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# The Development Situation, Future and Counter Measures of Remanufacturing Industry in China

**Abstract** Currently, resource supply and demand contradiction, and over-loaded environment capacity have become a bottleneck for sustainable economic development in China. Electro-mechanical products are approaching a peak of obsolescence, and massive abandoned electro-mechanical products are causing severe environmental pollution, huge waste of resources and potential safety hazard. Remanufacturing is repairing or modifying worn mechanical products using high-tech method, which buffers the contradiction between wasting and shortage of resources, and brings industry towards a comprehensive utilization of resource and environmental protection. As a new strategic industry, remanufacturing, which is highly coherent with the development strategy of the circular economy, is still in its infancy in China. This paper analyzes the developmental trends and problems of the remanufacturing industry in China, and proposes promoting measures based on the engineering practices of remanufacturing.

**Keywords:** remanufacturing, industry, measures, development

## 1 Introduction

1.1 Circular utilization of resources is an inevitable trend for sustainable development of the future industry in China

Throughout the history of the world, industrial civilization brought a modern life. Human beings have created tremendous material wealth, and unprecedentedly utilized and reformed the natural environment; and however, have also caused serious harms and increasing imbalance to the natural ecology.

Even China, as a developing country with a population

of 1.3 billion, adopts the most advanced technologies, with unprecedented demand of energy and resources. The amount of energy consumption throughout the country was up to 4.26 billion tons of coal equivalent in 2014, and 60% of resources including crude oil and iron ore relied on imports. In 2012, China's industrial manufacturing consumed about 22% of the global energy and nearly 50% of steel and cement, but only created 12% or less of the global economy based on GDP (Xu, S., 2014). Massive energy consumption made environmental pollution extremely severe, added by coal-based energy consumption structure. Due to the massive and coal-based energy consumption, China is in severe situation to cope with environmental pollution.

At present, China is still in a rapid development phase of industrialization and urbanization, which causes excessive consumption of resources and environmental problems. The increasing and acute contradictions between economic development and resource constraints and environment conditions have become prominent problems hindering the sustainable development in China. If China keeps adopting the traditional economic mode featuring high input, high consumption and high emissions, and fails in circular utilization of waste and worn products, resources, energy and environment would be unsustainable (Yang, 2014). Therefore, the inevitable requirements and fundamental approaches for the sustainable development of industry are as follows: To persist on the concept of green development, to pursue the road of circular economy, to establish and carry out the strategy of resource recycling, to set up a system of recycling of main resources, to remarkably improve utilization efficiency of resources, and to reduce consumption of resources and energy.

Up to now, the recycling and utilizing rate of obsolete steel and nonferrous metals in China has only accounted for about 10% and 25% respectively, while America's obsolete steel has reached over 50%, Japan's aluminum has exceeded over 90%, and European Union's lead has been more than 70%. The State Council (2013), in *The Circular Economy Development Strategy and Near-Term Action Plan*, required to establish a circular industry system and to promote the industrialization of resource recycling and utilizing. In accordance with the requirements of the

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resource recycling strategy, a recycling system consisting of raw materials like steel, copper, aluminum and lead shall be categorized and established.

### 1.2 Necessity of recycling of discarded electro-mechanical products in China

In recent years, China has made tremendous progress in industrialization, with more than 20 trillion CNY industrial value-added output, accounting for over 20% of global industrial output. More than 220 of 500 major industrial products are ranked among the leading ones of the world (see *Table 1*) (China Machinery Industry Federation, 2015; Editorial Department of China Industry News, 2014). China has become a manufacturing powerhouse with an increasing ownership of electro-mechanical products.

**Table 1**

*Output of Major Electro-mechanical Products in China & Their Global Shares*

Product	Output	Global shares
Machine tool	9.59 million	38.0%
Engineering machinery	8.13 million	30.0%
Automobile	221.17 million	25.0%
Electronic product	2.00 billion	85.3%

