Effect of Texture Width on Tribological Properties of Cast Iron Surface

Chen Gang[1], Chen Lei[2]

[1]Merchant Marine College, Shanghai Maritime University, Shanghai 201306, China;

[2]Shanghai Maritime University, Shanghai 201306, China.

Abstract

Using laser processing technology in the cast iron sample surface width of different structure knitted circular depressions in composition, by BRUKER UMT -TRIBOLAB friction and wear testing machine tested different texture width of the cast iron surface under the condition of rich oil lubrication friction and wear performance of using before and after the friction surface contourgraph pits characterizing the morphology analysis, and by using precision electronic balance record the change of the the quality of the cast iron specimens before and after the test. The influence mechanism of circular pit texture width on tribological properties of cast iron surface under oil-rich lubrication was investigated. Research results show that the laser processing after the circular depressions of texture and texture width significantly affect the surface of cast iron in the oil lubrication, friction and wear behavior under the condition of the texture width of 50 μm of cast iron surface to obtain the best anti-wear and anti-friction effect, compared with not texture surface, the friction coefficient was reduced by 50% or so, wear is reduced by about 70%. This is mainly due to the good wedge effect produced by lubricating oil passing through the convergence region of cast iron surface with texture width of 50 μm during the friction process, and the larger lift generated by lubricating oil, which improved the lubrication state of the texture surface during the friction process, thus showing good tribological properties.

Keywords

Surface texture; Cast iron; Friction and wear; Rich oil lubrication conditions.

1. Introduction

Cast iron is the carbon content is more than 2.11% of the iron carbon alloy cast iron used in industry is the iron carbon silicon as the main elements of impurities such as sulfur and phosphorus containing manganese alloy according to different form of carbon that can differentiate cast iron is cast iron carbon content is more than 2.11% of the iron carbon alloy cast iron used in industry is the iron carbon silicon as the main elements of impurities such as sulfur and phosphorus containing manganese alloy according to different form of carbon, cast iron can be divided into two major categories of white cast iron and grey cast iron, two kinds of white cast iron and grey cast iron, grey cast iron has low wear resistance and mechanical properties of excellent buffer Process performance is good wait for a characteristic, therefore in the machinery manufacturing biomedical architectural decoration has been widely used in such fields as daily life [1, 2].

however, in the machinery industry, cast iron parts in high temperature and high pressure under the condition of complex environments such as wear-resisting performance varies, most of the time characterized by wear-resisting performance, to make it in use can appear premature failure, reduce the mechanical efficiency, shorten the service life of the surface improved technology is the effective measure to improve the tribological properties, including surface chemical heat treatment, surface coating and surface texture The surface texture technology is a simple, clean and environmentally friendly method based on the characteristics of natural biological surface roughness and friction resistance.

Surface texture is changed by the processing method in material surface processing of shape has certain depth and density of graphics, in order to improve the material's surface properties, such as tribology [3,4] such as Wang [5]research in different sizes and different texture depth of circular pit under the condition of water lubrication friction and wear performance of found circular depressions texture ratio of depth to diameter ratio and area, make its surface bearing capacity than texture samples increase more than 2 times.

Tang [6] to study the oil lubrication conditions, such as surface texture on the bearing capacity of the oil film dynamic pressure effect, the results show that the rate of 5% texture samples can have the biggest fluid dynamic pressure effect, make the oil friction fell by 38% on texture simulation calculation of friction process, the more the based on navier - stokes (navier-stokes) equations of simulated Arghir [7], such as establishing texture model based on navier-stokes equation, and dynamic pressure lubrication on a variety of shapes of single pit simulation calculation, found that dynamic pressure lubrication pits of fluid inertia effect is the main reason Qi Ye et al. [8] used THE CFD method of N-S equation to study the influence of surface texture depth on the bearing capacity of lubricating oil film, and the results showed that when the groove depth was 4 μm, the bearing capacity of oil film was the strongest.

