

STATE-OF-THE-ART LASER REMANUFACTURING

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Abstract

Remanufacture Engineering has become a new industry field while it just meets society requirements such as energy conservation, materials save and pollution reduction. Laser remanufacturing, as rising and high-tech remanufacturing technology, was introduced on aspects of connotation, characteristics and technical groups in this paper. It also reviewed current status of laser remanufacturing researches and applications, and pointed out the main problems for further developing of laser remanufacturing technology. At last, it stated the developing trends of laser remanufacturing technology.

Key words: remanufacture engineering, laser remanufacturing, metal components, researches and applications

1 Introduction

While resource and environment arouse concerns of the society, it has become one of main tasks in various industries to save energy, save raw materials and reduce pollution. Remanufacture Engineering comes just to meet such society requirements, which has become the new technology and industry fields. Remanufacturing takes the latter-half life of products as research objects to resume or upgrade their performance, which can

explore the great potential values of the used-parts to the fullest extent. Therefore, with predominance of energy conservation, materials save and pollution reduction, remanufacturing has become an important measure to support cycling economy and economical society [1-3].

2 Characteristics and technical system of laser remanufacturing

Laser remanufacturing is to remanufacture the mechanical metal components with various laser processing techniques such as laser surface treating, laser sintering, laser welding, laser cutting, laser drilling and so on. It employs the high-powered laser beam to rebuild the components on dimension and upgrade their performance without or with a little component deformation, which is coincident with the requirements of remanufacture engineering.

Laser remanufacturing techniques can be divided into two groups as laser surface treating techniques and laser forming techniques, see to Fig.1. The former includes laser cleaning, laser quenching, laser surface melting, laser alloying, laser glazing, laser cladding, laser shocking and so on. The latter mainly includes laser cutting, laser welding, laser drilling, laser rapid forming and so on.

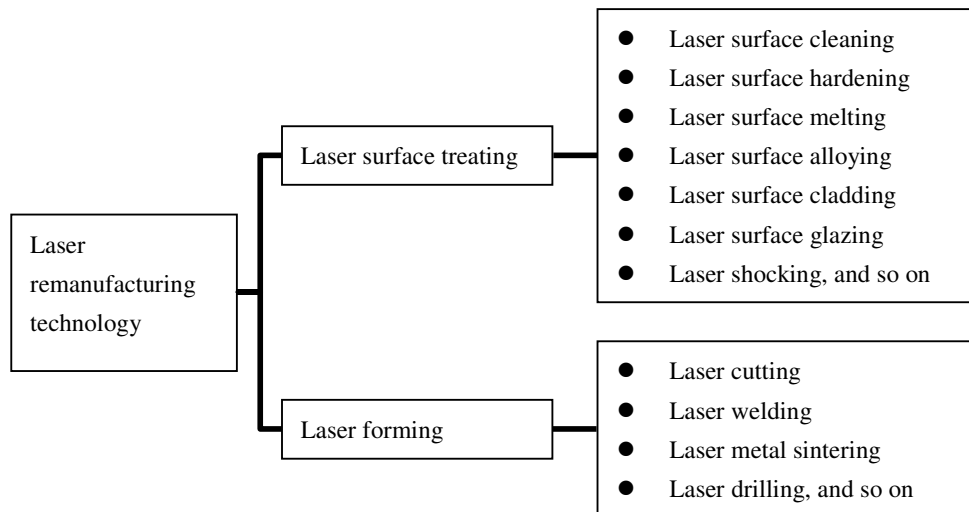


Fig.1 Classification of Laser Remanufacturing Technology

In comparison with the traditional repairing reducing-methods like machining and adding-methods like welding or surfacing, laser remanufacturing shows technical characteristics and superiorities on the following aspects[4-7].

- (1) Laser remanufacturing process the to-be-remanufactured parts without contacting the parts and without directive impact on the parts, which would not bring mechanical deformation to the parts.
- (2) No tools are worn in laser remanufacture processing

because it has no tools at all.

(3) Laser beam possesses high energy density, which can treat wide ranges of materials like metals and nonmetals, especially it can process the high-hardness and refractory materials.