With decades of accumulation, China's electro-mechanical products have entered an obsolescence peak. During the period of the 11th Five-year Plan, the output of Chinese internal-combustion engines was up to 300 million (Ministry of Industry and Information Technology of the People's Republic of China, 2013). The ownership of machine tools, engineering machines and automobiles reaches 8 million, 6.5 million and 170 million, respectively (Smart Research Consultancy Group, 2015). More than 60% of traditional machine tools have been worked over 10 years; 80% of engineering machines are beyond warranty period (Xu, B., 2014); 5 million of cars, 16 million of computers, TVs and fridges, and over 20 million of mobile phones are obsolesced each year; and about 800 million tons of solid wastes are produced every year (Xu, Liang, Shi, & Cai, 2015). It is predicted that by 2020 the total number of obsolete engineering machineries and cars will have reached 1.2 million and 12 million–16 million, respectively (Smart Research Consultancy Group, 2015). China has not been ready for dealing with such a massive amount of obsolete electrical and mechanical products up to now, and it is an emergency for China to promote the capability of dealing with obsolete electro-mechanical products. For this reason, the development of remanufacturing is an inevitable choice for China (Xu, 2005, 2007a, 2007b).

As an advanced “reusing” in the circular economy,

remanufacturing joints the circular industrial chain that consists of resources, obsolete products and remanufactured products, and builds up a green mode of development of industry featured by energy-conservativeness, environment-friendliness and sustainability (Yang, 2014). The development of remanufacturing could buffer the resource and environmental issues caused by massive obsolete electrical and mechanical products, promote reusing and recycling of worn electrical and mechanical products, and reduce repetitive manufacturing. Compared to new product manufacturing, remanufacturing could save 60% of energy, 70% of raw materials and over 50% of manufacturing cost, reduce over 80% of air pollutants and produce scarcely any solid wastes (Xu, 2005, 2007a, 2007b).

China's remanufacturing mode is based on repairing engineering and surface engineering technology. Remanufacturing could reduce environmental harms due to massive obsolete products and comprehensively utilize high-added value of obsolete products (Xu, Dong, Zhu, & Shi, 2012; Xu, Liu, & Shi, 2004), which is an optimize pattern and prior choice for resource utilization (Xu, Liu, & Shi, 2004; Xu, 2010).

### 1.3 Remanufacturing is an important direction for the industrial development

After decades of rapid industrial development (see *Figure 1*), China has become the largest manufacturing nation of the world. With the changes in the international and domestic developing situations, conflicts caused by extensive growth of economy have become sharply acute, and China's economy faces growing downward pressure. With over ten years of development since 2013, China's industry has entered a phase with medium-high growth. Currently, traditional comparative advantages supporting high growth of industry like resources, energy and ecological environment, demographic bonus and factor costs have been undermined, and new competitive advantages have not been developed. After years of extensive development with high input, high consumption and emission, China's industry enters into a crucial period that features high quality and effective growth.

With a growing conflict between downward pressure on economic growth and excess production capacity, the era of market development that only stimulated by large scale of production has gone. Large inventory of electro-mechanical products provides sufficient raw materials for remanufacturing. As an extension of manufacturing, remanufacturing engineering has a promising prospect in fields as automobiles and their components, engineering machines, agricultural machines, mining machines, military equipments, equipments of chemical industry and metallurgy, machine tools, household appliances and electronics, which has a huge development potential and can possibly form a new growth point of industry.

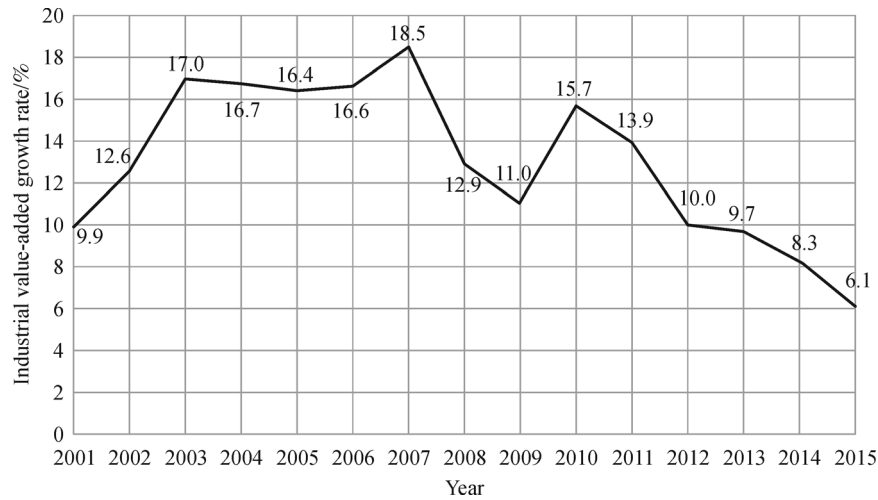


Figure 1. Industrial value-added growth rate in recent 10 years.

