Advances in Surface Weaving Technology

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ABSTRACT : *The micro stuctures of specific shapes, sizes and distribution on the surface of the material can achieve the purpose of reducing, obstructive, lubricaing, and noise reduction. The microstructures of specific shapes, sizes and distribution on the surface ofthe material can achieve the purose of reducing, obstructive lubricating, and noise reduction. and noise reduction, as well as the application of mechanical processing, medicine and other fields, and summarize the impact of key design parameters of The application of laser machining technology in surface fabrication is introduced and the effects of the geometric characteristics andsurface quality ofthe material are discussed. The application of laser machining technology in surface fabrication is introduced, andthe effects of the geometric characteristics and surface hardness of the laser processing process parameters on the surface weavingThe application of laser machining technology in surface fabrication is introduced, and the effects of the geometric characteristicsand surface hardness of the laser processing process parameters on the surface weaving. .*

KEYWORDS -*Surface texture Design parameters; Laser cladding; Process parameters*

I. INTRODUCTION

Surface texturing technology originated from the concept of biomimetic texturing proposed by scientific research scholars in the 1940s and 1950s, and due to the limitations of science and technology at that time, this technology has not been paid enough attention [1]. With the development of science and technology, the excellent properties of surface textiles in improving friction performance have attracted the attention of many scholars. At present, it has achieved better application in lubrication and friction reduction in machining, aerospace, medical and other fields, and has become an important way to improve the surface properties of materials [2-3]. However, the requirements for modern manufacturing equipment gradually increase with the more complex conditions of the working conditions, and the surface weaving technology still faces serious challenges, such as the system of test and inspection methods is not uniform, and the reliability of the obtained test data is insufficient; the straight edges and sharp corners of the weaving features are subject to cutting and stress concentration, and have limited enhancement effect on wear, and so on. In order to solve these problems, researchers have explored the design of surface texture from the key design parameters of surface texture, mainly including shape, distribution position, geometric parameters, combination form, etc. Many scholars have indicated that combined with the application of the surface texture in practice, the surface texture prepared under the appropriate processing technology and design parameters in order TO maximise the role of surface modification [4].

This paper summarises the characteristics and advantages of surface textiles, reviews the key design parameters and practical applications of surface textiles, and introduces the influence of process parameters of laser processing technology on the properties of the prepared surface textiles, with a view to providing reference for the research of surface textile technology.(10)

II. SURFACE STRUCTURING

Overview of surface texturing

Biologists have found that there are some regular microstructures on some biological surfaces with good friction reduction performance, such as a series of micro-bumps on the surface of lotus leaves, the surface texture of sharkskin, and the pattern on the surface of butterfly's wings, etc. The structural characteristics of biological surfaces in nature are shown in Fig. 1, and these microstructures on biological surfaces can have a beneficial effect on tribological performance, which is the source of inspiration for the design of surface weaving to reduce friction and drag on friction sub-surfaces [5-6]. surfaces for friction and drag reduction. Li Yajun et al [7] prepared pit weaves with different weave densities on the surface of 45 steel and tested them in two different lubrication environments, namely dry friction and oil depletion, and found that the wear ratios of the unweaved specimens were greater than those of the weaved specimens. Qin Liguo et al[8] applied surface textures to artificial joints, which may achieve double improvement of biological compatibility and tribological performance after multi-layer or composite design. It can be seen that when the design parameters are reasonable, the surface weave can effectively improve the tribological and biological properties.

III. Friction Reduction by Surface Textiles

The mechanism of reducing friction coefficient using surface textiles varies in different lubrication environments, which are generally classified as dry friction, boundary lubrication, and continuous lubrication according to the amount of lubricant in the operating environment of surface textiles. In the dry friction environment, surface microtextiles improve surface friction performance by trapping and storing debris and preventing its deposition on the friction surface, weakening the adhesive friction as well as the furrow effect [9-10]. In a boundary lubrication environment, the continuation of the friction and wear process reduces the depth of the surface texture, and the reduction of the pit volume leads to the spillage of lubricant to form a continuous film, which provides continuous lubrication. In addition, the lubricant overflowing from the pits will lubricate the surrounding surfaces, showing the phenomenon of "secondary lubrication" [11-12]. In the continuous lubrication environment, hydrodynamic film will be formed during the friction process of the friction pair, while hydrodynamic lubrication will be promoted by the local hydrodynamic lubrication of each pit, so as to improve the friction pair's load-bearing capacity and produce additional fluid effects [13-14].

