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ENGINEERING MANAGEMENT TREATISES

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Engineering Management Problems of Remanufacturing Industry

Abstract Remanufacturing in China is still in its early stage and faces pressures from society, policy, technology and management. Considering the current state of remanufacturing in China, this paper researched several key management issues involving various aspects from the perspective of remanufacturing players. Based on a needs analysis on the trend of remanufacturing development in China, the following six key management problems were researched; risk management of remanufacturing players, remanufacturing production management, remanufacturing quality management, authentication mode of remanufacturing in China, subsidy policy of remanufacturing industry, and performance assessment of remanufacturing. The characteristics of issues were analyzed and the corresponding countermeasures were put forward.

Keywords: remanufacturing, industrialization, engineering management

1 Introduction

The whole expense of production, from preliminary study, design, manufacturing, usage, maintenance, to discarding, was regarded as whole life period expense (Xu, 2007). The first half life, which possessed only 20%−30% expense, was paid great attention to in the traditional notion. Whereas the afterlife, which possessed 70%−80%, expense was ignored (Xu, 2008). Taking the second parts (after life, i.e., usage, maintenance, discarding) as the investigation target, Remanufacturing focuses on rebuilding or upgrading the performance of discarded products and gives them a new life (Xu, 2009).

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2 The conception of remanufacturing

Under the guidance of LCC theory, taking upgrading the performance of discarded products as a goal, high quality, resources & energy saving and environmental protection as the rule, advanced surface engineering technologies as key technologies, and industry production as development ways, Chinese remanufacturing is generic terms of a series of technique applications and engineering activities. It characterizes that the quality and performance of remanufacturing products are the same or better than the new ones while costing half, saving energy 60%, saving material 70% and decreasing the harmful effects on the environment (Xu, 2010).

The process of remanufacturing is shown in *Figure 1*. The old and discarded equipment are to be disassembled at first, and then the parts are cleaned and classified, where after they will be inspected to determine whether they are suitable for remanufacturing, and then the suitable ones are further processed to restore or upgrade the quality and performance. At last, they will be reassembled together with other parts to build new equipment (Zhu & Yao, 2009).

3 Development of remanufacturing

Remanufacturing has been developing in China for about 10 years. Chinese remanufacturing receives much attention and places more emphasis on technique. Remanufacturing is still in the primary stage of industrialization and the faultiness of supporting policies and management methods are prime reasons. The resistance comes from the following four aspects (Liu, Xu, & Shi, 2010).

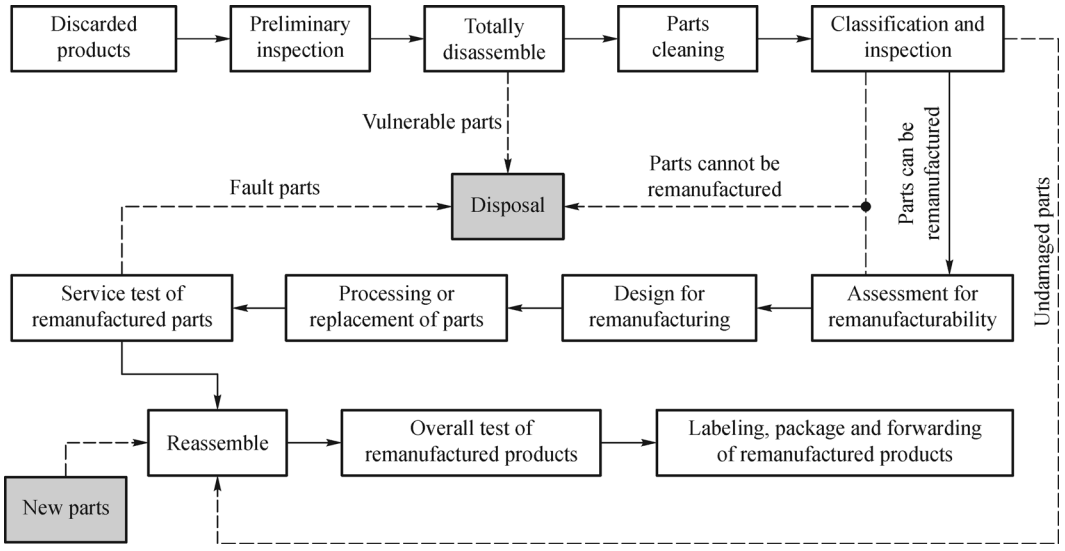

Figure 1. Process of remanufacturing.

3.1 Society

Chinese remanufacturing mainly develops in the domains of auto engines, generators, gear-boxes, starters, machine tools, etc. Remanufacturing products, including complete appliances and parts of which, have re-entered the market. Naturally, the recognition of remanufactured products is lower. Most buyers cannot differentiate the concepts of remanufacturing, as opposed to repaired equipment, and think of them as the same. They hold the idea that remanufactured products are second hand goods, and their quality cannot meet their requirements. The result is difficulty in the marketing development of remanufacturing products.