## 2 Remanufacturing engineering and industrial practices in China

Remanufacturing practice can date back to industrial practices on the maintenance of electro-mechanical products. Since in the early 1990s, some domestic enterprises have begun to explore appropriate industrial pattern of remanufacturing. They were usually remanufacturing enterprises of auto parts, including CNHTC Jinan Fuqiang Power Co., Ltd., Power-Remanufacturing Workshop at Shanghai Volkswagen Power Train Company Ltd., BOKE (Changshu) Motor Company Ltd., Guangzhou Huadu Global Autonomous Gearbox Co., Ltd., and were respectively engaged in exploring remanufacturing business in the following aspects: Heavy-duty truck engines, car engines, vehicle electrical motors and vehicle gear-boxes (Xu, B., 2014).

The State Council (2005), in the *Opinions of the State Council on Speeding up the Development of Circular Economy*, clearly noted that “China supports remanufacturing of waste electro-mechanical products”. Meanwhile, relevant departments like the National Development and Reform Commission (NDRC) launched the pilot projects of circular economy, and remanufacturing was listed as one of the four key fields. Jinan Fuqiang Power Co., Ltd, which is one of the earliest remanufacturing enterprises, was listed as a remanufacturing pilot enterprise. *Circular Economy Promotion Law of the People’s Republic of China* (The Central People’s Government of the People’s Republic of China, 2008) noted definition, connotation and applicable scope of remanufacturing in China, which indicated a solid legal guarantee for remanufacturing. NDRC and other 10 national ministries and commissions (National Development and Reform Commission, et al., 2010), in the *Suggestions on Promoting Development of Remanufacturing Industry*, provided guide opinions for accelerating

industrialization of remanufacturing and cultivating remanufacturing as a new point of economic growth.

The national policies have provided opportunities for development of remanufacturing industry. With the guidance of relevant ministries and commissions and active exploration and practice of research institutes and enterprises, remanufacturing has made breakthroughs in critical technology and equipment, pilot demonstration, standard documentation and industrialization. The Chinese government has promoted development of remanufacturing through pilot demonstration projects. The NDRC has approved two batches of pilot enterprises for automobile and components’ remanufacturing in 2008 and 2013, with 42 enterprises and 3 remanufacturing bases listed. The Ministry of Industry and Information Technology (MIIT) has approved two batches of pilot enterprises for electro-mechanical products remanufacturing in 2009 and 2014 (The Ministry of Industry and Information Technology, 2009, 2014), with 86 enterprises and 5 industrial bases. The MIIT also organized 40 relevant enterprises and public institutions to implement 5 key projects.

### 2.1 The automobile and component remanufacturing pilot

The NDRC officially launched the pilot of remanufacturing of automobiles and components in 2008, and selected 14 pilot enterprises from more than 40 applicants. It was the first time for China to conduct industrial practice of remanufacturing at a state level.

This pilot aims for achievements below through 2–3 years of experiments:

(1) The policy, management and supervising system for promoting development of automobile component remanufacturing.

(2) Exploring the measures to solve the problems arising after unleashing restricts on products producing and trading of manufacturing nation nationwide.

(3) Providing the experiences for adjusting the relevant management policy, revising laws and regulations, and establishing technical standards, market admittance mechanism and supervision of commodities circulation.

Typical enterprises with comparatively better conditions for remanufacturing were chosen for this pilot project to explore recycling, producing and selling remanufactured components, including China FAW Group Corporation, Dongfeng Motor Corporation, SAIC Motor, China National Heavy Duty Truck Group Co., Ltd, Chery Automobile Corporation Limited, and some major engine manufacturing enterprises like Weichai Power and Guangxi Yuchai Machinery Group, Ltd. The listed products include the engines, gear boxes, steering boxes, generators, starting dynamos, etc.

Owing to the restriction of laws and regulations, the basic principles below are specified for the pilot project (National Development and Reform Commission, 2008):

(1) Sources of old components. Pilot enterprises can only remanufacture components from sale network, but not purchasing from automobile dismantling enterprises.