Chen et al [15] in stainless steel surface processing out inclined weave and vertical weave, explore in dry friction and oil lubrication two different environments under the surface friction coefficient change law and weave relationship. The results found that the change of friction coefficient is mainly affected by the tilted weave, under the condition of oil lubrication, the sliding speed increases and the friction coefficient decreases, while under the condition of dry friction, the opposite trend is shown. Han Zhongling et al [16] prepared pits with different depths on 45 steel, and at the same time controlled the size of the lubricant quantity, explored the influence of pit depth and lubricant quantity on the friction reduction effect, and found that the lubricant quantity and pit depth synergistically affect the friction reduction results, the pit can play a better friction reduction role under the state of lack of oil and friction is minimum when the pit depth is 3um.WANG et al [17] prepared a pins and discs structure with the same process parameters, respectively. The circular and elliptical weaves with different depths, density ratios and sizes were prepared using the same process parameters, and the results showed that the cylindrical weave with a diameter of 300 mm, a density ratio of 5.04 %, and a depth of 40 mm had the lowest coefficient of friction, temperature rise, and wear under the same test conditions. The results show that the friction reduction mechanism of surface fabrics is different under different working conditions, so the tribological performance can be effectively improved by selecting the appropriate surface fabrics according to the working environment.

Surface fabric noise reduction

In addition to reducing friction and resistance at the contact interface, the design of surface texture can also achieve the purpose of noise reduction, and the noise reduction mechanism has the following two aspects: firstly, the surface texture can reduce the storage of abrasive debris on the surface of the structure, so as to effectively remove the abrasive debris, and at the same time, reduce the high-frequency components formed due to the friction fluctuation. Secondly, the continuous collision at the interface will be inhibited by the presence of surface texture, which interrupts the self-excitation of the friction system and thus achieves the purpose of noise abatement [18-19].

Zeng Kang et al [20] prepared M-type grooves on the surface of brake discs and observed the inhibition effect of M-type grooves on brake noise under different pressures and speeds, respectively, and they all have an inhibition effect on noise, and the noise can be significantly suppressed in a specific range. Shan Joy et al [21] investigated the effect of groove-type weave on friction vibration noise, in the low normal load, the plane of unprocessed weave produces almost no friction noise, while the processed weave of the specimen produces significant friction noise, uniformly increasing the normal load, the surface of the weave produces a gradual decrease in the friction noise and fluctuations in a small range. The smooth surface starts to produce significant noise, the intensity increases rapidly and tends to stabilise, from which it can be found that the normal load has a greater influence on the smooth plane, and the textile surface does not depend on the normal load.

Friction vibration and noise are unavoidable problems when driving and transporting systems work, and there are relatively few research results on the use of surface fabrics to reduce noise, so it is important to study the causes of friction vibration and noise and use surface fabrics to solve these problems to improve the friction vice operating conditions.

Surface fabric damping

Currently, the research on underwater turbulence damping is the focus of surface texture damping technology, where microstructures with regular size and shape are prepared on the surface of the specimen, which can play a good role in damping. The mechanism of underwater drag reduction can be explained as follows: the direction of the notch is consistent with the direction of the vortex, which is oriented to the vortex and promotes anisotropy, and drag reduction is achieved by effectively controlling the naturally occurring turbulent eddies, reducing the capacity exchange and shear stresses in the boundary layer, and locking the vortex generated by the viscous sublayer in the notch [22-23].

NASA Langley Research Center, a discovery breaks the traditional cognition that the smoothness of the object is not directly proportional to the drag, the tiny grooves on the surface of the object can effectively reduce the wall friction resistance when following the direction of fluid flow [24].ZHANG et al. [25] found that the rectangle compared to triangles and semicircles have a better drag reduction function; LANG Shasha et al. [26] found that the drag reduction effect of the micro-weave when the weave is arranged in an orderly manner is significantly better than that of the weave in a disorderly arrangement. better than disordered arrangement of weaves.TIAN et al [27] found that shark scales and edible skin seem to be able to reduce pressure drag by passive control mechanisms.Skin and streamers reduce pressure drag by controlling vortices to increase flow velocity within the boundary layer, reduce the exchange capacity and shear stress of the boundary layer, and lock the vortices generated by viscous sublayers in the notch.