Although on the surface texture in the friction behavior of friction test have more extensive research, and is generally believed that the surface texture, enhance the lubrication effect of lubrication is due to the lubricating oil in the texture of the dynamic pressure lubrication [9,10], but the lack of further research, and the experimental study on surface texture also is less, this article studied the circular depressions of the cast iron surface texture width in rich under the condition of oil lubrication tribological behavior and the effect of the texture of texture in the lubricating medium width influence the anti-friction mechanism has carried on the further research.

2. Experiment Content

2.1 Sample sheet preparation and femtosecond laser processing round pit texture technology

Experimental sample piece in front of the laser machining, in turn, with 600, 1 200, 2 000, 2500 mesh sandpaper, and polishing machine polishing sample piece of femtosecond laser machining parameter Settings are as follows: processing lens for 10 x telecentric lens, laser wavelength of 800 nm, laser pulse frequency of 1000 hz, average power of 30 mw, laser feed rate is 200 μm/s, processing times for every 10 microns depth processing, machining path for concentric feed .

Under the condition of the above parameters setting, on the sample piece respectively made a diameter of 50μm, 100 μm, 150 μm, 200 μm and the depth of 40 μm was then polished by 2 000 mesh sandpaper and 2500 mesh sandpaper and polished by a polishing machine, respectively.

2.2 Texture surface morphology characterization and friction and wear experiment

UMT-TRIBOLAB multi-functional friction and wear testing machine was used for the test. The pin-disc reciprocating friction pair was selected. The PIN was cast iron with a diameter of 6 mm and a length of 20 mm. The disc is cast iron with HRC64 hardness. Standard Cylinder Oil Mobil 412 was used for lubricating oil. The kinematic viscosity at 40 °C was 112 mm^2/s, and the kinematic viscosity at 100 °C was 11.4 mm^2/s.

Setting the reciprocating frequency is 6 hz, the load is 30N, the linear reciprocating stroke is 10mm, the friction test time is 1200s, the wear test time is 5h, the room temperature, adding 1mL lubricating oil on the contact table of the friction pair can ensure that the friction pair is in the oil-rich state in the experiment. The data of friction coefficient are automatically recorded by computer during the test, and each group of tests is carried out more than 3 times. The surface texture and the worn surface were observed and analyzed by microscope. Before and after the experiment, the sample was cleaned with alcohol, then cleaned with ultrasonic, then wiped with paper towel and dried in the oven, finally, the weighing was recorded by a precise electronic balance, and the average value was obtained after more than 3 times of weighing. The micro-diagram of the contact surface of the pin-disk friction pair is shown in Fig. 1.