(2) Authorization for remanufactured products. The remanufactured products shall be authorized from the original automobile manufacturing enterprises. Pilot enterprises mustn't produce and sell remanufactured products without authorization from original enterprises.

(3) Product market circulation. The remanufactured products shall be circulated in the after-sale service system of automobile production enterprises and shall not be directly sold in the public retail market.

(4) Quality standard and liability. The quality standard for remanufactured products is the same as those for the new ones. Remanufacturing enterprises should take responsibilities for the remanufactured product quality, whether the quality problems are caused by defects from original products or remanufacturing process. Remanufacturing enterprises should guarantee to keep the warranty standard and liability of a remanufactured product as that of a new one of the same type of the original product.

(5) Product trademark and identification. Remanufacturing enterprises should acquire the trademark authorization from the original manufacturer. Remanufactured products should use the product trademark of the original manufacturer, or add the remanufacturing enterprise's product trademark to the original one. The trademark "Remanufactured" should be placed at an apparent position of the product and should remain there permanently. After a unified identity system nationwide is established, remanufactured products shall be sold, circulated and used according to the new regulations on trademarks of remanufactured products.

## 2.2 The pilot project for electro-mechanical product remanufacturing

Since 2009, the MIIT has expanded the remanufactured

product coverage to electro-mechanical product. This is the deepening practice in remanufacturing. The pilot project purposes to offer the reference for formulating relevant technical standards and market admission conditions, optimizing regulatory system of circulation, enhancing construction of reverse logistics, and to provide experiences for industrialization of remanufacturing.

The first batch of pilots include 33 enterprises and 2 industrial cluster districts in 8 fields, such as engineering machinery, large-scale industrial electro-mechanical equipment, machining tool, agriculture machinery, mineral-exploiting machinery, locomotives, equipment for ships and information equipment for office (The Ministry of Industry and Information Technology, 2009). However, military and medical care equipments were not included. The pilot project required selecting a batch of typical enterprises with relatively larger production capability and product-holdings, and better fundamental conditions and developing potentials.

The approved pilot enterprises should meet the following requirements (The Ministry of Industry and Information Technology, 2009):

(1) Formulate relevant technical standards for quality control and producing process as soon as possible;

(2) Be qualified to detect and validate the main performance index of used and worn components and remanufactured products by appropriate technical approach;

(3) Own technical equipments for disassembling, cleaning, machining, assembling and testing and have the mass production capability;

(4) Be capable of preventing pollution using relevant equipment. Meet the relevant environmental standards and get acceptance from the third-party audit for quality management system and environment management system.

In 2014, the MIIT deepened the electro-mechanical product remanufacturing pilot. The second batch of pilot includes 53 enterprises and 3 industrial cluster districts. The product coverage has been expanded as follows (The Ministry of Industry and Information Technology, 2014):

(5) Large-scale and high value-added equipments and components, such as: Shield tunneling machines, gas turbines, heavy-duty load-carrying mineral vehicles, special industrial devices;

(6) Imaging equipment for medical care, general-type copiers and printers, etc;

(7) Critical power installation in process industry in service;

(8) High efficiency remanufacturing of electric motor.

## 2.3 Advancing program for internal combustion engine remanufacturing

Internal combustion engine (hereinafter called "IC engine") is the guiding power plant of transportation, engineering machinery, agriculture machinery and military equipment.



IC engine is an important and fundamental industry featuring long industrial chain, high relevancy, massive quantity of employment, and boosting consumption. China produces abundant IC engines and has a tremendous holding. The annual average growth rate of IC engines amounted to approximately 10%, and the total output was 300 million units during the period of “the 11th Five-year Plan” (The Ministry of Industry and Information Technology, 2013). In 2012, the total output was 77.6 million units with total capacity of 1.5 billion KW (The Ministry of Industry and Information Technology, 2013). The total output was over 400 million units in the period of “the 12th Five-year Plan”. Rapid growth and holding of IC engines provides the raw materials for remanufacturing, which is an important trend of green and circular development of the IC engine industry.

