Metallurgical Failure Analysis Report

Report No: MFR-024-42
Date : 25.09.2024

Customer : M/S.ETL

Part No. : S2HT52107O

Part Name : OUTER SPRING (K0PG)

Wire Dia. : ø 8.00mm.

Material : SAE 9254

Report Outline

Background:

One of the field failure outer coil spring received from customer end for failure analysis, As received condition photograph of failed spring is as shown in photograph 1. The spring in the as received condition found to be with rusty in condition in several portions including fracture faces, and also with powder coating peeled off.

Method

1. Stereo microscopy
2. Scanning electron Microscopy & EDS
3. Metallurgical Microscopy (Nital 2%)

Sample Details

Sample	Spring Details	No. of Cycles/ No. Of km field	Failure Type
Outer Coil Spring	Part No: S2HT52107O Wire dia:ø 8.00mm Grade: SAE 9254	12,000 KM's	Premature fatigue failure

Broken at end coil / end grinding portion

Photograph 1: As received photograph of the broken spring and broken at end coil from one end.

Conclusion

Failure mode appears to be premature fatigue failure and the root cause for the fatigue initiation found to be due to the presence of external notch type damage /dent in between spring ID & OD, which appears to be acted as stress raiser during the application and resulted in breakage.

The metallurgical, mechanical, shot peening and raw material properties found to be satisfactory for the broken spring.

Comments:

1. Refer photograph no 1,7-8 and 11-13 for the as received condition of failed spring, which was found to be in rusty condition in both fracture face. It is also evident from the above photographs that, the peeled off condition of powder coating both at fracture & adjacent locations and several mechanically damaged portions due to abuse of the springs.
2. The fracture location is identified at the end coil, that is grinding portion of the spring. The failure mode appears to be premature fatigue failure and fatigue initiated from the surface in between spring ID and OD and propagated further towards core. (Refer photographs no 2-5 & 7-8).
3. At the fatigue initiation site the spring surface found to be powder coating is peeled of in condition and mechanically damaged and formed notch type dent (refer photograph-9) and shot peening coverage has worn out , which confirms that, the damages was occurred externally after the spring manufacturing. Due to the formation of notch type dents in between ID and OD surface, which has acted as a stress raiser during the application and caused fatigue initiation (Refer below photograph no 2-5 & 7-9).
4. The fracture faces and adjacent locations are found to be in rusty condition including mechanically damaged portions along with extensive mechanical damages / powder coating peel off due to abuse of spring externally (Refer below photograph no 11-13)

5. The shot peening coverage at other portion of the spring found to be satisfactory and hence the compressive residual stress found to be satisfactory. (Refer photograph no-10 & Table:1).
6. The EDS results ruled out the presence of any non metallic inclusions or slag entrapment's, which could be carried from basic raw material used (Refer photograph no-6).
7. Metallurgical properties like microstructure, decarb level and hardness for the failed spring found to be satisfactory (Refer photograph no 14-15).

Fractographic & Morphological Analysis:

1. The spring was found to be failed due to premature fatigue failure, which has initiated at end coil in between ID and OD, where formation of external notch type mechanical damages / dents damage are evident. Also the springs surface found to be with extensive damages, powder coating peeled off and rusty, which confirms that the springs are abused.
2. The material is free from any detrimental defects like seam/crack/rust pits etc, which could be carried from basic raw material.

Microstructure Analysis:

1. Microstructure of failed spring at 500x is tempered martensite for failed spring (Refer photograph-14).
2. Material is free from any decarburization (100X). (Refer photograph-15).

Hardness:

The average hardness was found to be 585 HV.Which is satisfactory.

Residual compressive Stress:

The surface and peak residual compressive stress follows -526 & -892 Mpa. Which is satisfactory.

