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Review on the research problems and development history of metal fatigue

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Abstract: *In order to make ordinary people better understand what is the fatigue of the book, many scientists have carried out research, at the same time, from the discovery history of metal fatigue and its role and harm to describe it. I refer to the research of these great scientists and write a general outline, hoping that people will have more cognition of metal fatigue in the future and better understand metal fatigue.*

Keywords: *Metal fatigue, development, research of problem*

1. An introduction to metal fatigue

When it comes to metal fatigue, everyone must feel very strange. Can metals also be tired? it will be. Like people, if it exceeds a certain limit, it willFatigue.

The body of the person is overworked can fatigue, how metal still can fatigue?To illustrate the concept of metal fatigue, take a paper clip and straighten it with your fingers. You try to break it with your fingers without any tools, try it, even if you try as hard as you can. But if you bend it back and forth a few times, the paper clip will easily break.This phenomenon shows that metal materials have greater strength under constant force than under varying force. Under the action of forces of varying magnitude, though these forces are far from the extent to which they would normally be destroyed under the action of a constant force, the material fails. This phenomenon is called fatigue failure of metal.The phenomenon of fatigue fracture of metal materials was gradually discovered with the rise of modern industry. In ancient times, most structures built by human beings were static and constant force structures, such as house buildings and bridge structures. Although the bridge also bears variable load, the dead weight of the ancient bridge material is much larger than the dynamic load of the bridge, so it can still be regarded as a structure bearing constant force.

2. How to detect metal fatigue

Metal fatigue is a very complex process, from micro to macro, it is affected by many factors, especially those factors which have little influence on the static strength of materials and components, but have significant influence on fatigue, such as surface defects and stress concentration of components.

Although it is impossible to completely avoid metal fatigue, scientific research shows that metal fatigue can be detected in advance.

Japanese scientists have invented a special coating mixed with lead titanate powder. When metal is knocked, an electric current will pass through the coating film on the metal surface, and the size of the current is related to the fatigue degree of the metal. By measuring the current, you can know how tired the metal is.

In addition, ultrasonic, infrared, ray and so on can carry out physical examination of metal. In recent years, many possible accidents caused by metal fatigue have been avoided through various detection methods. X-ray diffraction, for example, can detect metal fatigue caused by stress concentration. Before the zero component is formed and put into service, even in the manufacturing process, the stress concentration phenomenon is found by means of detection, and measures are taken to equalize the stress, which can effectively eliminate the fatigue failure.

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3. Origin and development of metal fatigue problem

The situation is very different after the rise of modern industry. First, due to the widespread use of metal materials, the dead weight of the structure is greatly reduced, and the change of external load is more prominent. Secondly, due to the rise of the machinery industry, rotating machines, moving vehicles and ships, their loads are a large number of variable loads, resulting in the vast majority of the internal stress of the material can be seen as alternating stress. As a result of fatigue fracture accidents occur repeatedly, gradually attracted people's attention and research.

After the first industrial Revolution, with the invention of steam engine and other equipment, followed by a large number of fracture accidents. It is found that the service life of components under cyclic loading is far less than the design life, even less than half of the design life. Subsequently, some targeted studies were carried out and the veil of fatigue fracture of metal components was gradually lifted. Since then, people gradually understand the nature of fatigue problem, and see the dawn of overcoming metal fatigue.

4. Some problem about Metal fatigue in the history of human

Although metal will fatigue like people, it is essentially different from human fatigue; After fatigue, people can recover after a certain rest,Metal fatigue can never recover, resulting in many malignant damage accidents, such as ship sinking, plane crash, bridge collapse and so on. It is estimated that,

In modern machinery and equipment, 80% - 90% of the damage of parts and components is caused by metal fatigue. Because of the external force on the metal parts

Beyond a certain limit, cracks that cannot be detected by human eyes will appear where the internal resistance of the material is the weakest. If the external force on the component remains unchanged, it is small

The crack will not develop and the material is not easy to damage. If the component is subjected to an external force whose direction or size often changes repeatedly, then gold

The tiny cracks inside the material will sometimes open, sometimes press each other, and sometimes grind each other, so as to expand and develop the cracks. When the crack expands to a certain extent the metal material is weakened so that it can no longer bear external forces, as long as there is a little accidental impact, the parts will break. So, metal

The damage caused by fatigue is often sudden, and there is no obvious sign for people to notice. In May 2002, China Airlines a Boeing 747-200 passenger plane

The plane disintegrated on the way to Hong Kong airport and all the people on board were killed. The investigation found that the plane disintegrated in the air

As mentioned above, there are many accidents caused by metal fatigue. In the early years, people could not find out the cause of these things and knew that there was electricity

Some methods to find and eliminate metal fatigue were developed after sub microscope.