Accelerating development of the IC engine industry will contribute to further transforming the production mode of IC engines from one-way straight production mode—“Massive production, massive consumption, massive disuse” to a circulation mode—“Resource–product–failure–remanufacturing”. Implementing the key engineering of IC engine remanufacturing can achieve the results below:

- (1) Improve the technical equipment and industrialization capability;
- (2) Accelerate the industrialization, normalization and marketization of IC engine remanufacturing;
- (3) Improve market occupying rate of remanufactured IC engines;
- (4) Improve remanufacturing capability and competitiveness worldwide, and boost upgrading of IC engine industry.

The purposes of this program are to promote remanufacturing capability, enterprise scale, and technical equipment in the IC engine industry conspicuously, and to achieve remanufacturing capability of 350,000 units of IC engines.

This program issues five key engineering projects: 1) Remanufacturing Demonstration Project for Entire IC Engines and Critical Components, 2) Remanufacturing Demonstration Project for Key Assorted Components, 3) Remanufacturing Demonstration Project for High-Efficiency and Cleanness Upgrade of IC Engines, 4) Promoting Project for Technological Procedures and Equipment in Remanufacturing, and 5) Demonstration Project for Reverse Logistics System Construction in Remanufacturing (See *Table 2*).

#### 2.4 The developing trend of remanufacturing industry in China

On May 19, 2015, the State Council formally issued “Made in China 2025” plan, which first designed to transform China from a manufacturing giant into a world manufacturing power at a national strategic level. Green manu-

facturing engineering is one of the five key projects in this ten-year plan (The State Council, 2015).

Green manufacturing engineering requires acceleration of the construction of the manufacturing system featuring “green”, and boosts the resource circulation and reuse with high efficiency. It also puts forward the idea of cultivation of remanufacturing industry, including advanced, intelligent and in-service remanufacturing.

(1) Advanced remanufacturing: Remanufacturing of the critical components of the large-scale equipment featuring high added value, high technology, high reliability, such as aero-engines, gas turbines, shield tunneling machines, heavy-duty load-carrying mineral vehicles and medical-care imaging equipment.

(2) Intelligent remanufacturing: Improving the intelligence of remanufacturing traditional electronic information products, e.g., electro-mechanical products, general type of copiers and printers; establishing information system for tracking the used and worn components and remanufactured products, and improving self-diagnostic and online monitoring capability.

(3) In-service remanufacturing: Remanufacturing electro-mechanical in-service equipment in process industry with inferior performance, recurrent failure and backward technology, such as those in the fields of petrochemical and chemical engineering.

As a typical mode of green manufacturing, remanufacturing will further focus on large-scale production, normalization and specialization.

### 3 Current obstacles to remanufacturing industrial development in China

In recent years, the NDRC and the MIIT have implemented remanufacturing pilot demonstrations, and have made certain progress on the cataloguing of critical remanufacturing technologies and on the quality identification of remanufactured products. However, China’s remanufacturing is still at the initial development phase, and the development falls far behind the developed countries. Massive production has not been achieved yet, and construction of the reverse logistics system has been seriously delayed. Most of the critical equipments are imported, and most of the enterprises are small and noncompetitive. China’s remanufacturing industry needs to cope with many challenges and obstacles such as product acceptance, technology, policy and reverse logistics.

#### 3.1 Low market recognition for remanufactured products

The public have prejudice against manufactured products, which are often misunderstood as “retrofitting” ones. This is rooted in the problem that the remanufactured products and the retrofitted ones mixed up in the Chinese market. As a matter of fact, remanufacturing requires high-tech