(4) Laser beam has excellent focusing speciality, which can remanufacture the selected areas of the components and upgrade its performance with small thermal-affected zone and little thermal deform.

(5) It is easy to combine various laser techniques together and complex-remake the components according to their characters.

(6) It can perform near-net-shape remanufacturing of the worn parts.

(7) It is a flexible process, which can be combine with CNC system and industry robot system. Therefore, it can remanufacture the large-sized and structure-complicated components.

(8) It is green technology, and the remanufactured products own perfect properties.

Owing to the distinct technical advantages, recently, laser remanufacturing arouses further researches and wider applications.

3 Current status of laser remanufacturing

Laser cladding remanufacturing is the most popular among the various laser remanufacturing techniques. Therefore, main tasks of laser remanufacturing still focus on restoring dimension of local areas for the surface worn, erosive or local-defected components, and also improve their properties. In 1981, British Rolls-Royce company employed laser cladding technique to rebuild the blade shoulder of RB211 gas turbines. Then, several countries payed more attention to research and application of laser cladding, and patents on laser cladding increased [8, 9]. British P.R. Aeroengine Company applied laser cladding process to repair turbine engine blades. Japanese used laser cladding to surface modify and repair motor engine components such as cylinders and pistons while they laser clad austenitic stainless steel, martensitic stainless steel, nickel-base alloy or cobalt-base steel coatings on the components to meet the performance requirement[10]. US Navy Laboratory repaired warship propeller paddles via laser cladding. US Gremada Industries Inc. employed laser cladding technique to remanufacture mechanical components and repair heavy-duty machinery for US Caterpillar to take place of the high-cost component-replacing maintenance strategy[11].

Researches on laser remanufacturing is rapidly developing on processings, processing equipments, materials, application foundation, quality control and its related standards or criterion. In China, the researches and applications on laser remanufacturing have been expanded. More and more institutes and universities put efforts into laser remanufacturing. And also, a series of corporations who develop and apply laser remanufacturing techniques emerges, such as DALU Laser Technology Company in Shenyang City, Liaoning province, and Kechuang Laser Remanufacture Limited

in Zhejiang University of Polytechny, Hangzhou City, Zhejiang province [12, 13]. Laser remanufacturing has successfully created a lot of instances, such as steam turbines, fans and electric engines in petrochemical and power industries, components of heat-rolling plate, bar and high speed wire rod tandem mill lines in metallurgical industries, wagon cartwheels, locomotive shafts, rails and railroad switches in railway industries, hot-end components assemblies in aero-engines of airplanes and internal combustion engines of large ships. Tianjin University of Technology systematically researched laser cladding remanufacturing technology. They investigated interactions between laser beam and supplied powders, remanufacturing quality and performance control for the products, developed the laser remanufacturing processing equipment, auto-processes and related software systems, and applied the technology to remanufacture the pump body and main shaft of oil extracting pumps, crankshafts of large diesel engines[6, 7, 14, 15]. As for the difficult problems in titanium alloy parts maintenance, Prof. Huang and his team in Northwest University of Technology developed the laser remanufacturing technique for titanium alloy parts such as aero-engine blades. They investigated remanufacturing forming theory, processing methods, performance control and evaluation methods of the remanufactured products. Jiangsu University developed laser shock-peening remanufacturing technique. Generally, laser shock-peening is used to strengthen the new products such as aero-engine blades to improve their fatigue performance. However, Prof. Su and his team in Jiangsu University spreaded it to remanufacture the used-parts to change the residual stress in the remanufacture-deposited metal and improve serving life of the remanufactured parts[16]. National Key Laboratory for Remanufacturing in Beijing City developed the laser remanufacturing technology with various lasers such as CO₂, Nd:YAG and diode lasers. The authors of this paper, in National Key Laboratory for Remanufacturing, explored the forming theories, processes, novel materials and applications of laser remanufacturing, and successfully remanufactured various parts which had never been successfully repaired before, such as heavy-duty gears and automobile engine aluminum alloy covers.

