Implementation of Machine Tool Remanufacturing Management System

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Abstract. Aiming at the information management problems of machine tool information, remanufacturability evaluation information, parts information, processing technology and remanufacturing design information in the process of used machine tool remanufacturing, a web-based machine tool remanufacturing management system was developed. The system can flexibly and efficiently manage all kinds of information data in the process of machine tool remanufacturing, and satisfy the function of user's remanufacturing evaluation and design. The system is mainly consisted of the four functional modules and related model databases including machine tool information management, estimation of remanufacturing cost, assessment of remanufacturing process resource environment property and remanufacturing processes management. The implementation of the system effectively helps enterprises to solve the problem of information processing in the whole remanufacturing process, and realizes the standardization of the process.

Keywords: Machine Tool Remanufacturing, Management System, Remanufacturing Processes Management

1. Introduction
Remanufacturing is considered as a useful end-of-life strategy that can help reduce the overall environmental burden from the product by processing waste materials while at the same time keeping reliability high [1]. Recycling and remanufacturing of end-of-life products are value-added processes and have great environmental benefits[2]. Remanufacturing engineering can bring the used products back to life and solve the problems of resource and energy conservation and environmental pollution. Remanufacturing engineering has developed rapidly in China. Remanufacturing engineering has not only entered into national laws, but also has some staged results in terms of practice and basic research. China has become one of the international remanufacturing centers.

Machine tool is a typical mechatronics equipment, which has high recycling value and remanufacturing potential. In the remanufacturing process of the used machine tools, it is necessary to use information technology to evaluate and manage the whole process. First, the remanufacturability...
of the used machine tool products needs to be evaluated, secondly, the remanufacturing design and process plans need to be effectively managed, and finally the remanufactured machine tools need to be evaluated and managed. Energy saving and emission reduction is an important strategy for the development of China's manufacturing industry, and remanufacturing is an important measure among them[3-4]. Literature [5-7] researched the remanufacturability evaluation methods and models from the aspects of technology, economy, and environmental impact. Literature [8-10] researched the process of remanufacturing products and prediction of remanufacturing cost. The above theoretical studies lack effective and practical tools to achieve their functions.

In this paper, the remanufacturing management system of machine tool is designed and developed. The information management technology is applied to the development process of machine tool remanufacturing. The Remanufacturability is evaluated from the economic, technical and resource environment. This system can effectively help technicians carry out remanufacturing problems of machine tools, and provide remanufacturing information management functions such as process plans and performance reports.

2. Architecture of machine tool remanufacturing management system

The machine tool remanufacturing management system adopts B/S structure, and users interact with the system through browser. The system programming language is java language, MyEclipse is used as the development tool of system software, and the development environment is Tomcat server and MySQL database. The system is developed based on SSH framework, which can achieve division and cooperation between business layer and persistence layer, and realize MVC mode, namely, complete separation of model, view and controller. If we modify the view layer web page, we only need to make appropriate adjustments in the model layer, which will not affect other layers. While improving the reusability of the system, it reduces the coupling between layers, which is conducive to improving the efficiency of developers. The system architecture is shown in Fig. 1.

![Machine tool remanufacturing management system architecture](image)

**Figure 1.** Machine tool remanufacturing management system architecture.

From the beginning of the used machine tool remanufacturing, technicians need to input the information of the used machine tool in the system, evaluate its economy, resource and environment consumption, modify the used machine tools that have passed the evaluation, and record the corresponding modified information. The workflow is shown in Fig. 2.
Figure 2. Machine tool remanufacturing management system architecture.

The system operation steps are as follows:

(1) After the user logs in to the system, enter the basic information of the remanufacturing machine tool, including the name, type, and number information of the remanufacturing machine tool and its subsystems and units, the remanufacturing machine tool acceptance time, and the remanufacturing machine tool delivery time, etc.

(2) Estimation of remanufacturing cost analyzes from the three aspects of machine tool recycling cost, remanufacturing cost, and comprehensive cost, and then considers whether it can move on to the next step after comprehensive consideration.

(3) Assessment of resource and environment evaluate the impact of resources and environment in the remanufacturing process of machine tools to determine whether it is possible to move on to the next step. In this assessment, the resource and environment problems involved in the remanufacturing process are used to determine the impact index, which is divided into factor level I and factor level II. The weight of each index is determined by AHP, and the resource and environment assessment is carried out according to the scoring rules.

(4) During the remanufacturing process of the machine tool, it needs to be performed from three aspects: mechanical precision recovery, motion accuracy recovery and improvement, control performance improvement. The system stores the corresponding procedures and data.