From a hydrodynamic point of view, the reason why flexible surfaces achieve the drag reduction effect is that flexible surfaces can slow down the transformation of the laminar boundary layer into a turbulent boundary layer, so that the boundary layer remains in a laminar flow state for as long as possible. Therefore, the surface weave derived from the surface of the flexible material can actively control the fluid, enhance the drag reduction capability, reduce the navigational resistance of the marine navigation equipment, and improve the working efficiency of the equipment.

Surface texturing applications

Surface texturing technology has been applied in machining, medical treatment, equipment manufacturing and other fields to achieve good results, especially in tool machining technology has been very mature, in the application of bearings, mechanical seals, artificial joints have also shown excellent improved performance.

Surface fabrication in the improvement of tribological performance: Guo Wanpeng et al [28] in the pumping pump on the preparation of bionic hexagonal surface fabrication, the results show that the surface friction coefficient of the surface fabrication with the increase in rotational speed and load gradually reduce the friction resistance can be reduced by about 40%. Ge Chang et al [29] prepared stepped surface textures on piston rings and cylinder liners, and the results showed that choosing the appropriate texture design according to different working conditions can reduce friction and friction fluctuations.

Surface fabrics in improving lubrication: Lu Jisong et al [30] prepared a series of regular arrangement of surface fabrics on water lubricated bearings, the results show that when the surface density of the surface fabrics and the depth-to-diameter ratio at the optimal value, can make the water lubricated bearings of the film thickness ratio up to the maximum value as well as the friction factor is reduced to a minimum, and with a lower rotational speed from the mixed lubrication state into the hydrodynamic lubrication state. Zhou Long et al [31] also found that a suitable surface texture can maximise the film thickness ratio of piston rings to improve their lubricity.

Surface weaves are applied in enhancing biocompatibility: KIM et al [32] prepared grooved surface weaves on a cardiac muscle model, and under specific conditions, these tissue structures exhibited the anisotropic action potential propagation and contraction properties of natural tissue structures. Of greater interest, cell geometry, action potential conduction velocity, and expression of cell-cell coupling proteins can respond to subtle differences in the basal nanoscale features of the surrounding extracellular matrix.QIN et al [33] generated microstructures with nanoripples and islands on Co-Cr-Mo alloys. Cell adhesion and proliferation studies showed that the promotion of cell activity was due to the enhanced adhesion of MC3TC-E1 osteoblasts on the HMN surface. Osteoblast morphology analyses showed that cells had a high rate of extension on the HMN surface, whereas they remained predominantly rounded on the polished surface. Cell-material interactions at the nanoscale can be artificially controlled to specify structure and function at the tissue level.

Application of surface weave in enhancing adhesion: Kerry Zheng et al [34] prepared ortho-hexagonal pit microweave on the inner surface of tubular vascular scaffolds, and the results showed that the pit microweave could reduce blood adhesion and decrease the resistance to blood flow, which lowered the probability of blood clogging and prolonged the stent's service life.ZHOU et al [35] prepared micropits in the surface of the electrodes, and the results showed that the microweave in the air can reduce the contact area between the electrode and soft tissue, and thus the electrode surface makes the adhesion of soft tissue significantly reduced.

In addition to this, the surface texture also has unique applications in the fields of noise reduction, improvement of surface optical properties, and enhancement of electronic components, which has a broad development prospect in the field of improving the surface properties of components.

Research on Laser Processing of Surface Texturing

With the development and application of surface texturing technology, the application of surface texturing has become more and more extensive, and the research and development of surface texturing processing methods and equipments have become a priority in order to meet the needs of various industries. At present, the mainstream surface textile processing methods mainly include laser processing, electrochemical processing, photolithography processing, etc [36]. Among them, laser processing surface texturing technology is currently the most mature non-contact rapid prototyping technology, which has the advantages of high controllability, precise processing, and fast speed compared with other processing methods [37-38]. In addition, in the process of preparing weaves using laser, the instantaneous impact of huge energy will harden the surface of the material, and the tribological properties of the friction vice will be further improved [39]. At present, the preparation of microtextures by laser processing mainly focuses on the effects of laser power, processing speed, and the number of repetitions on the surface properties of textures.