3.2 Industry

The disagreement of remanufacturing criteria causes chaos in the remanufacturing market. Some companies, big and small, claim that they are remanufacturers, but, in fact, they are just maintenance or repair businesses. They cannot offer the warranty of quality and performance for their products equal to (or nearly equal to) new products. These differences have been obstacles in the normal development of remanufacturing.

3.3 Company

The remanufacturing companies (remanufacturers) have lots of troubles in their development processes because there are conflicts in or an absence of government policies. There are difficulties on the establishment of reverse logistics net and shortages of professional employees and/or special equipment. The uncertainty of the quality of recovered materials, the complexities of production and the lack of a functional remanufacturing information system are all hindrances to the development of remanufacturing.

3.4 Technology

The development of Chinese remanufacturing is dependent on maintenance engineering and surface engineering. The technologies used are primarily surface engineering technology, nano surface engineering technology and automated surface engineering technology. These technologies are being adopted by more and more remanufacturers who, nevertheless, stay away from production-scale application because of high standards and technical demands. Such companies are keenly aware of immaturities of some key technologies. As a result, this blocks the way to remanufacturing industrialization.

4 Engineering management of remanufacturing

In the traditional manufacturing supply chain, there are steady supplies for materials or parts inventory and a fixed production flow or process, as well as lead time and rated man-hours. Mostly, a Material Requirements Planning (MRP) system can be used to achieve the information-based JIT (just in time) management. The situations remanufacturing faces are fairly complex and have never been a part of manufacturing (Guide, Jayaraman, & Srivastava, 1999; Guide, 2000). Chinese remanufacturing faces the same problems that Nasr had mentioned, such as uncertainty in recovery amount and breakage status of scrapped products, disassembly and cleaning rate, etc.

(Nasr, Hughson, Varel, & Bauer, 1998). These can be accounted for by the lack of fixed rules in remanufacturing management methods.

4.1 Remanufacturing operation management

Here, operation management includes logistics (both forward and reverse) management, inventory control, production planning and quality control. Because of that, the remanufacturing products are present only in the market for service after sale in China. Therefore, a remanufacturer generally appears as a contract remanufacturer or part of an OEM. They actually need authorization from manufacturers to develop remanufacturing activities on the corresponding products. Compared with those whose products can be sold in any market; the problems mentioned above may be relatively easy to treat.

4.1.1 Reverse logistics management

The sources of cores are vital to remanufacturers, also the establishment of reverse logistics, and there are many research findings and research programs about it. The objective of logistics management is to achieve the benefit of maximization to every participant in the supply chain. But, most research on reverse logistics management are qualitative analyses or case studies and do not associate reverse logistics with traditional forward logistics (Da, Huang, & Zhang, 2004). Moreover, the majority of research fell into the considerations on static objects or single operation cycle and was limited by several ideal assumptions. They focus on the structure of organization of the logistics system while ignoring the studies on the structures of information or decision of the system. So, the studies on logistics management in remanufacturing field need further research and discussions.

However, maybe the most effective channel to get cores is the simplest one now, i.e., remanufacturers get the cores through the channel they sell products, but reverse. The authors have examined a representative remanufacturer, whose products are heavy-duty auto engines, both new and remanufactured, and its cores have 3 sources: a) returning for defects under warranty, b) purchasing through its contract distributors or service shops, and c) doing as a contractor, there into, the 3rd source is stable. The ratios of them are approximately 20%, 60%, and 20% respectively. An average of the logistics cost of each discarded engine is about 600 CNY.

4.1.2 Inventory control

In manufacturing, inventories may be monitored and controlled through a MRP or ERP system and approximately calculated based on EOQ or EPL models. But there are still no complete theoretical or practical systems to better develop the inventory management in remanufacturing (Van der Laan, Dekker, Salomon, & Ridder, 1996). So, Qiao and Da suggested that more studies on remanufacturing inventory control should proceed (Teunter & Van der Laan, 2002).

For Chinese remanufacturers, there are two typical inventories, namely cores inventory and remanufactured inventory. There are few stable sources of cores for OEMs to develop remanufacturing, and they must encourage their franchisers to reclaim the discarded products from users. Because the requirement is finite and the recovery ability is greater than that of sales, so the cores inventory is inevitable. The remanufacturer must limit the number of recovered discarded products for remanufacturing. However, there is a forecasting for requirement in the next period (maybe one year) and according to a certain fluctuation the recovery planning is drawn. Here, the remanufactured inventory is restricted, and of course a reserved stock is needed.