Depth from surface (mm)	RCS (MPa)
0	-526
0.04	-680
0.08	-892
0.12	-765
0.16	-612

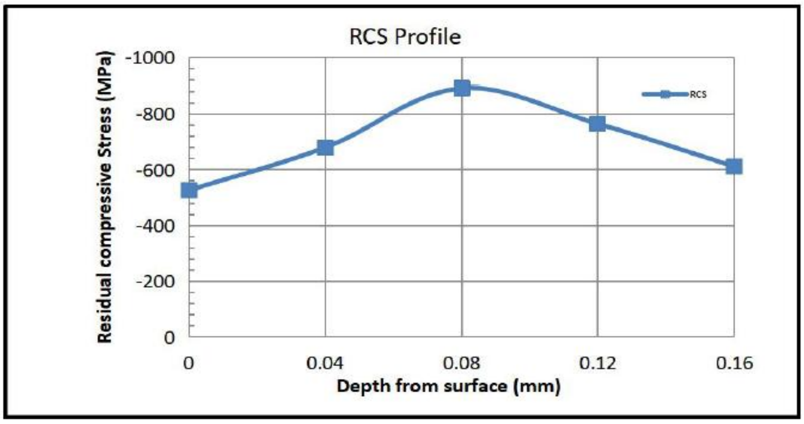
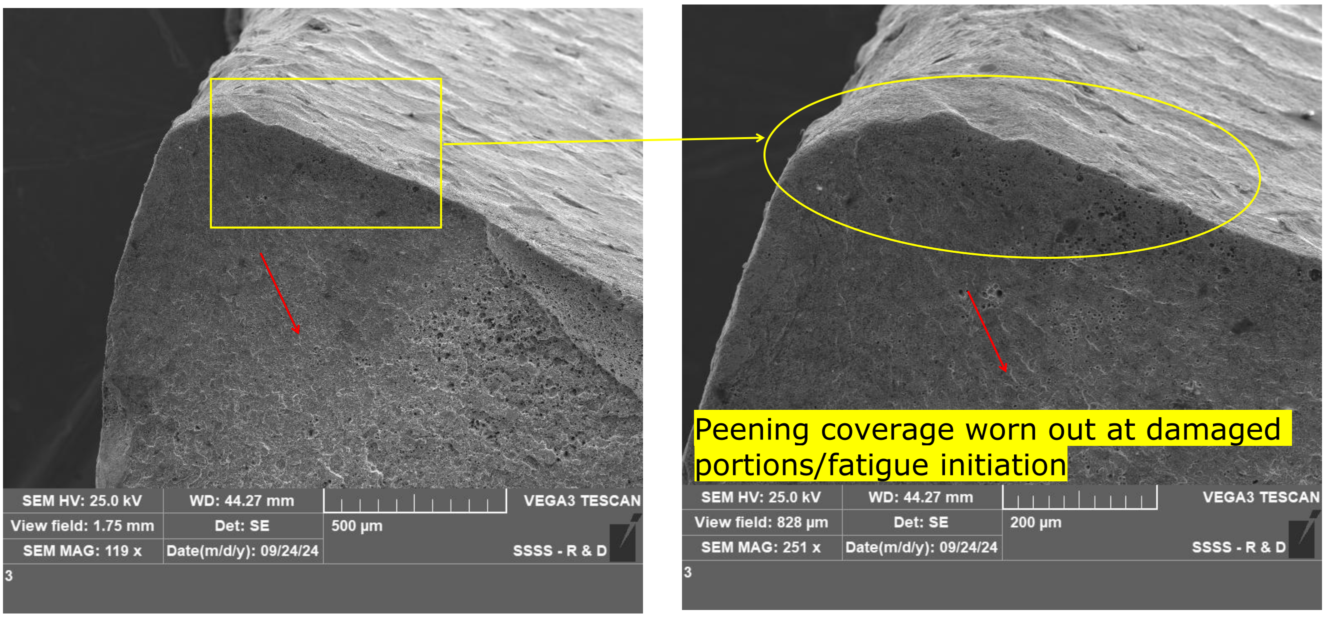
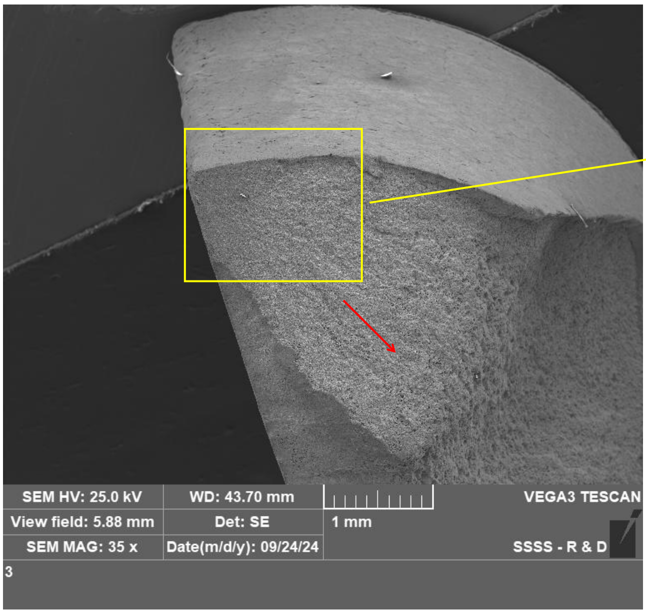


