Applied Research of Magnetic Memory Method (MMM) on Amusement Devices

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Abstract:

Because of the stress concentration, amusement devices will be destroyed. Lab experiments results show that the surface magnetic field on the fatigue damage region is changed regularly. The surface magnetic field before the micro-cracks appeared is stronger than after appeared. Compared the tip with the middle of the crack, the magnetic filed is different. In order to validate the experiments results, testing on amusement devices had been done. The dubitable region according to magnetic signals had been retested by MT or ET. It is confirmed that Magnetic Memory Method (MMM) can be used to inspect fatigue damage and micro-cracks of ferromagnetic materials. And a new MM signals analyzed method is given according to the testing results.

Key words: MMM; fatigue damage; micro-cracks; amusement devices

1 Introduction

Stress concentration is one of the main reasons which induce the fatigue damage and crack in the component of structures of amusement devices. And the fatigue destroyed always occurred without any warning. How to evaluate the stress concentration and how to detect the fatigue damage region are the urgent problems. It is the best way to resolve those problems that founding a NDT method to get the stress state of the equipments by detecting the indirect and easily obtaining factor. Magnetic Memory Method (MMM) is the new method to evaluate fatigue damage by measuring the surface magnetic field variable.

MMM based on Magneto mechanical effect can be used to monitor stress concentration levels and even predict the lifetime of the specimen through the distribution of magnetic field on the surface of a specimen without extra preprocess of magnetization. Previous studies have shown that MMM method can be used for evaluating changes in microstructure and local stresses of ferromagnetic materials[1-8]. Magnetic field on the surface of component can be tested without direct contact, so maybe MMM can be used expediently on amusement devices.

In this paper, the MMM was applied to test the fatigue damage and stress
concentration region. The result show that MMM is a good and fast method to monitor the fatigue damage and predict warning of amusement devices pivotal parts.

2 Experimental in Lab
We had done two experiments\(^{[9-12]}\) to confirm that MMM is an effective method to monitor fatigue damage and plastic region in lab.

The materials used in the experiment both were a medium carbon steel. The first sample was designed for plastic region detected experimental, as shown in fig1_a. The second sample was designed to be standard sample for fatigue experiment, as show in fig1_b with a small change.

![Fig.1. Sample and scan region](image)

The experimental results were shown in fig2 and fig3.

Fig.2. shows the distributions of the plastic region surface magnetic. Results show that the distributions of surface magnetic variety acutely, and that is means MMM can be used to detect the plastic region.

![Fig.2. The surface magnetic variety on plastic region](image)

Fig.3. shows the abnormality of magnetic field was detected in the centre of the sample. The abnormality is caused by the micro-crack and the geometrical
discontinuity. As the effect of geometrical discontinuity on magnetic field distribution is little affected by the stress load and there is a great change of magnetic field distribution after the application of stress, micro-crack is considered to be the major factor that causes the magnetic abnormality.

The magnified magnetic field distribution in fatigue region shows a variational magnetic signal (as shown in Fig.4.) which changes along with the fatigue numbers. This means that surface magnetic field is influenced by the microstructure variety caused by fatigue.

Fig.3. The surface magnetic variety because of micro-crack

The peak to peak magnetic fields of fatigue region under different bend cycles are calculated and the relationship between this value and cycle number is shown in Fig.5. The results from other lines and other samples are similar. Fig.4 shows that magnetic signals change along with stress cycles and there is a leap of magnetic signal before fracture. A primary conclusion can be drawn that the magnetic peak-to-peak value is sensitive to fatigue evaluation.

Fig.4 Surface magnetic field distributions under different fatigue cycles
These two experimental results show that MMM can be used to detect the region suspected of damage.

3 Applied on Amusement Devices
We want to found the way to use MMM on amusement devices. According the results in lab, we chose some typical amusement devices to apply the MMM and found some typical signal consistent with these phenomena shown above.

Fig.6 to Fig. are the sample which were get from the actual amusement devices.

Fig.6 Surface magnetic field distributions on the girder
The abnormality of magnetic field shown in Fig.6 is occurred by stress concentration. We retest the component by ET and MT, but nothing was found.

Figure 7. Surface magnetic field distributions on the railway covered by dirt

We got the curve as shown in Fig.7 from the railway covered by dirt and oil, the thickness of the cover is about 5mm. We retested the railway by ET and MT, and found some strange signals. The crack appeared when the cover was removed.

Figure 8. The crack on the orbit
The magnetic field distributions on the orbit present different curve between the center of the crack and the edge, as shown in Figure 9 and Figure 10. The phenomena can be easily explained. In the center of the crack, the stress had been released and the abnormality of magnetic field is caused by the changed size of the orbit. In the edge of the crack, the stress concentration is bigger than other, so the abnormality of magnetic field is greater than other place. The different is very important for using MMM on Amusement Devices. It means that we can use MMM to repair or care the component before crack appearing.

![Figure 9. The abnormality of magnetic field of the edge of the crack](image)

![Figure 10. The abnormality of magnetic field of the center of the crack](image)

### 4 Conclusion

Studies of MMM application have been carried on Lab and the real amusement devices. The phenomenon of magnetic field change has been got from fatigue damage region and crack. The phenomenon can be used on amusement devices to test the fatigue damage and stress concentration region.