**Table 2**  
*Key Projects of IC Engine Remanufacturing (The Ministry of Industry and Information Technology, 2013)*

Key project	Demonstration details	Objectives
Remanufacturing Demonstration Project for Entire IC Engines and Critical Components	<p>The demonstration focuses on the creative research results with critical and common technologies, such as: High-efficiency and non-destructive disassembly &amp; assembly, green cleaning, performance optimization matching and upgrade of the entire IC engine remanufacturing, in the fields relative to the engines for the mid/heavy-duty commercial vehicles, the passenger vehicles, engineering machinery, agriculture machines, and for fixed electricity-generating equipment, ships, petroleum drilling and locomotives.</p> <p>The demonstration focuses are the technology research &amp; application achievements, such as performance quality inspection, life appraisal, process quality control in the fields relative to boosters, electricity generators &amp; starters, oil pumps, fuel pumps and water pumps. Meanwhile, conduct the technological procedure research and demonstration application to measuring, assembling and balancing; create management processes associated with remanufacturing; have the massive production capability and complete the relevant technical specification.</p>	<p>Aim for the remanufacturing production capacity of 180,000 engines for mid/heavy-duty commercial vehicles, 70,000 engines for passenger vehicles, 60,000 engines for engineering machinery, 20,000 engines for agriculture machines, and 20,000 engines for fixed electricity-generating equipment, ships, petroleum drilling and locomotives, in 2015.</p>
Remanufacturing Demonstration Project for Key Assorted Components	<p>Comprehensively apply the technologies for upgrading fuel system, adoptive modification of replaced fuel, power optimization matching; modify the IC engine in stock for the purposes of high efficiency and cleanness. Improve major properties of remanufactured products. Increase the fuel economy and decrease the emission. Gain the demonstration promotion effectiveness.</p>	<p>Aim for the remanufacturing production capacity of 500,000 boosters, 1.5 million starters, electricity and generators, and 800,000 units of oil pumps, fuel pumps and water pumps, in 2015.</p>
Remanufacturing Demonstration Project for High-Efficiency and Cleanness Upgrade of IC Engine	<p>Intensively support the R&amp;D, industrialization demonstration and application of the technologies-prototyping and manufacturing, dismantling and cleaning, non-destructive testing and life appraisal in remanufacturing, as well as typical remanufacturing technologies and equipment listed in "Catalogues of Remanufacturing Technology and Equipment for Electro-mechanical Products".</p>	<p>Build an advanced platform for optimized design and electric control system development of the gas engine in 2015, and initially develop to large-scale production of remanufacturing with high-efficiency cleaning.</p>
Promoting Project for Technological Procedures and Equipment in Remanufacturing	<p>Expand the recycling channel and establish a stable network system for recycling old components. Relying on the sale network system for IC engines and fully utilizing other recycling channels, construct a reverse logistics system with the high-quality, high-efficiency and low-cost logistics featuring large-scale, professional, informatization and standardization for IC engine remanufacturing. Guide the remanufacturing enterprises to cooperate with IC engine customers, specialized logistics service organizations and maintenance service enterprises, so as to build a long-term stable recycling mode—Old for remanufactured product, contract purchasing, etc.</p>	<p>In 2015, widely promote and apply the applicable technology and equipment, and greatly improve the technical level of remanufacturing industry.</p>
Demonstration Project of Reverse Logistics System Construction for Remanufacturing		<p>In 2015, the major enterprises engaging in IC engines and critical components construct relatively complete recycling system for old components relying on their own network, and form the recycling capability of 3 million units/years of the entire IC engines and critical components.</p>

recovery and upgrading for original functions, and the functions of remanufactured products should be the same as those of the new ones or even better. The enterprises and sectors, remanufacturing any products (whether the entire engines or components) with any technology (replacement or repairing), should be assistant to the principle—The quality and function of remanufactured products must not be worse than the new ones of similar type.

### 3.2 Obstacles for construction of reverse logistics

“Old components”, raw materials for remanufacturing, are difficult to be recycled because there is no recycling system for waste and old components in China. On the one hand, the relevant policies need to be revised. Take as an example, the *Regulations on Recycling of Abandoned Vehicles* issued by the State Council (The State Council, 2001), which is still effective since 2001. It notes that the five major assemblies of abandoned vehicles must be sold to iron enterprises as raw materials. Moreover, most of “old components” from abandoned vehicles shall not be imported either. Mandatory write-off standard for engineering machinery products is still absent in China. Specific measures for administration on “old components” in customs’ import and export regulations are needed in China. On the other hand, the recycling object for old “components” is not clear. Reverse logistics, as a new mode, is still in an exploration stage, and the capacity of recycling components should match the capability of remanufacturing.

### 3.3 Backward critical remanufacturing techniques

In China, the research of critical techniques is focused on engine remanufacturing, which cannot satisfy the rapid development of other remanufacturing sectors like engineering machinery in a short period of time. In addition, the lack of pilot plant test in R&D process of some critical techniques reduces remanufacturing efficiency and liability.