Just as stated above, laser remanufacturing technology has been successfully applied to many industry fields. It settled many persistent problems in equipment maintenance and showed great economic and social effects.

With contrast to the general repairing techniques such as thermal spraying and brush electroplating, laser remanufacturing takes higher cost of start input because the laser system cost is higher. However, the processing cost is low, and the cost of remanufacturing a part is even less than 25% of the original part price. And also, the laser remanufactured parts which cannot be finished with the traditional technique, has higher added value. It can be said that laser remanufacturing holds high ratio of performance to cost. Therefore, it shows properous

application prospects in various industries.

4 Problems in laser remanufacturing development

Laser remanufacturing is a rising high-tech industry fields, which is still at its infancy stage. Therefore, there still exists many problems as the followings.

(1) High threshold value to access laser remanufacturing fields

High cost of laser remanufacturing system requires the owner to take a high input at the first stage. And also, laser remanufacturing is a multi-disciplinary intercross high-tech fields, which is related to the theory and technology in many subjects such as materials science and engineering, mechanics and manufacturing, maintenance, auto-control, optoelectronics and so on. All of these bring troubles to spread laser remanufacturing, and only the persons who own a certain capitals and grasp some related knowledges can get a good start and gain good opportunities in laser remanufacturing development and application.

(2) Recognition lack of the public

Nowadays, plants and enterprises on equipment maintenance are still lack of necessary recognition to laser remanufacturing. Fortunately, with the national policies of cycling economy, energy-conservation and discharge-reduction carrying out, more and more institutes and enterprises have taken measures to research and apply laser remanufacturing technology.

(3) Mono-format of processing in application

Application successes of laser remanufacturing is still mainly on laser cladding for the local surface damaged part remanufacturing. It has not embodied the distinctive characteristics from traditional repairing or maintenance. In fact, a lot of structure-complicated and precious parts need not only local surface remanufacturing, but also three-dimension shaping remanufacturing. And also, laser remanufacturing mainly employs CO₂ laser system, which limits the job to have to be finished at workshop. Many large equipment components need to be restored on spot. All of these urgently need other laser processing techniques to spread into remanufacturing fields from the original manufacturing fields.

(4) No standing standards in industry

Standards stand for maturity of a technique. However, nowadays, there is not yet any laser remanufacturing standards to be followed in industry.

5 Trends of laser remanufacturing developing

As a rising industry, laser remanufacturing are rapidly developing on its processing equipment system, technical theory and processing methods. With concerns of technology and economy development, it should be strengthened on the following aspects for the future.

(1) To develop laser remanufacturing technology based on various laser systems

It is necessary to employ functions of high-power diode laser, solid laser and fiber laser systems, and develop the related remanufacturing processes based on them. These systems are mobile, can be easily moved to the wanted

places and work on spots, which hold the virtues such as compact structure, reliable performance, high energy conversion ratio and so on. Therefore, on-spot laser remanufacturing will be a new direction, which can greatly shorten the dead time in production and reduce the related economic losses[17-18].

(2) To combine various laser remanufacturing techniques together

With industrialization of remanufacture engineering, remanufacturing has become an important measure for machinery to achieve the targets of energy-conservation, discharge-depletion and environmental protection. Therefore, the laser remanufacturing techniques, who attribute to environmental protection and green production, meet a great opportunity. The techniques, like laser cleaning, laser drilling and other laser processing techniques, will be explored for remanufacture engineering. Then the mono-format on laser cladding will be broken.

(3) To expand to three-dimension volume shaping from surface layer repairing

On the basis of surface layer laser repairing and rapid forming, laser remanufacture shaping the three-dimension body will become popular. However, its theory and technology are the difficult problems. Accordingly, the flexible laser systems for three-dimension laser remanufacture shaping need to be improved.

(4) To set-down related standards about laser remanufacturing

Laser remanufacturing standards have aroused extensive attentions of government, enterprises and institutes. China National Standard Bureau has agreed to set up National Laser Remanufacturing Technology Standard Committee. Therefore, to frame the standards about laser remanufacturing is a pressing job.

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