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Development and implementation of smart maintenance activities for machine tools

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ABSTRACT

Analyzing and revising current machine tools with regard to their maintenance-friendliness, servicing and inspection activities leads to a split-up between production and maintenance responsibilities. The illustrated algorithm allows for the identification of collateral components which require replacing when adjoining components are replaced even though their own service life is not yet exceeded. A modularization approach was elaborated for the application of this method reducing the design of a machine tool to maintenance-relevant parameters. The respective routines were programmed in a software environment for an easy and quick implementation and launched for an exemplary machine tool.

1. Introduction and motivation

The increasing costs of investment for modern production systems make it indispensable for their operators to achieve the optimum utilization of their machines [1]. The evaluation is increasingly based on overall equipment efficiency (OEE). OEE includes the factors performance, quality and availability [2]. As far as technical aspects are concerned, availability offers the biggest potential [3]. One possible approach to increase availability is the optimization of maintenance-friendliness [4].

2. Objective

The objective of the "maintenance-friendly machine tool" project is to increase machine availability and, thus, overall equipment efficiency. The analysis and modification of a machine tool support the consistent application of TPM (Total Productive Maintenance). The progression of wear should be slowed down to a larger extent than before by maintenance services carried out by machine minders, and the period required for repair work is reduced through design for maintenance. Thus, availability can be improved through an increase of MTBF (mean time between failures) and reduction of MTTR (mean time to repair) (Fig. 1).

As part of this project, two approaches are pursued that are both trying to increase maintenance-friendliness. Maintenance-friendliness can be improved selectively through design-based or organizational countermeasures on the basis of analyses of critical assemblies and components. Plus, so-called collateral parts can be identified, which, for reasons of profitability, should sensibly be replaced as part of scheduled maintenance instructions even though their service life may not yet have been reached.

3. Approach

An evaluation system is developed for the identification of components and assemblies that are critical in terms of maintenance-friendliness; called index for maintenance-friendliness (IMF). Parallel, an algorithm is generated for the identification of the so-called collateral components (AIC). The implementation of the methods requires data from the manufacturer and the operating company to be taken into consideration as part of an integral approach (Fig. 2) [5]. In the next step a modularization of the whole machine tool based on the maintenance activities is introduced. With these results actions to enhance the maintenance-friendliness can be taken. A practical implementation will show the suitability for daily use in a real production environment.

4. Index for maintenance-friendliness (IMF)

Many machines in modern industry countries are usually operated by skilled, highly qualified workers whose activities in some areas are limited to monitoring machines and to relatively short set-up times compared to long machine operating times. This

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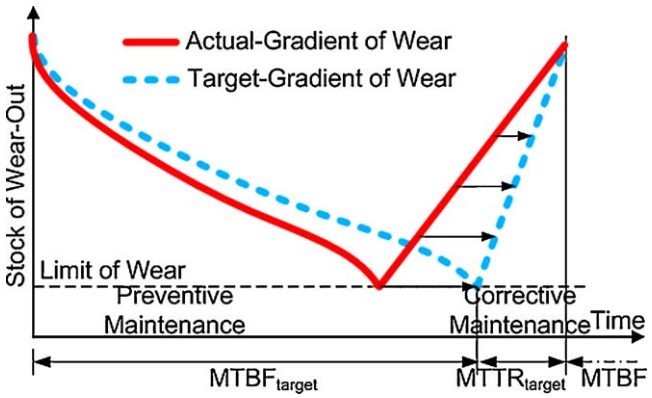

Fig. 1. Aim.

is enough time that maintenance could be carried out by the machine operator himself. The IMF shall serve as decision guidance for dividing maintenance and inspection activities between maintenance staff and machine operators.