Table 1: Residual compressive stress values and graph

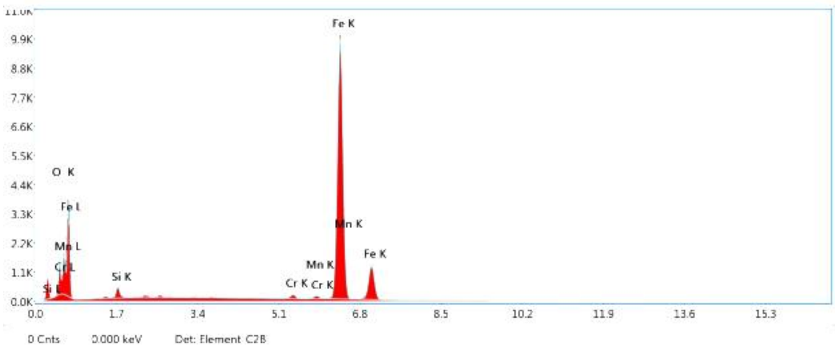
Scanning Electron Microscope & EDS



Photograph 02-03: Fracture face :1 Premature fatigue failure and shot peening coverage worn out at the damaged location/initiation (10X)



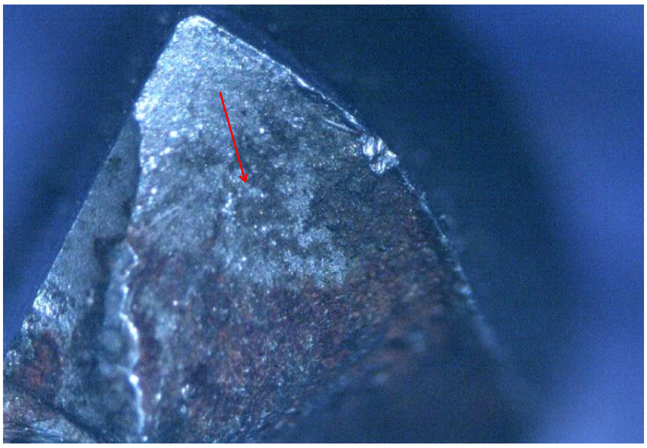
Photograph 04-05:Fracture face:2 Premature fatigue failure and shotpeening coverage worn out at the initiation (10X)