The term "fatigue" of metal was first put forward by French scholar J. v. Spencer. At that time, this concept was first used when giving lectures at the University of Paris.

However, it was German scientist A. Waller who studied metal fatigue. He discovered the characteristic of metal fatigue in the 1850s

S-N curve, and the concept of fatigue limit is put forward. In 1890, Gerber studied the effect of average stress on metal fatigue life,

In the later years, many concepts related to metal fatigue were put forward. After the 1950s, IU, as with electron microscope and fracture force

With the rapid development of science, the micro model related to metal fatigue is established in the micro aspect, and the mechanical model of fatigue crack and metal fatigue are studied in the macro aspect The expression of fatigue rate continues to achieve new results[1]

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5. Further use of Metal fatigue in the future that human already achieved

Metal fatigue failure can be divided into three stages: ① micro crack propagation stage. Under cyclic loading, due to the non-uniformity of microstructure in the object, micro cracks first form in some weak parts, and then the cracks expand along the direction of the maximum shear stress at an angle of about 45 °to the principal stress. At this stage, the crack length is approximately within 0.05 mm. If the loading is continued, the micro crack will develop into a macro crack. ② Macroscopic crack propagation stage. The crack basically propagates in the direction perpendicular to the principal stress. With the help of electron microscope, the fatigue bands left by each stress cycle in this stage can be observed on the fracture surface. ③ Instantaneous fracture stage. When the crack expands so that the residual section of the object is not enough to resist the external load, the object will break suddenly under a certain load.There are usually two areas on the macro fatigue fracture: smooth area and granular area. The starting point of fatigue crack is called fatigue source. The fatigue source on the actual component always appears in the stress concentration area, and the crack expands from the fatigue source to all around. Due to repeated deformation, the two surfaces of the crack are sometimes separated and sometimes squeezed, which forms a smooth region, that is, the second stage propagation region of fatigue crack. The surface of the instantaneous fracture area in the third stage presents a rough granular shape. If the change of cyclic stress is not steady, the stress amplitude does not remain constant, and the crack propagation is fast, slow or stopped, the fatigue arc of shell or beach marks can be seen with the naked eye on the smooth area .[2]

6. Fatigue life in the metals

Under cyclic loading, the number of stress or strain cycles required to produce fatigue failure is called fatigue life. For practical components, the fatigue life is often based on work

Make an hour meter. The fatigue life of components before engineering cracks is called crack formation life or crack initiation life. Engineering crack refers to macroscopic visible or detectable crack, and its length is not uniformly specified, generally within the range of 0.2 ~ 1.0mm. The fatigue life from engineering crack propagation to complete fracture is called crack propagation life. The total life is the sum of the two. Because the engineering crack length is much larger than the metal grain size, the crack can be regarded as the boundary of the object, and the surrounding material can be regarded as a uniform continuous medium. The crack propagation law can be studied by using the method of fracture mechanics.

In order to facilitate analysis and research, fatigue is often divided into two categories according to the number of failure cycles: ① high cycle fatigue (high cycle fatigue): fatigue with failure cycles higher than 104 ~ 105, which belongs to the fatigue of general vibration elements and transmission shafts. Its characteristic is that the stress level acting on the member is low, and the stress and strain are linear. ② Low cycle fatigue (low cycle fatigue): fatigue with failure cycles less than 104 ~ 105. Typical examples include fatigue of pressure vessels, gas turbine components, etc. Its characteristics are: the stress level acting on the component is high, and the material is in a plastic state. The fatigue of many practical components under variable amplitude cyclic stress is neither pure high cycle fatigue nor pure low cycle fatigue, but a combination of the two.

Accordingly, crack growth can also be divided into high cycle and low cycle. The crack propagation law of high cycle fatigue can be studied by linear elastic fracture mechanics; The law of low cycle fatigue crack growth should generally be studied by elastic-plastic fracture mechanics, but the problem is very complex and has not been well solved[3]

7. Conclusion

To sum up, metal can also get tired. From the perspective of human history, the lack of understanding of metal fatigue has caused a lot of accidents. However, the probability of these accidents has been reduced through research on metal fatigue, and it is believed that humans will make better use of metal fatigue in the future.

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