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Analytical Models on Optimization of Internal Gear Skiving Conditions in Automobile Production

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[Abstract]

This research is aimed to propose and provide analytical models that can effectively optimize process conditions of an internal gear skiving.

In ordinary gear cutting methods such as hobbing and gear shaping, many studies have been made and this enable efficient optimization of process conditions by means of simple geometrical calculations. However, in case of skiving, a few studies with regard to process conditions can be found, as a result optimization of process conditions are conducted empirically. Therefore, in this research several analytical models that can be useful in effectively selecting process conditions were proposed.

At first, method for designing skiving cutter was introduced. In this method, the cutter tooth flank was generated by the gear to be cut, by means of solving the equation of meshing. Then, the cutting edge was extracted as the cross line constituted by a plane that consider both step angle and rake angle with the generated conjugate surface. Series of coordinate transformations were applied in order to represent the cutting edge on the blank coordinate, so that the skived gear could be evaluated.

Secondly, the effect of cutter design parameters such as cross angle, offset angle and rake angle on the cutting depth, clearance angle and effective rake angle were analyzed for purpose of optimizing the design parameters. Optimum parameters were proposed and together with the experimental results and their validity and effectiveness were discussed.

Thirdly, based on the optimization results, analytical models that can calculate profile and lead deviations of a skived gear was proposed. In this model terms that take into account inevitable tool setup and manufacturing error such as run-out and pitch error were added. Comparing the analytical results with the experimental ones, the proposed model showed to be useful in effectively choosing the appropriate process conditions.

Next, model that can estimate the fluctuation frequencies of cutting forces for purpose of reducing vibrations that may happen during the cut was proposed. In the model, the cutting

force was assumed as a sum of vectors that represent cutting depth; i.e., only the thrust component of the cutting force was taken into account. Given the natural frequencies of the cutting machine, cutter rotation speed that is most likely to reduce vibrations were predicted. Experiments were also carried out in order to verify its effectiveness. As a result vibrations and gear accuracy was consistent with the predictions, which means that the proposed model is useful.

Finally, as the overall result, mass production of internal gear for automobile by skiving method was achieved. Thanks to previous mentioned studies on cutter design, cutter design optimizations, process conditions optimizations, techniques to avoid vibrations during the process, enabled the implementation of this method in mass production.