Investigation of Remanufacturing Technology and evaluation system of Heavy Duty Caterpillar Engine

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Abstract:
In this paper, the research development of equipment remanufacting technology in the world was introduced. And the feasibility of remanufacturing for heavy duty caterpillar engine was analysed.
The conception of remanufacturing for engine was discussed and the classification of key technology for remanufacturing was summarized. Based on the analyzing of key part's failure mode and remanufacturing characteristics of heavy duty caterpillar engine , this paper introduced the remanufacturing technology program for a tank diesel engine , and introduced a preliminary evaluation criterion which is an exploratory development for the construction of index system on the remanufacturing engine.
Key words: heavy duty caterpillar ; engine ; remanufacturing technology; evaluation system

1 Introduction

With the resource increasingly drying up and the environment contaminative pricking up, the significance of continual development was understood gradually by people.

The remanufacturing engineering is came into being and became one new engineering subject as the resource requirement was increasingly went up by human being. And it is regarded importantly by all the countries and become one important technology support to carry out the strategic of continual development[1,2].

Owing to the mal-conditions of operating and the high reinforcement, heavy duty caterpillar engines have a very short service life comparing with the civil vehicle. It is the unequal-life of the engine's parts and working surfaces that results in the failure of some parts and working surfaces and the engines goes to out-of-service. Short service life of engine and unconformity with the life cycle of vehicle had become a bottleneck to the maintenance in the armored cavalry[3].

It is urgent for the ensuring and maintaining of armored equipment to start the remanufacturing of armored vehicle engine based on high technology for prolonging its service life. Notable benefit in economy and military fairs will be gained by the same service life with the vehicle after remanufacturing of the engine.

2 feasibility analysis

The manufacturing technology used in the heavy duty caterpillar engine is following the old technology of the soviet times, which have 50 years up to now. And a great many new technique and material have occurred in these 50 years.The suface engineering technology, which adopting many surface intensify technology to consolidating the surface of material and getting the high wearability, was developed from the 1980s. It provides a technology base to remanufacturing the equipment engine[4]. Now, the employ life-span of civilian engine have reached at 8000～10000h as using the new technology, new material and new surface treatment technology. According to the "cannikin theory" of product life, it will prolong the life-span of engine as long as increasing the length of those shortest board, which can influence the performance of engine, Namely, prolonging the life-span of key friction mate for engine such as cylinder/piston, bending axis/tile, camshaft/valve adjusting set[5]. All these provides the sustain of theory and practice.Therefore, it is feasibility both in theory and technology to remanufacturing the equipment engine from the above analysis.

3 Remanufacturing of heavy duty caterpillar engine

3.1 Conception of remanufacturing for heavy duty caterpillar engine

Not all the products are suitable for remanufacturing. Heavy duty caterpillar engine has an obviously difference in designing, fabrication process , working condition and service life with civil vehicle engine. For example, the friction surface has a same life to the main body of engine (equal-life designing as DEUTZ engine)and most parts have wear out after an overhaul life of a civil vehicle engine, while for heavy duty caterpillar engine, it is another case that many parts have an ability to service more long, some are even in the better state. So the remanufacturing of heavy duty caterpillar engine is different from the civil in the goal, technique project and method[6].

Generally speaking, the fixed parts such as case, housing and bearing block have a long life while the service life of moving parts is shorter and the friction surfaces have shorter life than the parts which deliver the torque. It is the unequal-life of parts and their working surfaces which result in the failure of some parts/working-surface and out-of-service of equipment as a whole. In other words, the unequal-life of parts and their working surfaces provides a material base for remanufacturing[7].

Because of the long terms of design and service,

remanufacturing is an upgrade procedure for heavy duty caterpillar engines. Based on the prototype version, many advanced technology and new parts are adopted to promoting some key performances of the old products greatly, i.e. the remanufacturing of engines is coincident with the society of resource-saving and green environmental protection.

The goals of heavy duty caterpillar engine remanufacturing are as follows: based on the systematic analyzing to engine, improve the wearing and friction state of engine's fricative pairs by the surface strengthening of key parts applying the multi-surface engineering technology, find a more suitable material with matching surface modified nature to reduce the attrition of working surfaces, and finally double the service life of the engine.

3.2 Key remanufacturing technique

A lot of key techniques applied in remanufacturing come from the up-to-date achievement of science and technology such as advanced surface technique, micro and nano-coating and wear-resistance self-recovery material and technique, renovation heat treatment technique, molding technique of remanufacturing blank and up-date of outdated products. The main classification of key technology for remanufacturing was summarized as Fig.1[8].

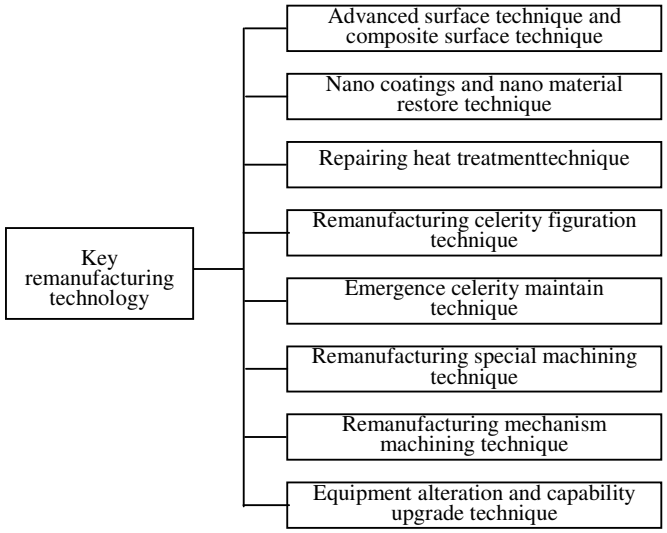

Fig.1 Classification of key technology for remanufacturing

The key technique of remanufacture engineering includes many types, in which the advanced and compound surface techniques play an important role in repairing and strengthening the failure surfaces of waste and old parts. Various surface coating techniques are widely used because the attrition wear and corrosion of waste and old parts appear mainly on the surface. Based on micro and nano-materials, for micro and nano-coating and wear-resistance self-recovery technique, a special coating technology can be used for reinforcing surface with promotion of performance, or self-recovery technology forming film at affected position of friction surface guided by tribochemistry to solve the problems in remanufacturing. The holistic performances of parts can be recovered from initialization of inner construction by renovation heat treatment technique. Besides the technique mentioned above, normal and some special machinery are also used in remanufacturing engineering.