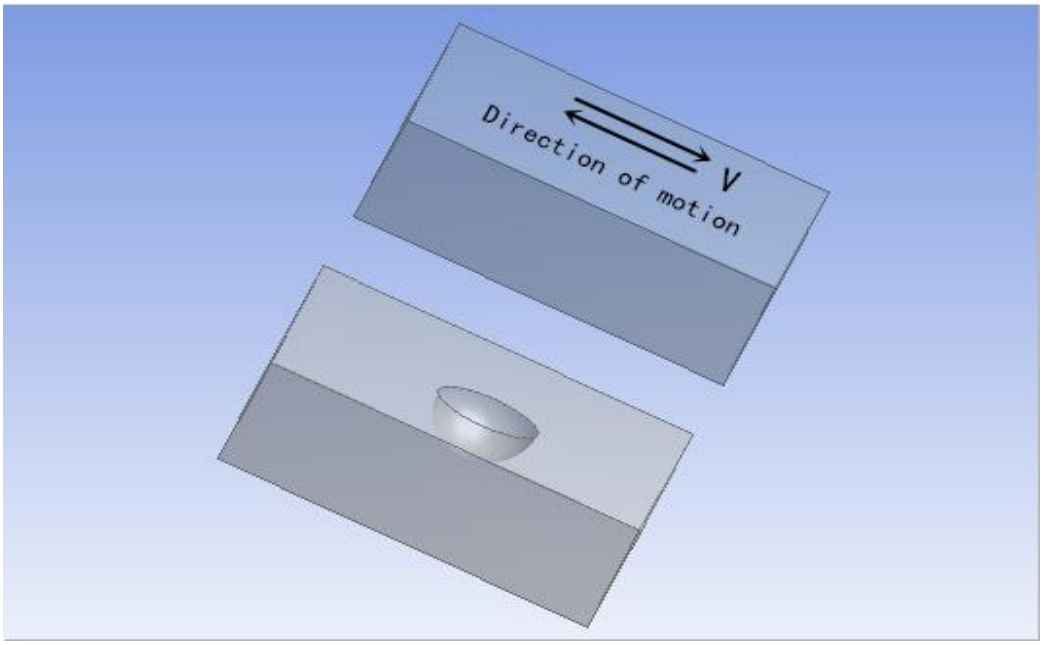

Fig.1. Microschematic diagram of pin-disc friction pair

3. Discussion of experimental results

3.1 Surface texture morphology analysis

Fig. 2 shows the original micro morphology of the pit with diameter of 100μm.Can see round pit is not smooth level off rules, outer round pit full of undulating coral organization, this is because the laser processing is using a laser focus on make sample surface heats up quickly, so that the surface melting or gasification, part of the molten matrix can be in internal and external laser processing in texture after solidification, resulting in a recasting phenomenon, due to uneven local cooling speed, recasting parts will form a rough coral tissues.

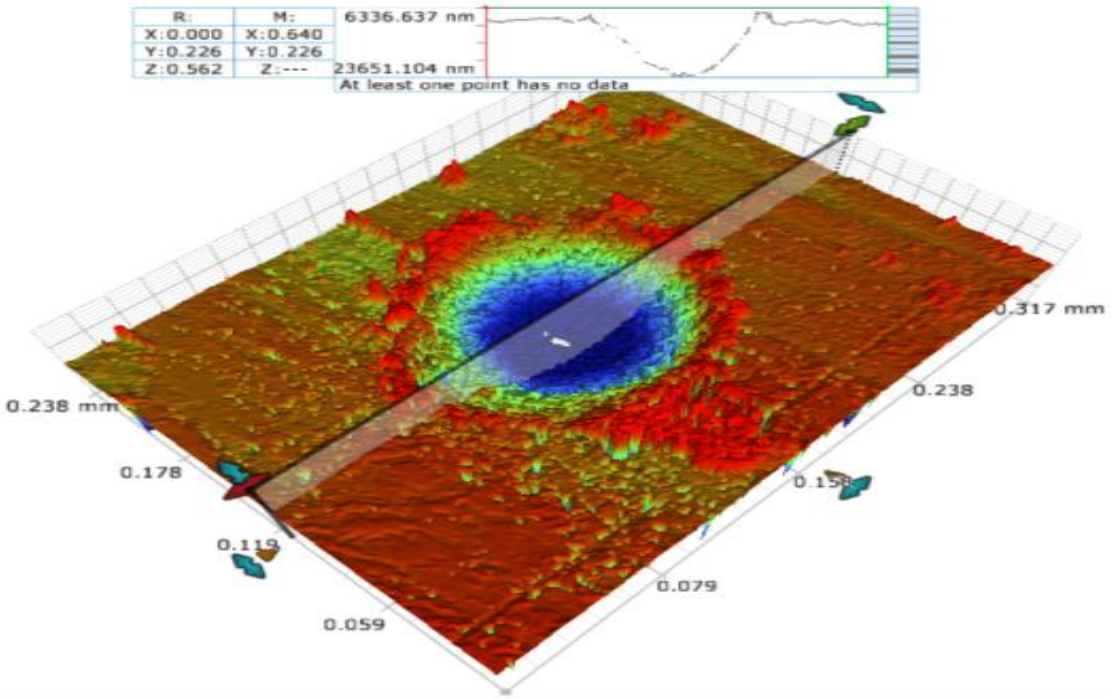

Fig. 2. Microstructure of pit texture with width of 100μm

3.2 Analysis of friction test results

Fig. 3 shows the curve of friction coefficient of 1200s on the surface of cast iron without texture and with different texture widths under oil-rich lubrication conditions. It can be seen that the friction coefficient of samples without texture varies from 0.11 to 0.12. The friction coefficient of the whole process is large, indicating that the friction performance of cast iron without texture is poor in Mobil 412 oil Compared with untexture, the friction coefficient of different texture widths showed a downward trend and remained within a certain range, indicating that the width of circular pit texture had an influence on the friction coefficient.