The IMF assesses a single maintenance or inspection activity according to six factors (Fig. 3). The IMF is used to identify critical activities in terms of mean time and level of difficulty as well as critical assemblies in terms of maintenance intervals, mean time, costs and level of difficulty. It serves as a direct instrument to identify and deduct flaws of single assemblies in terms of maintenance. The resulting findings can be used to modify existing machines or to improve future machine concepts. Since operators can determine the bounds of individual factors themselves, a value of 100% means that, from the operator's point of view, no more improvements can be achieved as the maintenance activity exactly meets the operator's expectations. All bounds in the following tables result on field data (standard deviation) and specific, individual requirements. These bounds may be set in a different way in order to consider specific demands.

4.1. IMF components

Except for the level of difficulty, which is assessed according to ERA–TV [6] (collective wage agreement), a minimum and a maximum tolerable value have to be specified for all IMF addends. Both values can be chosen freely by the machine operator and thus can be adapted to existing framework conditions. In the course of this paper exemplary values will be used for IMF calculation. The starting point for the assessment of individual factors was the credit system specified in the ERA collective wage agreement.

4.1.1. Difficulty of an activity (D)

Generally speaking, the difficulty of an activity is very subjective and can therefore not be measured in numeric values. It is, however, an important element of wages which is why this paper draws on the ERA collective wage agreement for Baden-Württemberg, Germany [6] in order to assess the difficulty of a specific activity. This agreement is based on five different types of requirements which are classified according to different levels. The difficulty of an activity is characterized by the amount of specialized knowledge needed for the job, vocational training, work experience and on-the-job training. The assessment of the level of difficulty often serves as a direct element for wage finding,

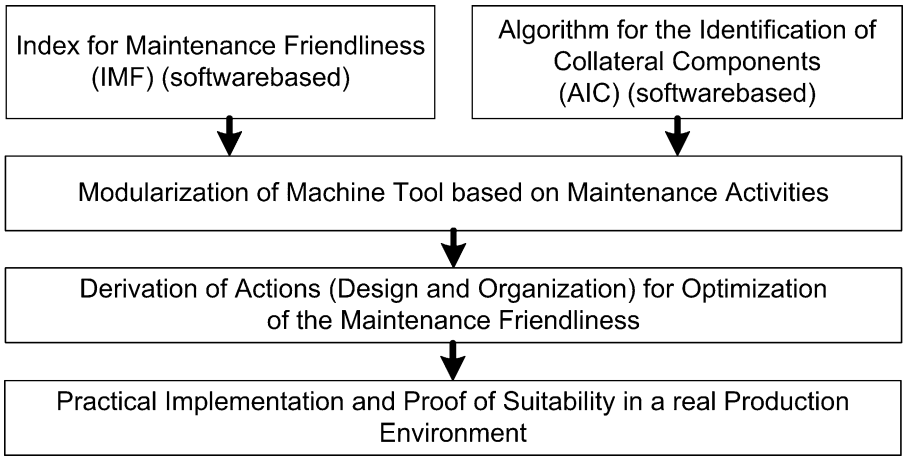

Fig. 2. Approach.

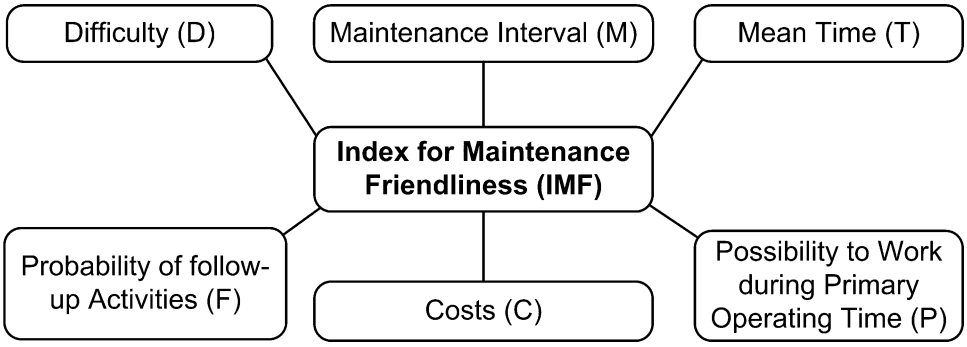

Fig. 3. Factors of index for maintenance-friendliness (IMF).