Failure Analysis of Suspension Coil Spring for Passenger Car through Sem Microstructure Investigation

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Abstract- This paper present premature failure analysis of automotive coil spring through metallurgical consideration, mechanical property, manufacturing and running conditions are common factor behind premature failures. Following the automotive industry required reduced weight of coil spring at higher strength; this reduced is required weight of coil spring at higher strength of material to maintain quality and reliability. The better understanding to design according to required load and stresses of the spring, the advantage and disadvantage of higher strength of material are known. In this work has been done with the help of SEM images and material composition testing in ASTM standard and environment, manufacturing process timing occur due to impurities and maintenance causes includes the failure analysis of a suspension system based on metallurgical methodology. SEM image of specimen have been captured and analyzed. It appears that suspension system has imperfection in the materials which are responsible for the premature failure.

I. INTRODUCTION

Suspension system of automotive vehicle is very needful part, trey are responsible to absorb road sock and isolated passenger curb to road shock, comfort, safety, handling, road holding and ride quality. Suspension system made of mechanics, spring and damper. These parts are control arm, knuckle, ball joint, rubber bushing, coil spring and shock absorber, to assembled in significant form and each parts are its intendant function. So they are very important to reduced premature failure of suspension system because due to failure causing accident and harmful for human safety, rider and passenger, other person to travel around the region. The commonly premature failures have produced due to coil spring and dampers and other part to support these two major parts. So in this paper presented metallurgical investigation of suspension coil spring and common failure of suspension system, to perform the real time failure due environment of drive condition and rider comments, so many sample will be used to take SEM visualized images and chemical composition testing of material on optical emission analyzer spectrometer DV4 model with ASTM standard methods.

Helical coil spring is used as primary elastic member of automotive suspension system are several used in automotive sector. The coil spring assembled in suspension system to absorb shock energy and smoothly realized occur due to road irregularities. The dynamic respited loading condition occurred fatigue failure in helical coil spring in various ways, pre manufacturing defects, raw material impurities, manufacturing process defect, surface imperfection, improper heat treatment, tampering process defect, corrosion and decarburization are responsible to premature failure in suspension coil spring [1]. In the running condition the stress on inner surface of active coil in suspension spring at a position of higher stress and coil surface itself is vulnerable to imperfection in spring material and such surface higher stress consecration, these stress concentration point beginning of crack formation due to fatigue loading [2]. So it is recognized that helical coil springs often fractured at the transition position from the bearing coil to the first active coil [3]. The following aspects such as poor shot peening because of no gap or small gap between the bearing coil and the first active coil, bending

stress due to pivoting of the first active coil about the end tip [4], larger eccentricity of the loading force induced larger maximum net-tensile stress [5], and corrosion due to collection of corrosive fluid in the smaller gap between the bearing coil and the first active coil [6]. The above summary of suspension coil spring found various type of defect. This work present metallurgical analysis of fracture helical coil spring, Chemical, visual inspection and SEM analysis has been performed.

II. CHEMICAL COMPOSITION

The chemical composition of helical coil spring material was determined by using optical emission analyzer spectrometer model DV4 and given a table. The chemical analysis shows that the material is in accordant with low alloy steel. However ASTM E415-2008 method used to perform analysis.

Material	centage in New Spring	Percentage in Fracture Spring
(Fe)	96.74	96.64
on (C)	0.514	0.524
on (Si)	1.40	1.40
ganese (Mg)	0.706	0.706
ur (S)	0.006	0.006
sphorus (P)	0.023	0.023
el (Ni)	0.009	0.009
mium (Cr)	0.594	0.594
ybdenum (Mo)	0.002	0.002
per (Cu)	0.008	0.008

Result shows that chemical composition of material is as per requirement. So that material was perfect composition wise.

III. SEM ANALYSIS

1. *Fatigue Analysis:*

The specimen was in two parts due to fatigue failure reason for this failure before expected life has been investigated by SEM. The pictures taken SEM of specimen analyzed.