Among them, the friction coefficient of cast iron with width of 50 μm was stable between 0.030 and 0.036 at last, and the friction coefficient was reduced by more than 65% compared with untexture. The friction coefficient with a width of 150μm finally stabilized between 0.023 and 0.030, and the friction coefficient decreased by more than 70%, which was significantly lower than the surface of untextured cast iron.

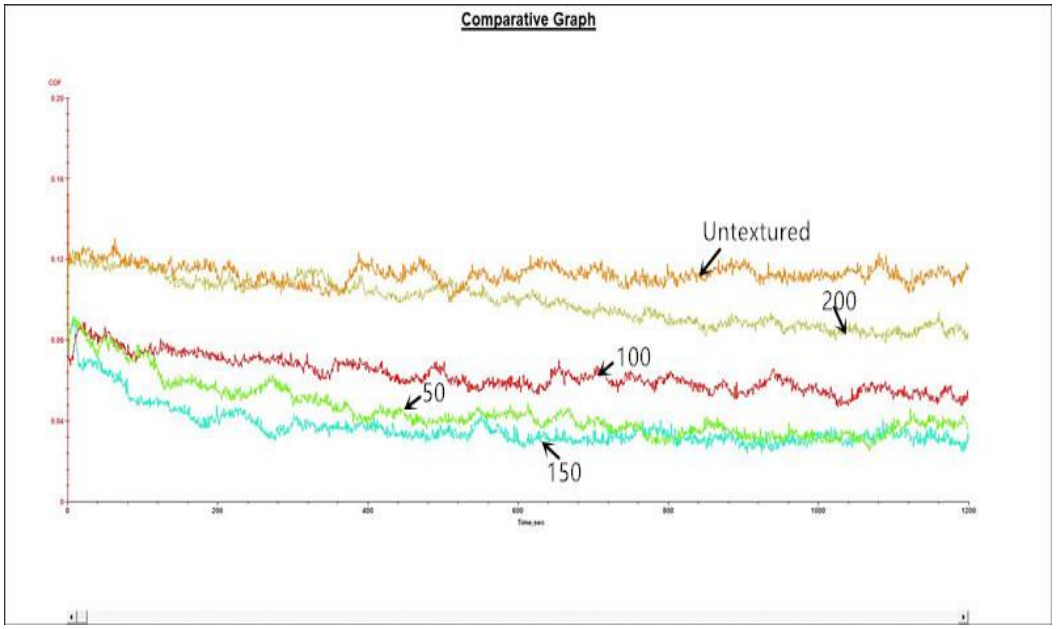

Fig. 3 Curve of friction coefficient of 1200s between untexture and different texture widths