(5) The system evaluates the performance of remanufactured machine tools. The system can query, add, modify, and delete information such as the original information of the remanufacturing machine tool, the design information of the remanufacturing machine tool, the process information of the remanufacturing machine tool, the information of the remanufacturing part, and the resource and environment attributes.
3. Function module of machine tool remanufacturing management system

Machine tool remanufacturing management system includes five main function modules: basic Information management module, estimation of remanufacturing cost module, assessment of resource and environment module, remanufacturing management module, user management module, as shown in Fig. 3.

![Diagram of Function module of machine tool remanufacturing management system.](image)

**Figure 3.** Function module of machine tool remanufacturing management system.

3.1. Estimation of remanufacturing cost Module

The cost of remanufacturing machine tool $M_R$ is mainly composed of the purchase cost $M_1$, the remanufacturing processing cost $M_2$, and other costs $M_3$.

1. Purchase cost $M_1$. The cost of remanufacturing companies buying used machine tools from the market.

2. Remanufacturing processing cost $M_2$. $M_2$ includes remanufacturing man-hour cost $M_{21}$, component replacement cost $M_{22}$, and material consumption cost $M_{23}$. The component replacement cost refers to the replacement cost of wearing parts such as bearings and paddling. The remanufacturing man-hour cost includes the man-hour cost of dismantling, cleaning, testing and classification, reprocessing, and reassembly. Therefore $M_2 = M_{21} + M_{22} + M_{23}$.

3. Other cost $M_3$. The apportionment expenses of the enterprise operation, such as management expenses, sales expenses, etc.

The cost of remanufacturing machine tool $M_R$ is expressed as: $M_R = M_1 + M_2 + M_3$.

With the improvement of machine tool remanufacturing technology, the performance of some machine tools after remanufacturing can reach the new machine tool performance, and some accuracy indexes even exceed the new machine tool. Therefore, when the price of remanufactured machine tools is lower than that of new machine tools with almost the same performance, remanufactured machine tools will have a greater purchase attraction for customers. This system choose 90% of the price of new machine tools as the evaluation standard.

3.2. Assessment of resource and environment Module

Used machine tools are a kind of electromechanical products with great remanufacturing value. The bed, columns and other basic components can be directly reused. After remanufacturing and repairing
parts such as guide rails, spindles, and saddles through advanced surface engineering technology, they can be directly reuse. In the remanufacturing process, it will bring resource consumption and environmental emissions, such as noise and pollutants generated during dismantling, and environmental pollution caused during cleaning. Therefore, it is necessary to evaluate the resource and environmental attributes of its remanufacturing process and determine whether it can be beneficial to remanufacturing in order to comply with the development concept of circular economy and environmental protection.

The evaluation of resources and environment adopts the comprehensive evaluation method of AHP and fuzzy evaluation. Its main evaluation indexes include auxiliary raw material consumption, energy consumption, air pollutants, water pollutants, solid wastes and physical pollutants. The impact degree of resources and environment is quantified by the 10 point scoring method, and it is divided into different grades, as shown in Table 1. According to the scores, the impact degree of resources and environment is judged. If it is at or B, it indicates that it can be remanufactured.

**Table 1.** Degree of impact on resources and environment.

| Quantification | E  | D  | C  | B  | A  |
|----------------|----|----|----|----|----|
| Score          | 10 | 8.9| 5.67| 2.34| 1  |

3.3. **Remanufacturing management module**

The machine tool remanufacturing process steps are divided into disassembly, cleaning, inspection and classification, remanufacturing, assembly, commissioning and acceptance. Remanufacturing is mainly performed from three aspects: mechanical precision recovery, motion accuracy recovery and improvement, control performance improvement. The mechanical precision recovery, mainly repairs the basic parts of the machine tool, including the bed rail, the spindle box, etc. The motion accuracy recovery and improvement include the remanufacturing of the transmission system and the modification of the tool holder. The control performance improvement mainly includes CNC system, servo system and auxiliary system. Remanufactured machine tools are inspected strictly in accordance with the factory standards of similar CNC machine tools.

Based on the above-mentioned process flow and remanufacturing content, the system records various types of information and data in the remanufacturing process of the machine tool, including remanufacturing design information, remanufacturing process information, remanufacturing component information, remanufacturing drawing information, and so on. The system uniformly manages this information, making it easy and quick to query, call and modify in the system, improving work efficiency and shortening the remanufacturing cycle.

4. **Conclusion**

Machine tool remanufacturing can effectively solve the problems of low utilization rate and low technical level of used machine tools, which is in line with the development trend of circular economy and green manufacturing. In this paper, a software support system is designed and developed based on the work flow of machine tool remanufacturing, which can effectively manage the information data from remanufacturing feasibility evaluation to remanufacturing process. This system can effectively help remanufacturers evaluate the remanufacturability of machine tools, manage various types of process data, help analyze and improve remanufacturing processes and methods, and promote the informationization and standardized development of machine tool remanufacturing.

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