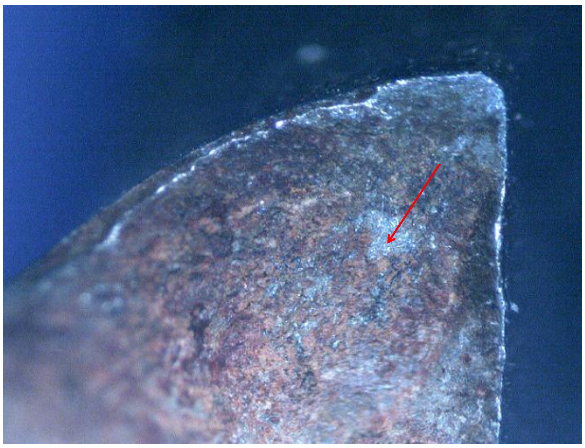


Element	Weight %
O K	4.14
SiK	2.10
CrK	1.01
MnK	0.72
FeK	92.03

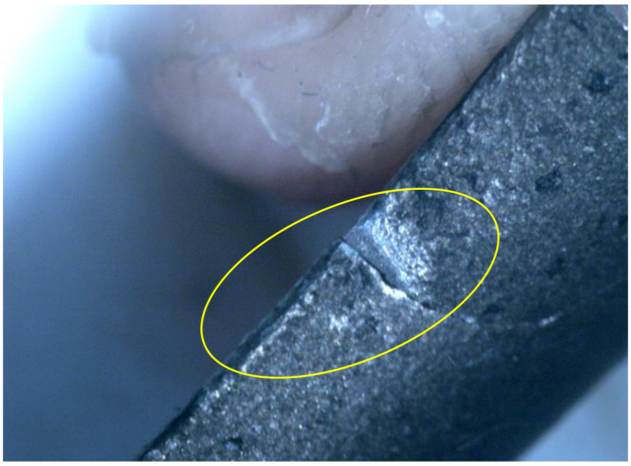
Photograph no 06: Free from the non metallic inclusions and material abnormalities

Stereo Microscope Images

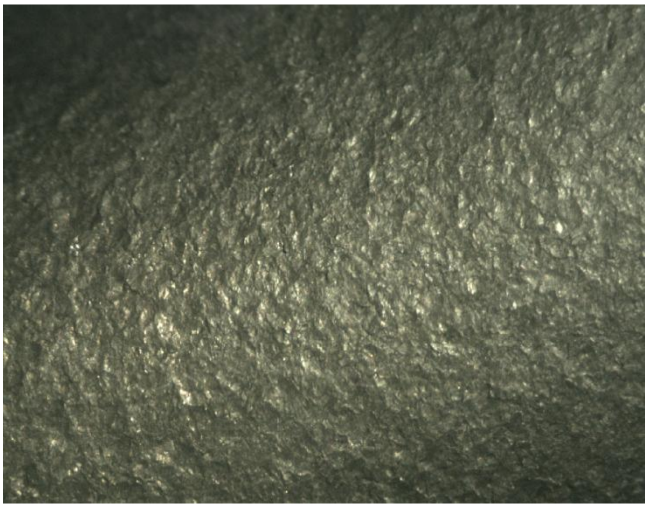




Photograph 07 & 08: Stereo microscope of fracture initiation and rusty condition of fracture faces (10X)



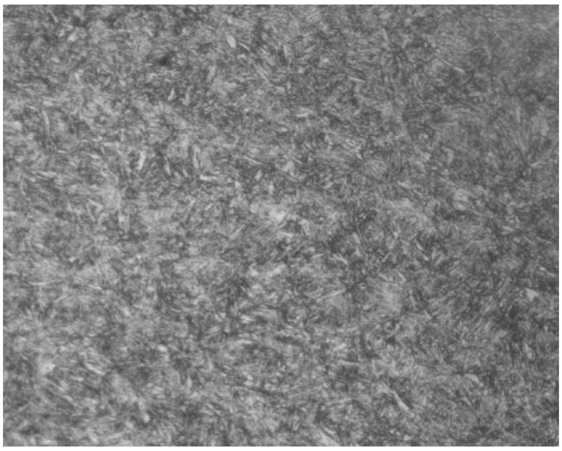
Photograph 09**:** External mechanical damage/notch type dent and worn out of shot peening coverage (10X)

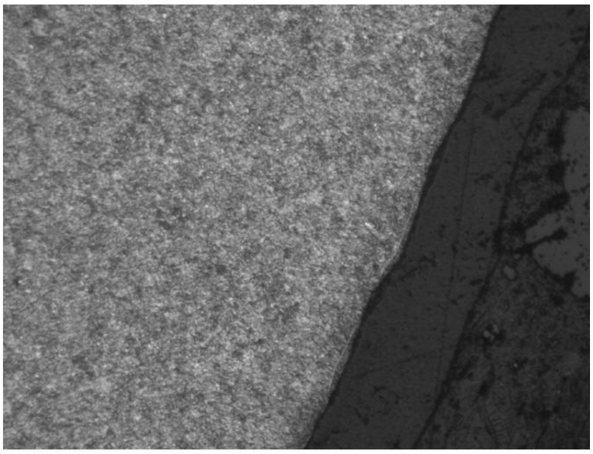


Photograph 10: Good shot peening coverage at other portion (10X)

Photograph 11,12 and13: Fracture face found to rusty in condition and adjacent coil found to be with extensive mechanical damage/worn out and powder coating peeled off in condition.

Microstructural Images





Photograph 14-15: Tempered Martensite (500X) & Nil decarburization (100X)