

# The Key Technologies of Laser Surface Texturing and the Relative Equipments

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## ABSTRACT

Recently, there are three challenges of engineering practices of surface texturing for the diversity of geometrical shapes and complex operating conditions of mechanical components, such as optimal design, machining and equipment. Our group has always studied focus on the optimization design of discriminating partition surface texturing, precision and micro machining technology, processing equipment and engineering applications. The concepts of optimization design of discriminating partition surface texturing and the processing of single pulse intervals laser micro-surface texturing (SPIL) were proposed. In order to enable the manufacture of the various machinery parts surfaces by the processing of SPIL, the precision and micro laser machining equipment with high versatility has been developed. A laser surface texturing production equipment has been developed to manufacture the textured four-cylinder, which can meet the efficiency and stability of industrialization.

**Keywords:** laser surface texturing; optimization design; equipment; engineering application

## 1 INTRODUCTION

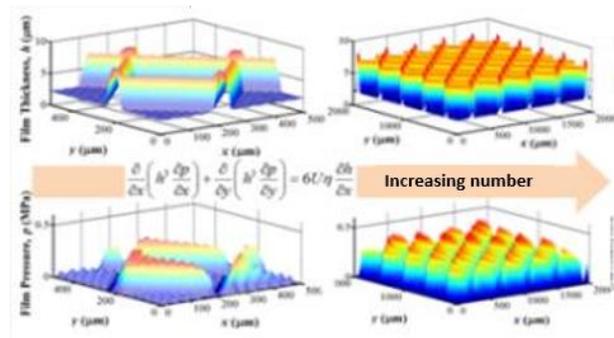
According to theoretical analyses and experimental experiments, surface texturing has been shown to have tribological performance increasing effects in mechanical components, such as cylinder liner – piston ring contacts, mechanical seals and bearings etc. [1]. However, there are three challenges of engineering practices for the diversity of geometrical shapes and complex operating conditions of mechanical components. The first is to design the optimal surface texture for improving tribological performance. The second is to manufacture the accurately textures with high efficiency and quality. Finally, the development of the precision and micro machining sets of laser equipments is a pressing issue.

Over the past decade, our group has studied focus on those problems follow the systematism concept of “Theory – Design – Technology – Process – Performance –

Equipments - Engineering practices”, and made many achievements.

## 2 OPTIMIZATION DESIGN OF DISCRIMINATING PARTITION SURFACE TEXTURING

The effect of the geometrical parameters and distribution schemes of textures on the comprehensive performance of mechanical components were studied, and the concept of optimization design of discriminating partition surface texturing was proposed [2-4]. According to the geometrical shapes and operating conditions of mechanical components, mathematical models of the friction pairs could be established by considering the regional discrimination and spacetime effects of the tribological characteristics. The simultaneous solution of the generalized Reynolds equation, oil film thickness equation, three-dimensional energy equation, three-dimensional heat transfer equation and force equilibrium equation will be presented by the multi-grid algorithm. In addition, the key experimental investigation was supplemented to verify the analytical results. Then, the design principles and optimization designs would be developed, and the designs system database could be formed.



