

THE COVERAGE FORM OF SURFACE COATING AND CRACK OF BASAL BODY UNDER MULTI-IMPACT LOADS

Shihong Shi¹, Keyun Di², Anjun Wang²

¹*College of Mechanical Electronic Engineering, Soochow University, China; Email: Shishihong@suda.edu.cn.* ²*Soochow University, China.*

Abstract: During the experiment for thick test piece with laser coating under multi-impact loads. We discover that the margin of stress force with the form of Total covering is lower than that with the form of partial covering. However, the life of the former is longer than the latter when they are under the same multi-impact stress force action. There will be an intensely deformative hardening and material floating phenomena on the lower part of the edge of covered coating on the basal body of the latter. And the same time, flaw is more easily to come into being and spread at this place, then cause abscission of coat.

Key words: Laser coat, cladding structure, repeated-impact crack.

1. INTRODUCTION

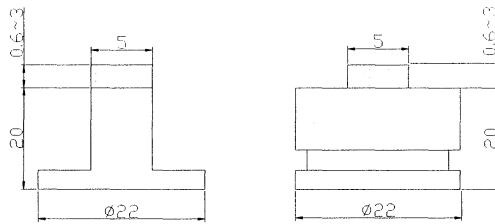
Covering of a coat of excellence performance functional material on the surface of parts. The surface function and operation performance of the part will be improved greatly. Various technology of surface coating prolongs the life of the machine parts working under execrable and complex condition. Then it improves security reliability of the whole machine or the system.

The coating structural member has various failure form under different external loads and working environment. During the experiment we discover that the thick test piece with different way of coating on it's basal body have the different failure method. The current research adopt the laser melting and cladding methods to make two coat on the basal body, one of which has the same width with the basal body and the other does not(figure 1). This article also concentrates in the research of metamorphose and crack behavior of the

Please use the following format when citing this chapter:

Shi, Shihong, Di, Keyun, Wang, Anjun, 2006, in International Federation for Information Processing (IFIP), Volume 207, Knowledge Enterprise: Intelligent Strategies In Product Design, Manufacturing, and Management, eds. K. Wang, Kovacs G., Wozny M., Fang M., (Boston: Springer), pp. 761-766.

basal body with the two structural forms under multi-impact loads which are modal in engineering.



(a)The basal body is totally covered by coat (b)The basal body is partially covered by coat

Figure 1. schematic of test piece

2. EXPERIMENT CONDITION

Test piece material: basal body is medium carbon steel (45#) or austenitic stainless steel (1Cr18Ni9Ti), coating is Ni-base self-fluxing alloy.

Test piece preparation: The Coat is prepared by TJ-HL-T5000 laser device, which use the powder transport method to process the test piece. The thickness of the powder is 1-3.5mm. The parameter of melting and cladding technique: Power of the laser: 3-4.5kw, Diameter of light spot φ : 5mm, Scan Speed V: 5-10 mm/s, Laser mode: multiple-moulding: Test piece post process anneal temperature: 200°C-400°C. All of the coat are inspected. The surface of coat is finely grind by surface grinding machine. And the surface roughness is Ra 0.16mm. The test piece is in figure 1.

Impact & Collision experiment have been done in multi-impact test equipment. And the frequency of impact is tuned to 4 Hz.

Adopt OLYMPUS GX51 optical microscope to observe the section structure, use CL-YD piezoelectric crystal impact force sensor and YE5852 charge amplifier, TDS3000 digital fluorescence memorable oscillo graph to measure, record and display the wave form of the impact force.

3. EXPERIMENT RESULT AND ANALYSIS

In theory, the limit loads and deformation of the coat and basal body can be approximately analysed by applied theory of plane deformation of the ideal rigid-perfectly plastic material and the theory of slippage line field(It has ignore elastic deformation and plastic deformation strengthening) [2, 3].

Figure 1 show that basal body is totally covered by coat, and the coat is the same width with the basal body. In figure 2 (σ is always negative in current experiment, The direction is opposite to the showing).Applying uniform impacting force on the coating layer, The direction of trace of main stress force is perpendicularity downward to coat layer, The Load limitation is $P_t = \sigma_1 = 2K$ ($K = \tau_{max}$, is limit shearing strength) meanwhile $\sigma_2 = \sigma_1 / 2$ (perpendicular to paper plane), $\sigma_3 = 0$ (flank is free surface). Slippage lines are two families of straight lines which are in quadrature with each other. They are should be 45° angle to main stress trace or the surface of test piece.

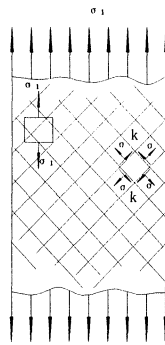
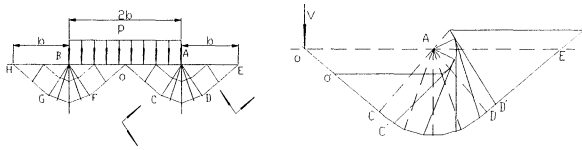


Figure 2. Uniformity stress force slippage line field

Figure 1(b) show that it is partially covered, of which the limit load and slippage of field of lines are the same with the former. The further detail information is indicated by figure 3(a). Provided HBAE is the basal body surface, of which p is impact force, which is working in extreme status, applying on the basal body surface through the coat layer and along the AB

