



Assessing the impact of China's vehicle emission standards on diesel engine remanufacturing



Ji-Hao Zhang, Ming Chen*

School of Mechanical Engineering and Power Engineering, Shanghai Jiao Tong University, Shanghai, China

ARTICLE INFO

Article history:

Received 16 July 2014

Received in revised form

2 March 2015

Accepted 14 March 2015

Available online 2 June 2015

Keywords:

Life Cycle Assessment (LCA)

Remanufacturing

Diesel

Emission standard

Strategy

Emission

ABSTRACT

The remanufacturing industry is one of the strategic emerging industries in China that are changing the traditional economic growth mode, developing a circular economy, as well as promoting development toward becoming a resource-conserving and environment-friendly society. Based on the current development of China's engine remanufacturing industry and government policy, this study analyzed the characteristics and development trend of the engine remanufacturing industry. Diesel engine remanufacturing is the earliest remanufacturing business in China and is the key to the development of the remanufacturing industry. Diesel remanufacturing mostly involves different stages of the vehicle exhaust emission standard implemented in China. A life-cycle assessment model was developed to investigate pollution prevention achieved in China by remanufacturing a China 2 standard heavy-duty diesel engine compared with a new one that has similar specifications and manufactured by the same OEM but meets the China 4 standard. Qualitative analysis indicates that a different remanufacturing strategy needs to be adopted for an engine in a different exhaust emission standard stage. The principle of remanufacturing is "Remanufacturing restores used automotive engines to like-new condition". However, remanufacturing a China 2 or 3 engine increases emissions. Therefore, the principle of remanufacturing does not always achieve the goal of remanufacturing development in China.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

In 2013, the output and sales of China's vehicle were 22.1168 million vehicles and 21.9841 million vehicles respectively, an increase of 14.76% and 13.87% compared with those of the previous year. By the end of 2013, China's vehicle ownership has reached 137 million units. In the same year, the State Council issued the "The notice about action plan of prevention and control of atmospheric pollution", which requires speeding up the elimination of "the standard yellow cars" and old cars, to accelerate the abandonment of the motor vehicle. During the year 2013, 1.35 million scrapped automobiles were recycled in China, an increase of 22.7% compared with those of the previous year (Ministry of Commerce, 2014). The continuous increase in vehicle consumption will consequently lead to an increase in the number of scrapped vehicles and engines in the future. By that time, there

will be a huge challenge to process the numerous scrapped vehicles.

Remanufacturing is a powerful tool that turns damaged products into resources. Used products are the core of remanufacturing, wherein new technologies and techniques are used to produce remanufactured products with equal functionality and quality as that of the original products. Remanufacturing can save up to 50% of the cost, 60% of the energy, and 70% of the material used to produce a new product and has an important role in improving environment protection and combating global climate change (Xu, 2012). Energy and environment problems have increased with the continuous economic development of China. China vigorously promotes the development of the remanufacturing industry owing to its excellent performance in energy conservation and emission reduction. The above factors are the main motivation for product remanufacturing in China, unlike in other countries where motivations for product remanufacturing include ethical and moral responsibility and environmental legislation as well as direct economic motives (Seitz, 2007).

Like some developed countries, China continuously introduces new vehicle exhaust emission standards to reduce greenhouse gas emission. These standards define the acceptable limits for exhaust

* Corresponding author. School of Mechanical Engineering, Shanghai Jiao Tong University, No. 800 Dongchuan Road, 200240 Shanghai, PR China. Tel./fax: +86 21 34206079.

E-mail address: mingchen@sjtu.edu.cn (M. Chen).

Table 1
Implementation date of exhaust emission standards and the emission limits of diesel engines.

Stage	Implement date	CO [g/kwh]	HC [g/kwh]	NOx [g/kwh]	PM [g/kwh]	
					≤85 kw	>85 kw
China 2	2003/9/1	4.0	1.1	7.0	0.15	
China 3	2007/7/1	2.1	0.66	5.0	0.1	0.13 ^a
China 4	2015/1/1	1.5	0.46	3.5	0.02	

^a For engines with a per cylinder displacement of <0.75 L and rated speed >3000 rpm.

emissions of an engine (Table 1). These emissions include hydrocarbons (HC), Carbon monoxide (CO), Nitrogen oxides (NOx) and particulate matter (PM). An engine and a vehicle would not be allowed for sale or use if they fail to meet these standards. The engine remanufacturing standard is the same as that of the other products. Remanufacturing restores used automotive engines to like-new condition. Since Jan. 2015, China has begun to implement the fourth stage of the vehicle exhaust emission standard (China 4). However, most remanufactured diesel engines do not meet the current standard for these remanufactured engines were geared to meet China 2 or China 3 standards. Today, it is necessary to evaluate the environment impact of remanufacturing a China 2 or China 3 diesel engine.

The paper is divided into seven sections. Section 1 presents the introduction. Section 2 describes the status of the engine remanufacturing industry in China. Section 3 uses the LCA method to calculate the difference in environment performance between the remanufactured China 2 diesel engine and the new China 4 diesel engine. Section 4 discusses the changes needed for engine remanufacturing on the basis of the LCA results. Section 5 concludes the paper. Sections 6 and 7 respectively present the acknowledgements and the references.