Winston Zhang et al [40] used a picosecond laser to process microstructures on the surface of stainless steel, and investigated the relationship between the surface morphology of the weave and the laser power, processing speed, and the number of repetitions, and the results show that the width and depth of the grooves will decrease with the decrease in laser power and the increase in processing speed, while the number of times of processing has a significant effect on the width of the grooves only. Kerry Zheng et al [41] used laser technology to prepare microstructures in hard tool alloys, and the results showed that when the laser power increases, the melt appears at the bottom of the structure and increases with the increase of the laser. Zhu Liang et al [42] used a nanosecond laser to prepare microtextures on cemented carbide and found that the residual compressive stress and microhardness were most affected by the laser frequency, followed by time, spot diameter, and the laser energy had the lowest effect. Mao Asia [43] used laser processing of microstructures on brass surfaces and found that the increase in energy increased the heat affected zone and the hardness value increased significantly, and the increase in the number of pulses significantly increased the hardness of the micro-pits. Deng Jianxin et al [44] used nanosecond lasers to machine microtextures on the front face of different tools, and the designed textures could significantly improve the hardness and wear resistance of the tools.

IV. Influence of Laser Process Parameters on Surface Texturing Properties

Surface engineering techniques such as laser cladding alloys, laser surface texturing and ion implantation can be used to improve the wear resistance of stainless steel, and the texturing treatment has no interface with the substrate and low-cost characteristics, which is more suitable for application in food machinery. Lin Naiming et al. through the study found that 316L stainless steel surface weaving unit edge has a raised morphology, the surface roughness of the specimen after laser weaving treatment increased, the surface hardness of the material increased; Xu Yangyang et al. in the nitriding cylinder surface with a diameter of 120 μm, the depth of 40 μm parameters for different densities of laser weaving treatment, found that the micro-pit around the generation of a certain thickness of the hard layer and the transition layer in the weaving density of 10%, the friction factor of the surface engineering techniques can improve the abrasion resistance of stainless steel. At a density of 10%, the friction factor is the smallest and the wear is the smallest; Sun et al. found that the crater structure on the surface of TC4 titanium alloy has a V-shape cross-section and the bottom of the crater is a little uneven. T.C. Hu et al. examined the dry friction and wear properties of laser surface texturing of 45 steel at room temperature and found that the friction factor of the untextured surface was higher than that of the textured surface and fluctuated drastically under 2N and 5N loads, and the wear rate of the textured surface was smaller than that of the untextured surface, and that the surface friction factor of the textured surface with 100 μm aperture was smaller when its density was smaller, and that the textured surface with 200 μm aperture was smaller at 33% of its texture density, at the same time, the surface friction factor of the textured surface was smaller when the density of its texture was smaller than that of its texture. The lowest surface friction factor was found at 33% of the fabric density. Chang Qiuying et al. prepared a 500 μm diameter laser cratered fabric on 45 steel, and found that the increase in the density of the laser fabric led to an increase in the amount of wear.

V. Conclusion

The theoretical and experimental studies of surface texturing show that texturing technology has great research value in improving the wear resistance, lubrication and corrosion resistance of high-end equipment components. At present, there are still limitations in the study of surface texture, if the surface texture in the synergistic effect at the same time to achieve a variety of functions, so that the surface properties of the material to be further improved is the direction of future breakthroughs.

(1) At present, most scholars have done a lot of research around the improvement of tribological properties of surface textile, and need to further explore the lubrication and friction reduction mechanism of surface textile, in addition, the design of surface textile parameters on the synergistic effect of other characteristics of the research is less, so the establishment of the mapping relationship between the textile parameters and the surface properties of the design of high-performance surface textile has an important significance in guiding.

(2) The development trend of the working environment of the equipment components is complex and extreme, the failure form of weaving coating in service in different environments needs to be focused on, in the future to establish a response to the failure system of weaving coating under the harsh working environment.

(3) Laser processing technology is currently the most widely used surface fabrication processing technology, but the laser processing of the pit array in the pit depth, diameter and micro-weave there are still large differences in the laser processing process on the friction reduction and lubrication effect of the influence mechanism needs to be further. Conclusion

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