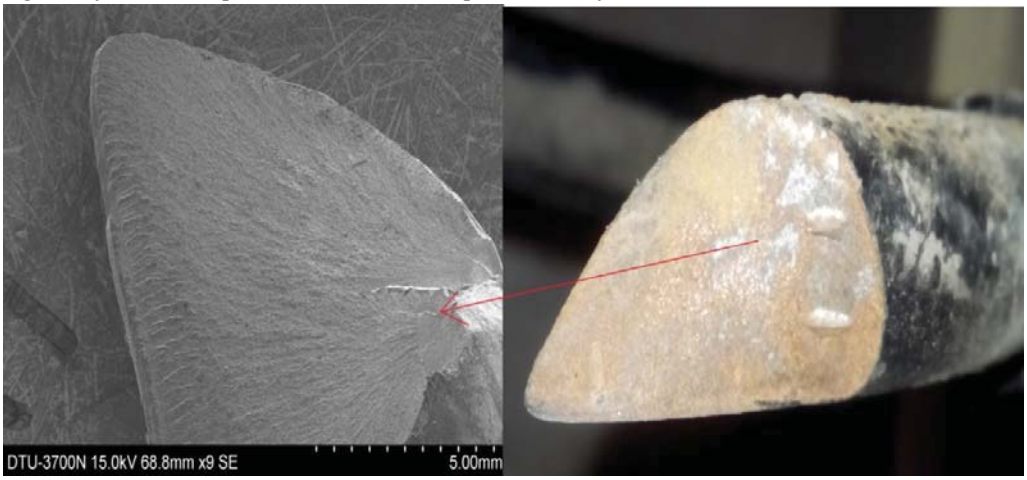

Figure 1:Broken Coil Spring

properties. In the figure two image shown first capture by SEM and second real image, in the figure fracture part developed due to localized stress, the geometry of spring changed in operating condition, due to this geometry change localized stress introduce stress concentration at a particular point on second coil or first active coil from curb in suspension spring. So due to the dynamic loading stress is higher than one particular point cause beginning of crack formation and after some time broken coil spring.

2. *Scanning Electron Microscopic Analysis:*

The fracture part of helical spring is investigate through SEM analysis spectro max for SEM analysis where at from fracture helical spring and polished using standard metallographic technique and etched with gyceria (30 ml dilute solution of HCl, 15ml HNO_3 and 45ml glycerol). SEM evaluation was come out on the fracture surface of coil spring the failed spring was cut from for SEM study its fracture reason.