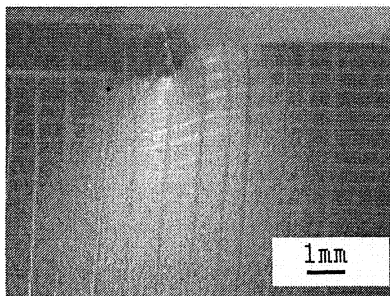
And then the question is equal to like wedge compressed in single side under such condition that it take A,B as vertex and vertex angle is $2\gamma = \pi$. Then we can construct the two connected slippage field of lines under the surface of the basal body, which is indicated by figure 3(a). By way of illustration of right side, the Slippage field of lines is composed of stress field OCA, ADE and center sector stress field ACD. Then we can get the solution that the extreme pressure $P_t = K(2 + \pi)$. Then the impact pressure force that is perpendicular to paper plane is $P = 2b \cdot K(2 + \pi)$, the figure 3(b) show that the circumstances which appear after the right part flow (solid line). It is easy to get conclusion that OCDE are flow down to O'C'D'E', Point A is singular point, Area OCA and ADE rigidity translation, Area ACD happens internal translation along the slip line.

Figure 4 is the right half part of the graph that is the section deformation of the piece that is partial covered by coat. In which the deformation of coat layer are uniformity deformation. A little pane in Figure 4 is the orthogonal chiseled line which had been drawn on the section before the test. We can get conclusion that basal body covered by coat has been forced to move downwards, because of the deformation of the little pane. The material of basal body outside of covering area has been squeezed and come into bulge, And the deformation in lower edge of coat where is the light region is the most fierce. The deformation is according to deformation of field of slip translation that shown in figure 3(b).



(a) Connected field of slip line (b) Field of flow in right part material

Figure 3. The field of slip line of the basal body with the coating layer of rigidity flat punch



Base: 1Cr18Ni9Ti; Impact stress : 158MPa; Times of Impact 1.28×10^6

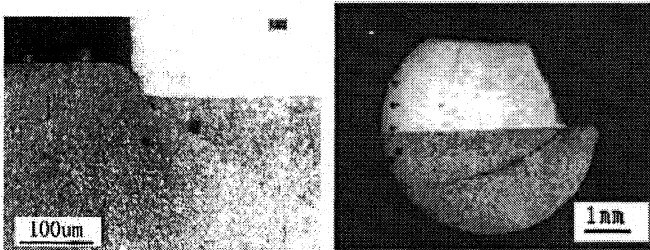
Figure 4. The deformation of basal body which totally covered by coat

On the part of the basal body with partial covered , A majority of test piece have came into emergence of crack which shown in figure 5(a) and (b) .According to figure 3 we can learn that the deformation in singular point A and b are the most violent and they are the start point of crack . The cracks are spread along with slip line AC or BF which are 45 degree angle to the surface. And in the second period it is perpendicular to the lines of forces gradually because of the alternatively impact force. So point A and point B have come into being cracks and meet in the middle of the basal body and then make the coat fall off.

During the test experiment, Most of the test pieces which is partial covered by coat layer have appeared similar crack, However we don't find any test piece that is totally covered has the same phenomena.

The deformation of the basal body shown in figure5(b) is small, that because the material in the surface of 45 carbon steel basal body get quenching harden as quickly hot and cooled when the laser melt and cover the material. And the material 1Cr18Ni9Ti shown in figure4 basically can not be quenched, then the ability of the plastic flow are more intensive.

The experiment discover that the basal body partially covered by coat appear fewer deformation and crack under strike of lower impact stress time after time. And it's life is longer and accord to the plastic theory^[2]. It is because that basal body partially covered with coat is wider than coat and then it can share the pressure force. However when the multi-impact load get more powerful, the material that close to edge part of the area covered by coat in the basal body of the partially covered test piece will produce fierce squeeze deformation and harden phenomenon . The character is that the deformation form of soft basal body is mainly squeeze deformation (figure 4); But in the same place, the rigidity basal body and basal body that can not get rid of rest tension stress will be easily to produce crack and spread into basal body along with 45°slip line figure5 (b), And then it is likely to be failure and it's life is far shorter than the structure of totally covered by coat. As the result of the experiment, we can draw a conclusion that on the part of form of covering of coat on the basal body, the structure of totally covered by coat is better under high impact stress.



(a)Base: 1Cr18Ni9Ti

Impact stress: 158MPa

Times of Impact: 5.5×10^4

(b) Base: carbon steel 45#

Impact stress: 261MPa

Times of shock: 46×10^4

Figure 5. The crack on the base and its spread direction

4. SUMMING-UP

(1) Under multi-impact loads, we can apply the theory of the field of slip line and the surface deformation on ideal perfectly rigid-plastic material to analyse the extreme load and deformation of coat and basal body approximately, And mechanics model inosculate with the slip deformation of the basal body of the test piece.

(2) Under multi-impact loads, if the impact force is smaller, the test piece whose basal body is totally covered by the coat allow lower limit stress force than that whose basal body is partially covered by the coat. Then the latter has longer life than the former. However when the multi-impact load get more powerful, the material that close to edge part of the area covered by coat in the basal body of the partially covered test piece will produce fierce squeeze deformation and harden phenomenon . The character is that the deformation form of soft basal body is mainly squeeze deformation (figure 4); But in the same place, The rigidity basal body and basal body that can not get rid of rest tension stress will be easily to produce crack and spread into basal body along with 45° slip line figure5 (b), And then it is likely to be failure and it's life is far shorter than the structure of totally covered by coat.

5. REFERENCES

1. Hu Chuanxi., (2000), Theory and Applications of Coating Technology, *Press of Chemical Industry*.
2. Yan Zongda., (1998), Plastic Mechanics, *Tianjin University Press*.
3. Xu binye., (1981), Concise tutorial of plastic theory, *Beijing, Qinghua University Press*.