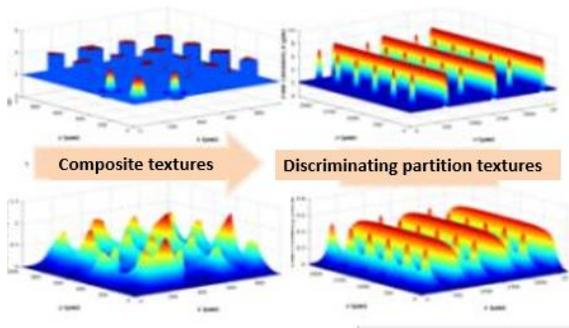
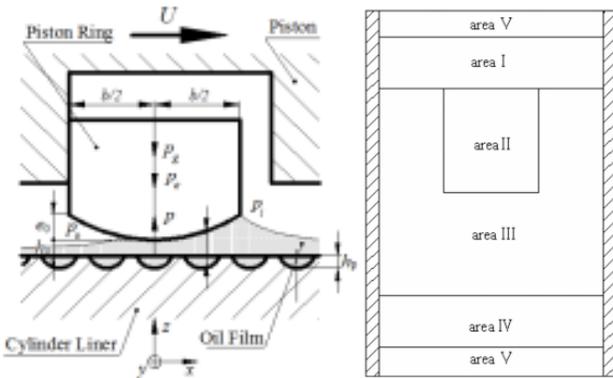
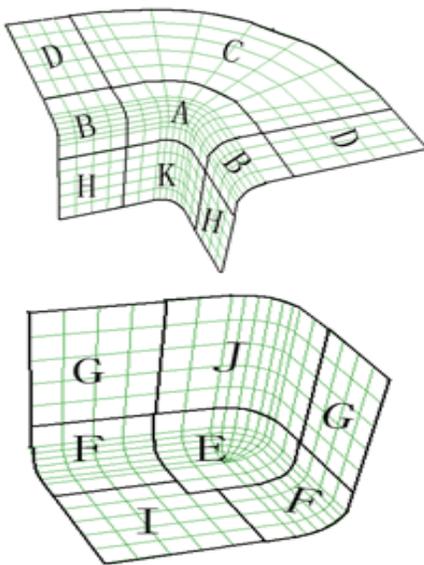


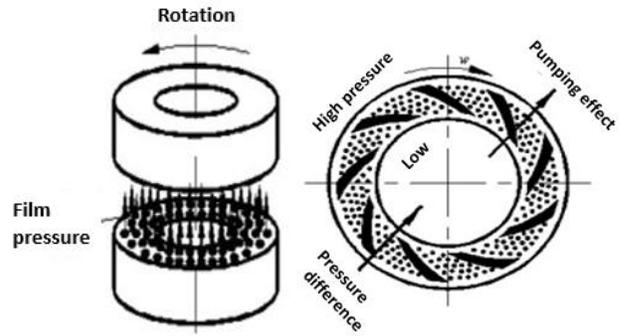
Figure 1: Hydrodynamic lubrication numerical analysis of surface texture.



(a) Cylinder liner-ring



(b) Mould



(c) Mechanical seal

Figure 2: The principle of discriminating partition surface textured typical machinery parts.

### 3 PRECISION AND MICRO MACHINING LASER TECHNOLOGY

By studying the function of laser interacting with material, the processing of single pulse intervals laser micro-surface texturing (SPIL) was proposed. The negative effects of heating effect could be minimized by the processing of single pulse intervals laser micro-surface texturing, and the accurately textures also could be manufactured by the processing of single pulse intervals laser micro-surface texturing with high efficiency and quality. Besides, one improved method to fabricate micro embossments on the metal surface through laser shock processing was developed. The hardness and wear resistant of the entire laser-shocked zones was improved remarkably due to the plastic deformation at a high strain rate. Therefore, laser shock processing has the ability to modify the geometric features and material performance of surface [5,6].

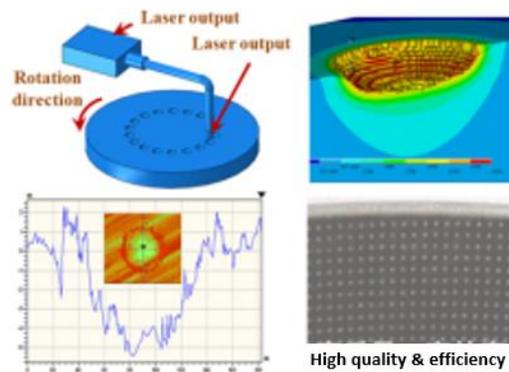


Figure 3: The processing of SPIL.