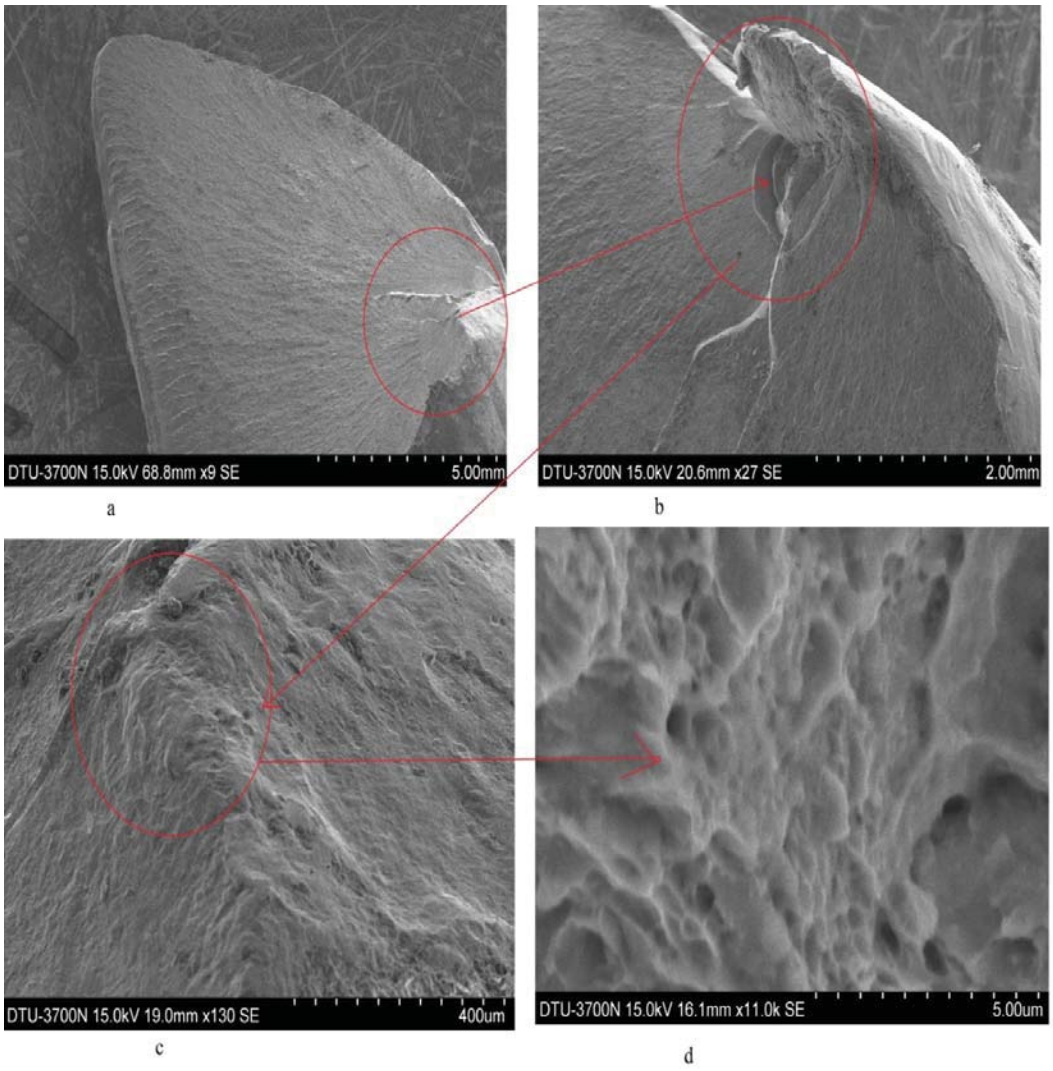

Figure 2: Surface Imperfections in Coil Spring

The figure shows surface imperfection in suspension coil spring, in the figure 'a' 5mm optical zoom the surface of fracture area was not proper some cold particle are presented this fracture reason, in figure 'b' increased zoom to show the better fracture condition to shows fracture area the crack recognized slowly and after some time suddenly break due to holes find out in the figure 'c' shows easily as well as in figure 'd' shows. So the surface imperfections can produce to some hardness in material to make crack, tool marks, surface impurities due to the raw material, scale embedded of base material during cold drawing. Two different surface defect holes sufficient to cause fails coil spring in figure 2 (c) and the second figure 2 (d) surface defects are inherited in the raw material. This type of fault can found when the surface defects diagnosis through the flaw detector does not worked normally. These type of imperfection in raw material occurred before manufacture of coil because this defect not due to coil manufacturing. If some pre active impurities present in the surrounding occur decarburization in raw material during heating for manufacturing of coil. While a surface imperfection caused by coil manufacturing is often not accompanied by decarburization shows inthe figure 2'd'.

In figure 2 'a, b' clearly show bad shot peened surface, suspension coil spring made by cold drawing process,

so shot peening is cold working process it is used to making a compressive residual stress layer and changed material mechanical property. If improper shot peened surface are also called surface defect and it is reduced coil life.