3.3 General planning

Unlike traditional overhaul, remanufacturing completes a progress of upgrading for promotion of performance and service life against the engine out-of-service.

Measured and analyzed systematically, the main parts of engine were sorted into four classes by their status: used without any treating, remanufactured, new and upgrade. The degree of wear was analyzed for the parts used continuously and remanufactured, and the service life of the parts was evaluated by life predicted method. The remanufacturing process was according to the new parts productive standard and the key parts were reinforced by means of multi-surface engineering technologies such as laser-quenching, ion-implant, ion-sulfurizing at normal temperature, magnetron sputtering, supersonic plasma spray, nanometer brush plating, nitriding, boriding, nanometer oil additive, intellectual oil infiltrating for lubrication ,and plasma submerge injection.

The procedure of remanufacturing to engine is stepped as follows: first, find out the main parts which have a strong effects to engine service life such as cylinder/rings, crankshaft journal/bearings bush on referencing the experience of repair factory; then by analyzing of work condition, materials, fabrication process and the normal failure form of these parts, basic test researching would be carried out in laboratory using some new material and craft especially the advanced surface engineering; the third thing to do is the bench test to compared various combinations of different methods. To some extant, the remanufacturing of these key parts determines success or not of remanufacturing to whole engine. Some other problems as scale deposit, carbon deposit, failure of sealing should be taken into consideration owing to the prolonged engine service life. As for the remanufacturing times (cycles) of main structural parts, it needs to be studied specially in fatigue life.

3.4 Treatment of main friction pairs

Because of particularity in use of heavy duty caterpillar engine, the remanufacturing program has its uniqueness and different technical measures would be used for different pasts. As the first time to remanufacture to the tank engine, we make our focus on the main key friction pairs which have s strong affection on the service life of engine while untreated new products were used for accessories section like turbocharger, oil pump and water pump.

3.4.1 Crankshaft and connecting rod mechanism

Recovering the size of journals by nano-electronic brush plating;

Anti-carbon deposit and TBS coat were used synchronously at piston crown to reduce heat transfer

from piston and improve the working condition of first ring groove while the piston skirt was plasma sprayed with Al alloy to recover size and strengthen.

At the friction surface of gas ring Mo layers were sprayed to reduce the coefficient of friction and abrasion of cylinder with rings.

A self-lubricating film was gained at inner surface of cylinder by medium-frequency quenching and ion sulfurizing at normal temperature. Supersonic plasma spray was applied at outside surface of cylinder for reducing cavitation wear.

3.4.2 Air distributing mechanism

Sulfurizing at journal of camshaft to reduce the friction and wear.

The coefficient between valve and guide was reduced by ion sulfurizing at normal temperature and nano-addition agent in the oil.

3.4.3 Engine body

Using supersonic plasma spray, the surfaces were strengthened and recovered in size for engine case, bearing saddle bore.

4 Design of evaluation criterion system

It is necessary that the stability of engine performance, reliability and anti-resistance abradability be verified by bench test to evaluate the processing set-up and technical measure used in tank engine remanufacturing.

The standards aim at the change of engine performance and the state of main parts, i.e. the engine's performance become bad or not, the abrasion of the main parts is overproof or not after running at test bed for 1000 hours guided by warrant test program.

The tests should be completed are as follows: full load characteristic test, constant speed characteristic test at rated speed, lub-oil consumption measure, lub-oil sample optical spectrum analysis, reliability test, engine vibration measure. Besides the items specified in the Chinese standard and military standard, the circulate flow measurements of oil and cool water were done for judging the states of oil pump and water pump indirectly, the vibration of the crankcase was measured to monitor the fit clearances of piston/cylinder and main journal/bearing.

The performance index measured must be converted first to number at the standard atmospheric condition by Chinese standard and then the change rates of performance reflecting engine technical statues be analyzed such as rated power, brake specific fuel consumption(BSFC), smoke, and specific lub-oil consumption. Based on the research to test specifications of civil vehicle engine and combining the working condition of tank engine, we take the criterion as follows: the test will be considered as meeting the demands of engine performance if the rated power reduces not more than 4%, lub-oil specific consumption increases not more than 25% and the BSU(Bosch smoke unit) increases not more than 10% after the reliable test.

As to the abrasion of engine parts, metallographic analysis and size measuring should be done for the parts remanufactured such as piston, cylinder, crankshaft, valve, camshaft. If the sizes of main parts are not overrun and there are not breaking-off on the working surface of bearings, we can say that the remanufacturing technique is successful.

5 Conclusion

Introducing the significance of remanufacture to tank engine, the author analyzed the service of tank engine and the failure of main parts first, then pointed out that the remanufacture for heavy duty caterpillar engine has its special content and style to normal civil vehicle engine. The applying of remanufacture technique is to promote the service life of tank engine by using modern surface engineering. After introducing the remanufacture technique program and measure in detail, a preliminary criterion was offered to judge if the remanufacture is success or not for the tank engine and it is beneficial to the building of engine remanufacture criterion system.

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