4.1.3 Production planning

The production planning is influenced by many other uncertain factors, such as customer demands, recovery rate of cores, disassembly rate, reusable rate of old parts and production time for different old parts, etc. Cheng and Su introduced the methods usually used in remanufacturing production planning and production scheduling and generalized the troubles they faced at present (Cheng & Su, 2008). For example, lack of effective methods to describe the uncertainties, absence of tools for model building, difficult to construct the general structural system and so on. Based on the analysis on the uncertainties in the processes of recovery, disassembly and production in remanufacturing, one may draw the conclusion that the methods of production planning and control in manufacturing cannot meet the requirement of that in remanufacturing. They also indicated that constructing and optimizing the model of medium and short-term production planning is certainly a problem needing a resolution, as well as the corresponding capacity requires planning.

In fact, the production planning of remanufacturing is born by marketing planning in China. Now, the production capacity of a remanufacturer is greater than actual production quantity because of the finite requirements. According to the experiences of J Company, an OEM remanufacturer, the number of old parts after cleaning should keep at a certain level that is higher than the predictive requirement level of a some period to ensure the continuous production and avoid idle capacity. Sometimes, the adjustment of production capacity is necessary because of the change of requirements. The authors can say that the situation will be more complex in the optimistic future.

4.1.4 Quality control

It has been stated that the quality of remanufacturing products is better than that of the new ones of same type. The remanufacturers say so, too. But how to prove it is not an easy business and there is no compelling argument for it. Combining remanufacturing quality characteristics with customer satisfaction, some researchers tentatively constructed the evaluation house of quality of product characteristics for remanufacturing based on quality function deployment, and put forward the idea of dealing with multi-life cycle quality management based on particularity of multi-life cycle and the ecological quality loop (Chen, Liang, & Ma, 2007). But they also acknowledged that the specific tools and methods are not yet ascertainable.

Now, we can just say that the improvement of parts in performance or quality will result in the better products and may, in turn, provide a longer life. Considering the techniques used in cores, the quality control must pay attention to the CCQs mentioned above. So the quality inspection program will be determined following the production programs and CCQs and some methods or tools generally used in manufacturing.

4.2 Remanufacturing standards system

The remanufacturing standards system is important to both R&D of remanufacturing technologies and remanufacturing engineering management. An effective integrated assessment system for remanufacturing is necessary to insure the development level of remanufacturing. At present, Chinese remanufacturing is in the incipient stage of industrialization, there is no more accumulation on techniques and experiences. The establishment of Remanufacturing Standards System (RSS) and Remanufacturing Integrated Assessment System (RIAS) will be helpful for optimizing production structure and normalizing production development.

Remanufacturing is an industry relating to lots of different product areas. Therefore the standards system is complicated. Here, both general character standards and directed standards are needed. According to development form and characteristics of remanufacturing, the frame of RSS was put forward by China National Institute of Standardization, just as *Figure 2* shows.

RSS includes basic standards, technology standards, operation standards, quality control standards and management standards. Among them are detailed speaking, standards on remanufacturing terms, lifecycle costs evaluation technologies, disassembly technologies, green cleaning technologies, life evaluation and forecasting technologies. Nano surface engineering technologies, automated surface engineering technologies should also be included. Some mature manufacturing standards can be consulted or used directly.

There was no running national remanufacturing standard until the end of 2010 in China, but some enterprise standards or industry standards are running in remanufacturing firms. In addition, some research units and remanufacturing firms take part in the institution of CR standards now, such as units in TC114, TC337, and TC415. According to messages issued by Standardization Administration of PRC, some remanufacturing standards are in the process of constitution and are being promulgated, just as Table 1 illustrates.

