate vs. density dependence. The established correlations, particularly the hardness-related one, can be used for predicting stabilized friction material wear rate based on non-invasive, routine tests of friction plate material. This may improve the production processes and quality checks, both on the side of supplier chain and automotive application.

5. References

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