Niniejsza rozprawa powstała w wyniku realizacji jednego z zadań projektu pn. „Doktorat Wdrożeniowy"- II edycja, finansowanego ze środków budżetu Państwa.
Id projektu: 410487, nr rej.: 0062/DW/2018. Dofinansowanie projektu 1 875 720 zł.
Całkowita wartość projektu 1 875 720 zł.

Politechnika Śląska

Dyscyplina Naukowa
Inżynieria Lądowa, Geodezja i Transport

ROZPRAWA DOKTORSKA

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Optymalizacja ilościowej i jakościowej analizy przekładni zębatych dla wybranych silników elektrycznych

Optimization process of quantitative and qualitative analysis of the gearbox for selected electric motors

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Katowice, wrzesień 2023 r.

ABSTRACT

Gearboxes are still one of the basic solution of the drive systems for many various trasnport systems, for e.g. in motor vehicles, rail vehicles, aircrafts or water transport. In addition to that they are used also as a basic drive system in wind energy sector as well as widely described machine sector. Wide and common usage of the gearboxes was presented in details in the first chapter.

Vibroacoustic properties of the gearbox are one of the most important properties of the gearbox itself. They are related directly with the gearbox vibration. The basic source of it is of course gear meshing zone, but at the later stage the generated vibration is transmitted respectively to the gears, shafts bearings and finally to the gearbox housing.

Gearbox housing internally excited (vibration generated by the gear meshing) and externally excited (like in thesis – reaction forces from the forklift main wheel), has the major impact for the surrounding environment as well as for the mating components and machines. Finally this interaction might lead to the occurrence of the resonance vibration.

Taking for account all the above statements it is clear how important is the process which leads to proper estimation of the dynamic and vibroacoustic properties of the gearbox during the design phase. Complex numerical model which includes all required parameters like geometrical parameters, materials and physical parameters as well as estimated working conditions might get the answer for the most of the questions related to the working process of the newly designed gearbox. But the most important is that this numerical modelling process will shorten the lead time to introduce the new product to the market as well as this will reduce the total costs of the prototyping and testing this product.

Most of the engineering questions will be answered based on the numerical model prepared by the author. Complexity of the model will be defined by including in the numerical modelling process various physical phenomenon which include the cases like: linear statics, linear dynamics (normal modes), linear dynamics – harmonic response and finally – vibroacoustic analysis.

Previously prepared numerical model was also validated with the measurement data taken from the gearbox test bed. Testing object – industrial gearbox marked as TDB 2360 – was tested and checked at the dedicated test bed (acceleration measurement at the gearbox housing). Such kind of measurement data were next compared with the same type values taken from numerical modelling.

In additional to that and taking for account that the author got the permission for

extension of the PhD thesis it was decided that the physical test bed will have to be upgraded. There were some margins observed which potentially could lead for the improvements of the measurement process itself as well as the improvement to get the better quality measurement data. Based on that author upgraded the current design by changing and applying into normal productions process the way, how the sensor is attached to the gearbox during the test. This sensor (single axis acceleration sensor) was completely separated from the moving cage and it was, at the same time, attached directly to the measured gearbox housing. Based on that all the unwanted and externally sourced vibration was completely removed from the system. Additionally – the human factor (operator at the dedicated stage) was also reduced.

Topics covered by this PhD thesis are also very important for the complete research and development processes at the R&D department within the ABM Greiffenberger company. The proposed methodology (the way how the numerical model is prepared and built), which include complexity of the gearbox working conditions are highly appreciated and supported by the rest of the R&D team. This methodology allows for massive time reduction costs when it not only comes to prepare the virtual model. This allows for the optimization of the process costs – many various, like design costs, validation costs, production costs etc.

Finally it can be stated that the utility process of the proposed methodology of the gearbox testing is highly recommended for everyone, who is interested with the design and numerical modelling of the complete systems together with their physical testing.

Finally it can be tested that the utility level of the PhD thesis is very high.