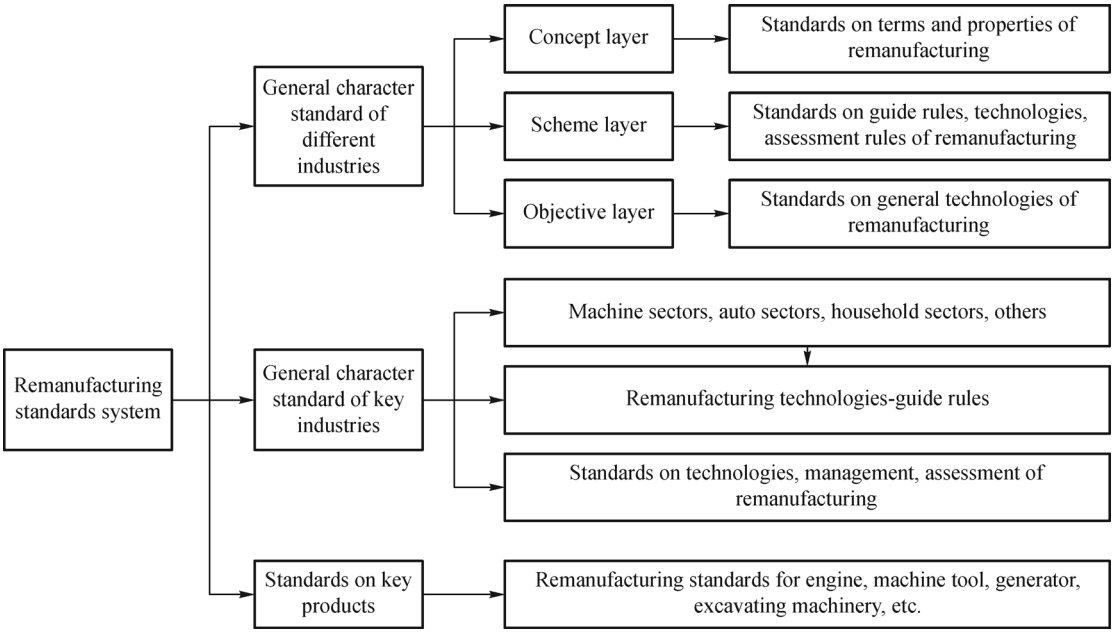

Figure 2. Frame of Remanufacturing Standards System.

Table 1

Remanufacturing Integrated Assessment System

Goal layer	Subsystem layer	Status layer	Elements layer
RIAS	Environment development	Resources saving	Saving power, saving metal, saving water, emission reduction, remanufacturing rate
		Resources consumption	Total power consumption per ten-thousand-CNY increment of industry, total water consumption per ten-thousand-CNY increment of industry
		Waste emission	Waste gas emission per ten-thousand-CNY output value, waste water discharge per ten-thousand-CNY output value, waste liquid discharge per ten-thousand-CNY output value, discarded solid waste per ten-thousand-CNY output value
		Environment improvement	Return rates of resources, reuse rates of old parts, resourcezation of parts that cannot be remanufactured, integrative use rate of solid waste, reuse rate of waste water, emission rate of waste gas and dust
	Economy development	Integrative indexes	Total output value, output value of remanufacturing, total value of remanufacturing capitals, remanufacturing products benefits
		Economic benefits	Earning rate of net assets, net interest rate of distribution, ratio of retained profits to cash flows, return rate per ten-thousand-CNY investment, output value rate of fixed assets
		Costs	Disposal expense on waste matters per ten-thousand-CNY output value
	Society development	Employee	Remanufacturing employees, growth rate of employment
		Economy	Annual expenditure for public welfare funds, annual taxes, annual per capita income
		Social security	Number and proportion of personnel with social security

4.3 Remanufacturing integrated assessment system

As a rational RSS can secure the development of remanufacturing industry, a reasonable RIAS can be used to evaluate or inspect the development status, level and trend of CR in order to provide support for the industry development decision.

In the proceeding of industrialization, CR can draw lessons from other countries or relationally mature industries, but some influencing factors should be taken into account, such as the features and targets of CR, exotic environment, etc. The principles of building RIAS include the following 3 aspects.

(1) In accordance with the demands of China's circular economy. As an important support model of Chinese circular economy, CR not only created well economic benefits for associated organizations, but contributed a lot towards environmental protection and society development. So, RIAS should reflect the economic benefit as well as the environmental and social benefits (Chen, Ma, & Yao, 2009).

(2) Following the characteristics of CR. CR now faces many problems from several aspects, and the normative operation methods are needed to resolve them. The RIAS should reflect and advance the application of remanufacturing technologies, maybe indirectly, and normalize the entrance and evaluation rules of remanufacturing industry to insure the quality of remanufacturing products. The RIAS also should reflect on the contributions to environment and society in order to receive public recognition and attract more buyers.

(3) Incarnating the coordination between different layers of CR system. A system may include several subsystems or layers, especially big one, and we cannot think much of one while ignoring the others. The RIAS should not only reflect the development status of one aspect, but also the relations between them, environmental protection and economic costs as well.

The calculation of the indices seems troublesome and overloaded with work. So, it can be treated by system engineering with the cooperation of organizations in the remanufacturing firms and industry. However, the system is temporary, and some other factors such as policies are to be added in.

5 Conclusions

Remanufacturing is the high-level phase of maintenance engineering and also a new form of advanced manufacturing. Chinese remanufacturing engineering is the high technology industrialization of repair and reform of discarded or old products. The standard rule is that the quality and performance of a remanufactured product are the same or better than a new one, costing half, saving 60% in energy, and 70% in materials. Remanufacturing is predictably the primary way to achieve sustainable manufacturing and are-cyclical economy in China.

The development objective of remanufacturing is to realize its significant role and potential in China's industrialization. In the process of industrialization, there are still a lot of hindrances to the development of CR, such as an incomplete technology system, immature target market, irrational policies, etc. Chinese remanufacturing has the support of her government, several enterprises, some research organizations and a large number of customers. Perfecting its mission is the challenge and primary job remanufacturing researchers face.

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