2. Status of engine remanufacturing in China

In the 1940s, remanufacturing activities for important parts of an automobile began to appear and gradually prospered in America with the development of the automobile industry. By the 1990s, the United States has basically established the automobile remanufacturing “3R” system (reuse, remanufacturing, and recycle). Most auto parts can be remanufactured. Standards for remanufacturing specific automobile components, such as the engine, have been put forward by the Society of Automotive Engineers (SAE). These remanufactured products are mainly used for aftermarket.

In 1947, Volkswagen became the first company to remanufacture auto parts in Europe. Nearly all auto parts can be remanufactured. One of the most important features of the European remanufacturing industry is that the automobile manufacturing enterprises themselves are engaged in auto parts remanufacturing. Remanufacturing must also consider the quality specifications set by the production enterprises of the original parts. Similar to new parts, remanufactured parts must consider the warranty period provided by the original manufacturers. Thus, remanufactured parts can be used both in the warranty period and the aftermarket.

Compared with America and Europe, the remanufacturing industry in China started relatively late. Sinotruk Jinan Fuqiang Power Co. Ltd. (FQ Power), the first company to establish diesel remanufacturing business in China, was founded in 1995. After nearly 20 years of development, China formed an integrated remanufacturing industry chain. Remanufactured auto parts are the main products in the remanufacturing industry; such products mainly include the engine, gearbox, generator, and starter. With the development of the remanufacturing industry, remanufactured products have

gradually expanded to drive shaft, oil pump, water pump, tires and other parts. The remanufacturing industry development in China is under the guidance of the government, which provides legal basis for industrial development in the way of legislation, constantly improves industrial management policies, and strengthens industry guidance and specifications (Table 2). Remanufactured products are mainly used for after-warranty repair and replacement.

Through learning from the remanufacturing experience of developed countries and analyses of research institutes, the Chinese government has adopted a pilot demonstration system to guide remanufacturing enterprises in exploring paths to develop the remanufacturing industry. In 2008, NDRC organized the first batch of automotive parts remanufacturing pilots with 14 selected auto parts production enterprises included, for example, FAW, Shanghai Dazhong Allied Developing Co. Ltd., Weichai Power (Weifang) Remanufacturing Co. Ltd. (Weichai Power), FQ Power, and Guangxi Yuchai Machinery Co. Ltd. (Yuchai), These companies are well-known enterprises in the field of automobile and auto parts manufacturing in China. In 2012, NDRC issued a list of remanufacturing products and acceptance for the remanufacturing pilot, which included eight companies that remanufacture products such as engine, gearbox, starter, and generator. In 2013, NDRC organized the second batch of remanufacturing pilots, and it included 28 enterprises. The pilot business scope included remanufacturing technology services, auto parts remanufacturing, and reverse logistics system.

Forty-two auto parts remanufacturing enterprises currently operate in China. The business covers the entire industry chain. Among these enterprises, about 60% are engaged in remanufacturing engines and their supporting parts. On October 2012, the engine remanufacturing production capacity was about 110,000 units, with 6000 units for gearbox and starter, and 1 million sets for generators. The actual remanufacturing output value was about 2.5 billion yuan (0.4 billion dollars), most of which came from the first batch of pilot enterprises (China Association of Automobile automotive parts remanufacturing Branch, 2013). During the period of the 11th Five-year Plan (2006–2010), the annual growth of the internal combustion engine output was about 10% on average, with a total output of approximately 300 million units. The expected production during the 12th Five-year Plan (2011–2015) is more than 400 million units (Fig. 1). The current internal combustion engine holdings or the number of engine remanufacturing enterprises indicate that China is a good engine remanufacturing base and has great potential for the development of engine remanufacturing industry.

The “Internal combustion engine remanufacturing propulsion plan” set goals for industrial development (MIIT, 2013). The goal requires engine remanufacturing industry production capacity and enterprises scale to increase, and technology and equipment level to improve significantly by the end of the 12th Five-year Plan. The engine remanufacturing industry production capacity is projected to reach 350,000 units of various types of internal combustion engine, with 6–8 enterprises having a production capacity of more than 30,000 units a year and 6 more enterprises below 30,000 units. More than 30 engine parts enterprises have the capacity to produce supercharges, generators, starters, oil pump, fuel pumps, water pumps and other key parts on a large scale. The goal for 2015 is that the machine remanufacturing production capacity of medium and heavy commercial vehicle engines, passenger vehicle engines, construction machinery engines, agricultural machinery engines and stationary power generation, marine, oil drilling, and railway locomotive engines reach 180,000, 70,000, 60,000, 20,000, and 20,000 units (Fig. 2). The remanufacturing industry reached 30 billion yuan (4.89 billion dollars), and the remanufacturing product

Download English Version:

<https://daneshyari.com/en/article/1744410>

Download Persian Version:

<https://daneshyari.com/article/1744410>

[Daneshyari.com](https://daneshyari.com)