Fracture Analysis of 40Cr Steel Pin Roll

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Abstract. Fracture of 40Cr steel pin roll happened along the cross-section at the spot of filling aperture. By the use of analysis of optical microscopy and microhardness, it can be known that filling aperture and its nitration case (ε phase) and large amounts of non-metal inclusions (bulk obscure inclusions) in steel were the main reasons which led to the facture of 40Cr steel pin roll.

1. Introduction
A factory using 40Cr steel production production link pin, the use of the process: the park under the steel bar - rough turning - quenching and tempering - fine turning - nitriding. The pin is broken in the cross section of the pin along the pin during operation. To analyze the cause of the fracture, a sample (including a part of the oil filler) was cut at the center of the shaft (near the axis). Another sample is equipped with a large pin with the pin, cut in the perfect parts.

2. Detection

2.1. Macroscopic tissue morphology detection
Fig. 1 shows the macroscopic morphology of the fracture surface of the pin. According to its surface characteristics, it can be determined that the pin is cut and is the result of the fracture of the torsional load. At the same time, the fracture at the filling hole belongs to the brittle fracture. In the figure by the hole at the whole (lower left) found unknown inclusions.

Fig. 1 Macroscopic morphology of pin fracture
Surface

Fig. 2 Non-metallic inclusions in the pin sample (cross-section), 100x

Fig. 3 Non-metallic inclusions in the pin sample (longitudinal section), 100x

Fig. 4 Non-metallic inclusions in the big break of the sample (cross-section), 100x

Fig. 5 Non-metallic inclusions in the pin sample (longitudinal section), 100x
2.2. Non-metallic inclusions detection
According to GB10561-89 "steel non-metallic inclusions micro-assessment method" to check the two samples of non-metallic inclusions, the results shown in Fig.2 – Fig.5 shows. It can be seen from the figure, the two samples of the main non-metallic inclusions iron manganese silicate or (and) sulfide, about 3 to 4 level. There is still a small amount of oxide inclusions in the sample (below grade 2).

2.3. Matrix metallographic microstructure
Fig. 6 and Fig. 7 are the microstructure (longitudinal section) of the pin sample and the matrix of the test specimen, respectively. Both samples are needle-like tempered sorbite. Figure 6 (pin) has a more obvious free ferrite, according to GB11854--89 "steel parts nitrided layer depth measurement and metallographic examination" to be assessed, should be 3 to 4, and there are carbides in a certain direction of the phenomenon, the organization is also thicker. Fig. 7 (big) in the free ferrite is less (according to GB11854--89 about 2).

2.4. Nitride layer microstructure
Fig. 8 shows the microstructure of the pin surface of the pinhole along the inner wall of the filler hole. Fig. 9 shows the microstructure of the nitride layer on the outer surface of the sample. In the two figures, the outermost white layer of the nitride layer is the ε phase, the secondary layer is ε + γ', and the heart is needle-like tempered sorbite. [1] Where the pin sample (Fig.8) of the ε layer in the outermost layer has more microporous, according to GB11854--89, the level of about 3 to 4.
2.5. Microscopic hardness of the surface layer to the heart

![Fig. 8](image1.png) Alignment of the inner wall of the pin hole, 500x

![Fig. 9](image2.png) The big break surface nitriding, 500x

![Fig. 10](image3.png) Pin hardness of the inner wall of the hole, 400x

![Fig. 11](image4.png) Depth of the layer 0.235mm (0.235DN349HV0.01)

The microhardness indentation is shown in Fig.10; Fig.11 shows the hardness distribution from the surface to the center of the pin. From the two graphs, the hardness of the nitriding layer is 831HV0.01,
the core hardness is less than 320HV0.01, and the depth of the nitriding layer is 0.235mm (0.235DN349HV0.01).

3. Analysis and discussion

According to the above test results, we can see:

The non-metallic inclusions (ferromanganese silicate and / or sulfide) in the sample are about 3 to 4, which seems to be slightly higher for important parts because of the large amount of non-metallic inclusions, especially large inclusions the presence of the object is more susceptible to the formation of cracks in the important parts of the alternating load (the inclusions are possible sources of cracks). [2].

The thicker needle-like tempered sorbite and higher grades of free ferrite, as well as the aligned carbides, need to be improved, but the quality of the nitride layer in the two parts is acceptable, and the matrix structure No major organizational defects. It is not possible to eliminate the effect of the oil filler hole in the pin cutting, since the opening of the oil hole in the vicinity of the hole causes a stress concentration ("notch effect") in the vicinity of the hole, [2]and particularly when the inner wall of the filler hole is nitrided, the formation of a brittle phase, coupled with the steel (near the oil hole) also found that there are unknown inclusions, which is likely to induce cracks and eventually lead to complete fracture pin.

4. Conclusion

Although the structure of nitrided layer and matrix needs to be further improved, there is no significant tissue defect. The presence of the pin oil hole and its nitride layer (especially the ε phase) and the large amount of non-metallic inclusions in the steel (especially the large unidentified inclusions) may be the main cause of pin fracture.

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