### 3.4 Insufficiency of supporting from policies and laws

China has issued a series of laws and policies to support the development of the remanufacturing industry. However, the lack of implementing regulations makes some of them difficult to operate. Some regulations need to be revised as soon as possible, as those regulations concerning the recycling of abandoned vehicles, concerning the import and export of used and worn components from electro-mechanical products, etc. Furthermore, China lacks market management system for circulation of remanufactured products. Enterprises cannot obtain the value added tax invoice when they purchase used and worn components, and get tax credit from government either, which greatly decreases the profit margin. The financial supporting policy

fails to get the expected results because of operating obstacles. Take the information management system for example. It has a complex operating system and rigorous audit process, which give some of the companies no financial subsidies because of irregular or incomplete product information input.

## 4 Counter measures

In order to accelerate the development of remanufacturing, the authors make several suggestions considering the obstacles hindering the development of remanufacturing in China.

### 4.1 Deepening the pilot demonstration of remanufacturing

It is necessary to enhance the development of remanufacturing by deepening the pilot demonstration programs that focus on significant sectors including automobiles and components, machine tools, electrical machines, engineering machines and office information equipments. Firstly, the pilot demonstration would boost the industrialization, technology and producing capability of remanufacturing. The industrial cluster district and the pilot demonstration should be advanced in a coordinated way. Secondly, timely discussion and research for technology and policy is needed to resolve problems in pilot projects, and a problem-solving mechanism should be established.

### 4.2 Accelerating the construction of remanufacturing public platforms

The main tasks for construction of remanufacturing public platforms are as follows: Integrating resources from the upper and the lower rings of the industrial chain; stimulating, with leading enterprises, the development of remanufacturing; promoting the capability of scientific research and industrialization of remanufacturing, and achieving breakthroughs in critical manufactured products. The industry alliance is an important platform to promote remanufacturing industry. Firstly, highlighting of the alliance and the leading enterprises in each sector can well promote industrialization and expand the scale of remanufacturing. Secondly, it is possible to set up a mechanism of frequent communication, and make a joint effort to technical research and application, and pilot demonstration. Thirdly, the alliance can also promote standard specification and professional preparation. Finally, the alliance can provide a chance to discuss new commercial mode and opportunity, and to explore the market. Currently, the remanufacturing industry alliance on IC engine has been established; meanwhile, other sectors such as machine tool and engineering machinery are making efforts to establish new alliances.

#### 4.3 Enhancing the supervision and management on product quality

Chinese domestic market shows that the quality of remanufactured products directly relates to the development of remanufacturing industry. The relevant institutions should continue to carry out remanufactured products identification, and issue remanufactured products lists, which would guide appropriate market recognition and acceptance. It is necessary to take the following measures: Establishing a three-fold remanufacturing standard system at the national, the industrial and the entrepreneurial levels, which includes standards on remanufacturing technology, product quality and production management; building up information platform for tracking old components, remanufactured products and feedbacks of product quality, with which the terminal consumers and the public can supervise the quality information in product life cycle.

#### 4.4 Accelerating the establishment of orderly and normative reverse logistic systems

In accordance with the principle of disperse recycling, concentrated delivery and normative utilization, it is necessary to establish a reverse logistic system. It is important to learn from the experiences of the markets abroad such as Caterpillar, which may help to solve market circulation obstacles. Meanwhile, it is essential to explore an appropriate system adapted to domestic situation, such as the 4S store system and the old-for-new pricing mechanism. Under the influence of the new information technology, the "Internet +" remanufacturing plan can be implemented by utilizing the internet technology to establish the reverse logistic system.

#### 4.5 Pushing forward the formulation of relevant policies

It is suggested that *Regulations on Recycling of Abandoned Vehicles* (The State Council, 2001) should be revised, and the relevant regulations on remanufacturing automotive components that identify the access conditions and commodity circulations should be formulated as soon as possible. It is necessary to establish a policy system for remanufacturing industry guiding the management of product quality, enterprise access, revenue as well as import and export. As for insurance of the benefits of the consumers, the relevant administrative regulations including product identification, package and advertisement must be confirmed. Moreover, the research of intellectual property for remanufacturing must be enhanced and the relevant problems should be confirmed clearly. It is essential to set up a system that link up recycling waste and used materials with remanufacturing, to work out a free circulation approach cross borders for appropriate waste & used components at the right time, and to establish the reverse logistic system and design the relevant supervision

system. It is important to introduce financial and revenue policies promoting the development of remanufacturing, to accelerate the resolution of such problems as taxation, and to enhance communication and coordination between ministries, commissions and enterprises.

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