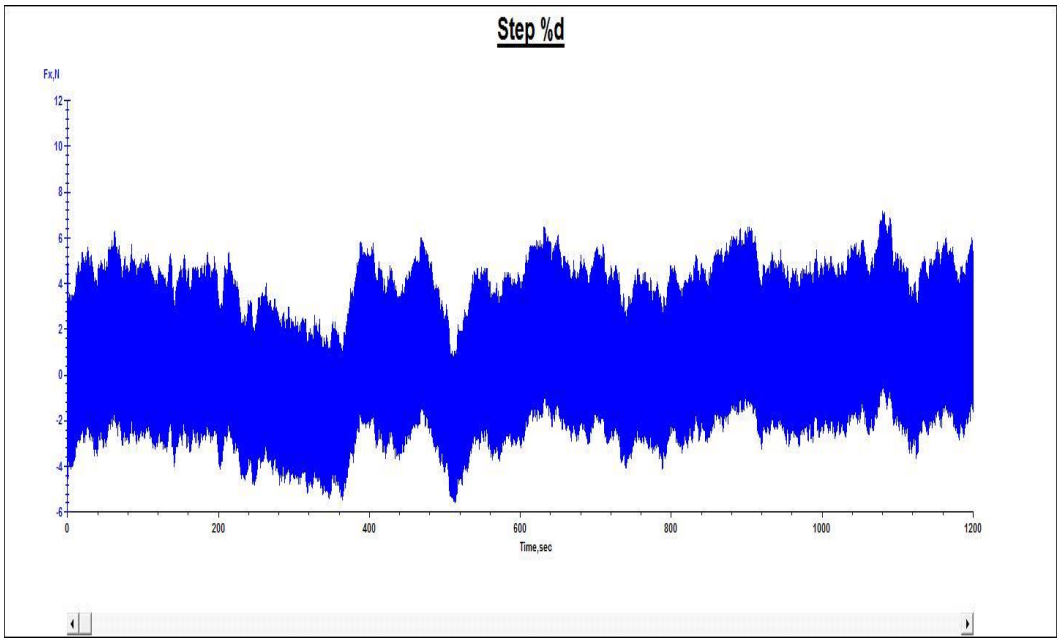

Fig. 4. Fluctuation amplitude of frictional force along X axis on untextured surface

By the size of the coefficient of friction can be intuitive to see different width of reducing friction of the texture effect, and the width of 50μm and width is 150μm of cast iron surface anti-friction effect is good, of which 150μm texture anti-friction effect slightly better in addition different texture on the X axis direction of friction force when friction changes can also be used to evaluate the anti-friction effect as shown in figure 4 is not texture surface under the condition of the oil-rich friction Fx value variation of 1200s .

Table 1 shows the extreme value and the extreme value of friction on the X-axis direction between untextured and different texture surfaces. It can be intuitively seen that the width of texture surface friction of 50μm has the smallest range of change, that is, it suffers less friction in the reciprocating motion friction process and has the best friction reduction effect.

Table 1. Extreme values of friction on different surfaces in the X-axis direction

WIDTH/μM	MAXIMUM/FX,N	MINIMUM /FX,N	DIFFERENCE/N
0	-5.628	8.331	13.959
50	-4.517	5.739	10.256
100	-5.962	6.295	12.576
150	-5.036	5.888	10.924
200	-5.962	6.887	12.257

3.3 Analysis of wear test results

Fig. 5 shows that the friction coefficient curves of cast iron surfaces without texture and with different texture widths show a linear downward trend under the condition of oil-rich lubrication for 5h. However, the total friction coefficient remains above 0.04, indicating a relatively large friction coefficient. Different width of the texture on the surface of both experience the process of decline to stable friction coefficient, the width of 50 microns of the surface of the cast iron after stable minimum friction coefficient, change between 0.015 to 0.023, compared with not texture surface friction coefficient reduced about 50% after stability, has good friction reduction effect interestingly width is 200μm of cast iron surface friction coefficient at will to 0.035 or so began to increase, eventually stable between 0.045 to 0.053, is greater than not texture surface friction coefficient.

