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New approach for bearing life cycle control

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Abstract

This paper presents a new approach for the control of the life cycle of bearings in machine tools. A new simulation tool has been developed using the well-known ISO 281 standard as a reference. This new tool improves the accuracy of the estimations in two fields: model-based and feature based prognostics. On the one hand, the tool is able to provide accurate end-of-life estimations thanks to the determination of accurate component loads for a defined manufacturing cycle. In addition, this new tool is able to be embedded in monitoring devices in order to use real machine tool usage data and calculate Remaining Useful Life of the analysed component. This last application can be combined with vibration monitoring of the bearing in order to detect unexpected component degradation.

Keywords: Life Cycle; Simulation; Condition

1. Introduction

Europe has world-class capabilities in the manufacture of high-value parts for such competitive sectors like aerospace and automotive and this has led to the creation of a high-technology, high-skill industry.

Simulation tools are currently a key complement to European machine tool industry expertise in order to increase competitiveness. In fact, according to Industry 4.0 [1] modeling plays a key role in managing the increasing complexity of technological systems. A holistic engineering approach is required that spans the different technical disciplines and

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providing an end-to-end engineering across the entire value chain. As noted by Abdul-Kadir et al. [2], “the developed tools are still not capable of supporting an inclusive simulation package”. In addition, the more and more important lifecycle concepts like energy consumption and component end-life and degradation are not always present in machine tool builders and part manufacturer’s calculations.

Another key principle of Industry 4.0 is to increase the knowledge of the process obtained through monitoring [3]. This knowledge can be applied, for example, for process control [4] and maintenance actions optimization [5]. The combination of models and process monitoring will be useful not only in the development and design stages, but mainly during the production stage in order to check that production is running smoothly, detect wear and tear without needing to halt production or predict component failure and other disruptions.

Twin-Control (http://twincontrol.eu/) is a novel concept for machine tool and machining process performance optimization. It combines a holistic simulation model, integrating most important features of machine tools and machining process, with monitoring and data management capabilities (Fig. 1).

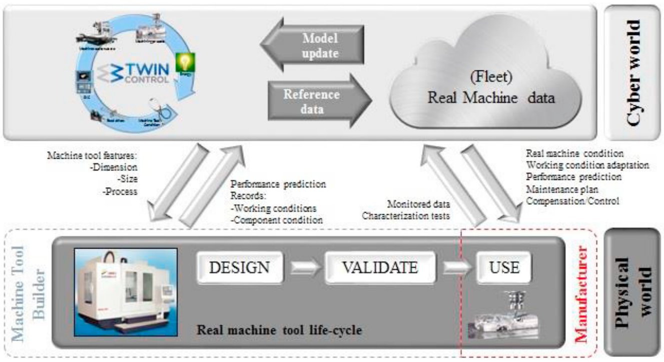

Fig. 1. Twin Model concept used in Twin-Control project.

This paper is composed of four sections. The first one presents the introduction and context of this research. The second one introduces the proposed new approach for bearings lifecycle study. The third chapter presents the background of the proposed approach and the developed calculation module. Next, a summary of some preliminary results obtained in experimental tests is provided. Finally, the conclusions and the future steps are presented.

2. Bearing life cycle control approach

Since the first patent related to bearings was published in the 18th century, these mechanical components have been widely used in almost every engineering field and they continue being a proper mechanical solution to a vast variety of design challenges. Thus, the improvements in engineering theoretical and experimental tools and more efficient industry processes have led to the need to perform exhaustive research on bearing life prediction methodologies.

Bearing life estimation theories started on 19^{th} century with the testing of rolling bearings performed by Strickbeck [6]. Goodman and Palmgren [7, 8] continued the work on the 20th century introducing the important concept of fatigue limit in rolling bearing life. A new milestone was set by Weibull [9] with his statistical theory of the strength of materials and in the 60s Lundberg and Palmgren [10, 11] presented their life theory of rolling bearings. This was the basis for the current L10 formula for the basic rating life of rolling bearing. Moreover, more accurate testing methods and complex analysis tools have let the researchers improve the rating life estimations and the modified rating life [ISO281] has become a powerful tool for better life predictions, taking into account aspects like oil condition or fatigue load.

Anyway, the deterministic prediction of the initiation of a failure in a specific bearing is impossible. For fatigue damages, bearing diagnostics is a powerful tool for avoiding undesired failures. Furthermore, if a bearing present some evidence of wear instead of rolling contact fatigue, the lifetime cannot be mathematically predicted on a statistical basis.