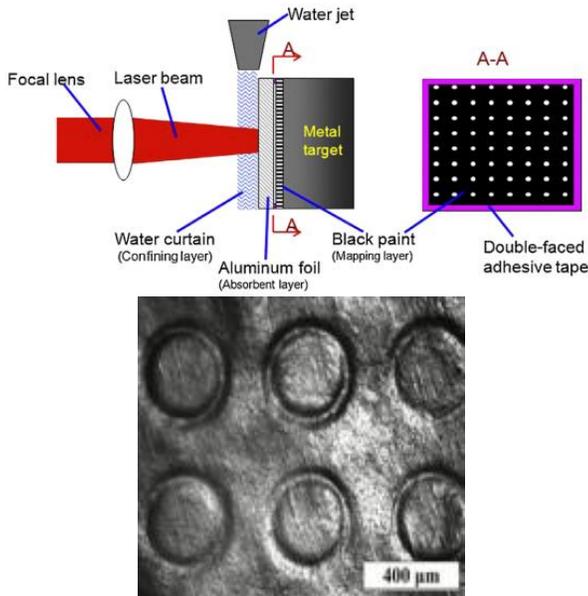


Figure 4: Laser shock processing.

#### 4 A SERIES OF SELF-DEVELOPED EQUIPMENTS

In order to enable the manufacture of the machinery parts surfaces by the processing of single pulse intervals laser micro-surface texturing (SPIL), such as cylinder liner, cam and mechanical seal etc., the precision and micro laser machining equipment with high versatility has been developed.



Figure 5: The precision and micro laser machining equipment with high versatility

Furthermore, faced the requirements of enterprises and applications, our group has already succeed in tackling the compatibility conundrum of the laser control system and the CNC system. A laser surface texturing production equipment for four-cylinder has been developed to manufacture the discriminating partition surface textured four-cylinder, which can meet the efficiency and stability of industrialization.



Figure 6: Sketch of equipment.



Figure 7: LST production equipment for four-cylinder.

## 5 TYPICAL ENGINEERING APPLICATIONS

This paper is based on the study on laser surface texturing technologies and equipments of our group in the past decade. Laser surface texturing technologies have been applied to engine, cylinder liner – piston ring, mould and mechanical etc., and our group have formed a series of engineering applications technologies, such as low friction technology of engine, composite surface textured mould and zero leakage and non-contact mechanical seal [4,7,8]. The practical engineering shows that laser surface texturing is an effective means for enhancing tribological properties of mechanical components.

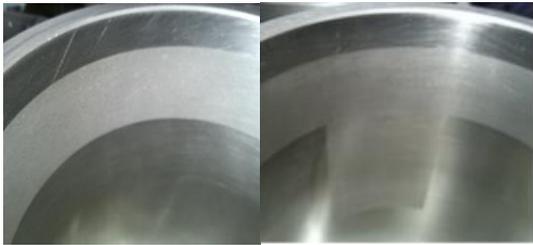


Figure 8: Pictures of different micro texturing schemes of cylinder liner surface.

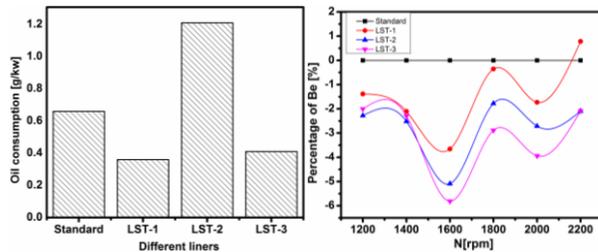


Figure 9: Research on discriminating partition laser surface micro-texturing technology of engine cylinder.



Figure 10: Pictures of composite surface textured mould and zero leakage and non-contact mechanical seal.

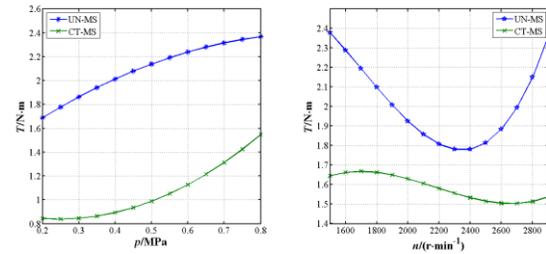


Figure 11: Performance of zero leakage and non-contact mechanical seal.

## 6 ACKNOWLEDGEMENTS

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