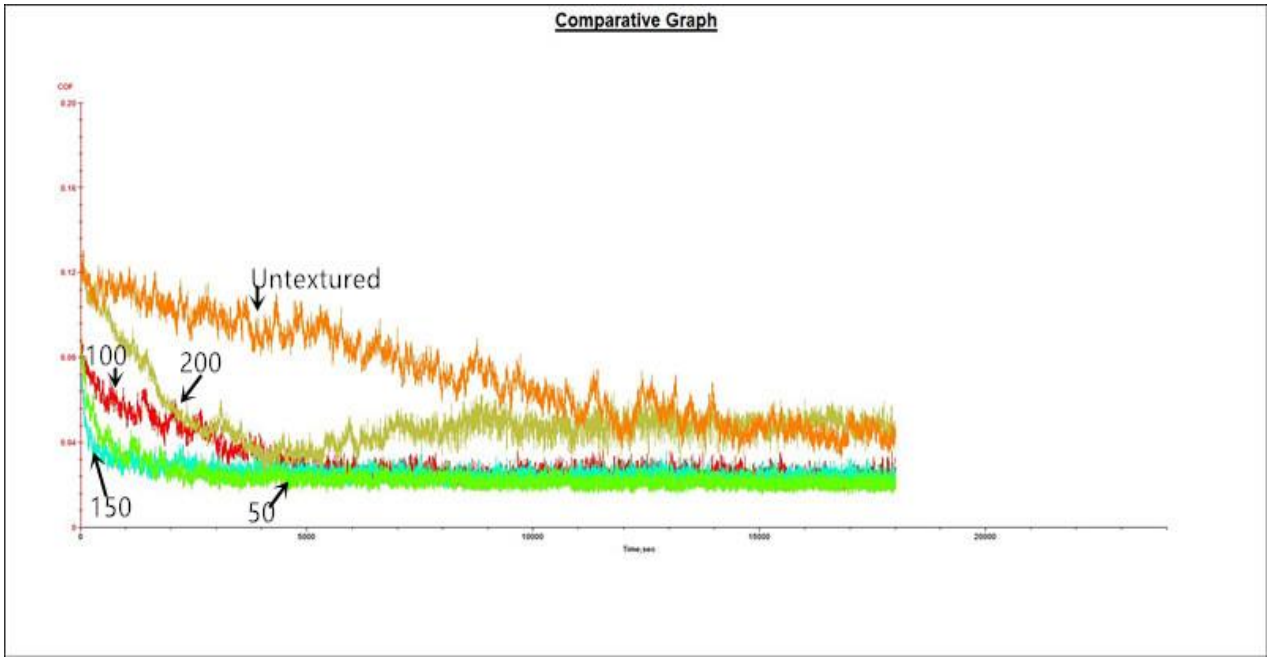

Fig. 5 Curve of friction coefficient for 5h of friction between non-texture and different texture widths

Reason is the early stage of the wear particles is less, with lubricating oil moved to the pits, combined with the lubricating oil lubrication lift the effect of reducing friction coefficient, and in the later because pit width is bigger, wear when the wear particles within the pits of a large number of accumulation, grinding grain cannot be squeezed out the friction pair with lubricating oil flow away, so wear particle will continue to interface between gathered around the pit and the friction pair, the coefficient of friction in a increases, while the number of friction pair between gathered grits saturated, the coefficient of friction will be leveled off.

Table 2 shows the quality and variation of the surface texture of cast iron samples before and after the wear test. It can be seen that the wear amount of cast iron samples before and after the wear test is much higher than that of other texture samples, among which the width of cast iron samples is 50μm, and the wear amount of cast iron samples is the lowest, with a reduction of about 70% compared to the wear amount of cast iron samples without texture, which has a better wear reduction effect.

Table 2. The quality change of sample before and after the test

WIDTH/μM	BEFORE /G	AFTER /G	REDUCE /MG
0	43.6563	43.6520	43
50	43.6430	43.6419	11
100	43.6529	43.6512	17
150	43.2548	43.2528	20
200	43.2860	43.2833	27

4. Conclusion

The laser processing technology in the cast iron surface was round pit width of 50 μm, 100 μm, 150 μm, 200 μm, the rules of a depth of 40 μm case processing round pit texture weave composition and its significant impact on cast iron surface texture width in the mobil 412 oil lubrication, friction and wear behavior under the condition of the texture width 50 μm, a depth of 40 μm of cast iron surface to obtain the best anti-wear and anti-friction effect compared with not texture on the surface of its falling about 50% in the friction coefficient and wear volume decreased by about 70%.This is mainly due to the good wedge effect produced by lubricating oil passing through the convergence region of cast iron surface with texture width of 50 μm during the friction process, and the larger lift generated by lubricating oil, which improved the lubrication state of the texture surface during the friction process, thus showing good tribological propertiesAcknowledgements.

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