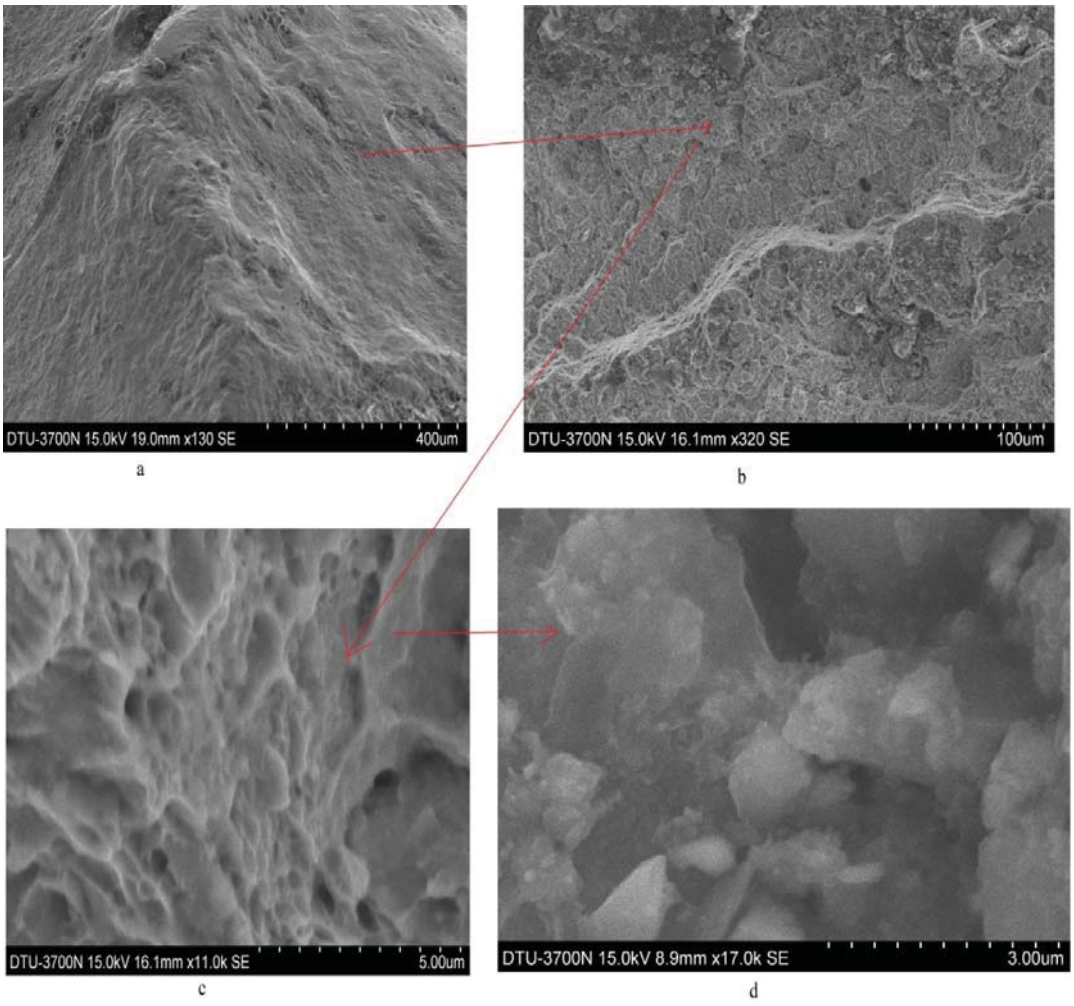

Figure 3: Internal Defects in Coil Spring

In the figure 3 shows internal crack in coil due to improper manufacturing process, in a figure 'a' small holes and crack is seen, so the more zoom in figure 'b' at 100um the coil structure have not similar over the all reason because material microstructure changed in dark reason due to phase change of material in improper heating process, this type of defect find improper heating process for example the material continuous heating properly can result prior austenite grain size increased significantly. Inappropriate heating treatment even result in microstructure to adopting pearalite in place ofmrartensite, these type of defect can easily recognized because the clear change in hardness. In figure 3 'a, c, d' shows small hole and crack of surface imperfection due to manufacturing or tempering process, the inter granular surface covered by an oxide due to trapped quench oil being heated in tempering furnace. These type of defect usually take place when heating system was not proper, the quenching crack and holes reduced the suspension coil spring life and causes premature failure.

In steel material some property change to its improper heating during phase change that's easily recognizes by coil hardness and microstructure change at fracture reason, Bainitic phase creation is another imperfection to create the inappropriate heating treatment. Unusually marten site bainitic ferrite basically more contains of carbon in ferrite solution. Maximum of carbon particle to transform a sample of bainite is in form of

cementite particles. Which is turn to be unsmooth than those are correlated with temper martensite. These tempering effects of metal are always milder when the microstructure in martensite, bainitic structure commonly accompanied by more percentage of preserved austenite than martenstic structures. Tempering induces the decomposition of the retained austenite into mixture of ferrite and carbides and the microstructure of bainite steel. Due to these internal imperfection suspension coils life reduced and caused premature failure in coil spring.

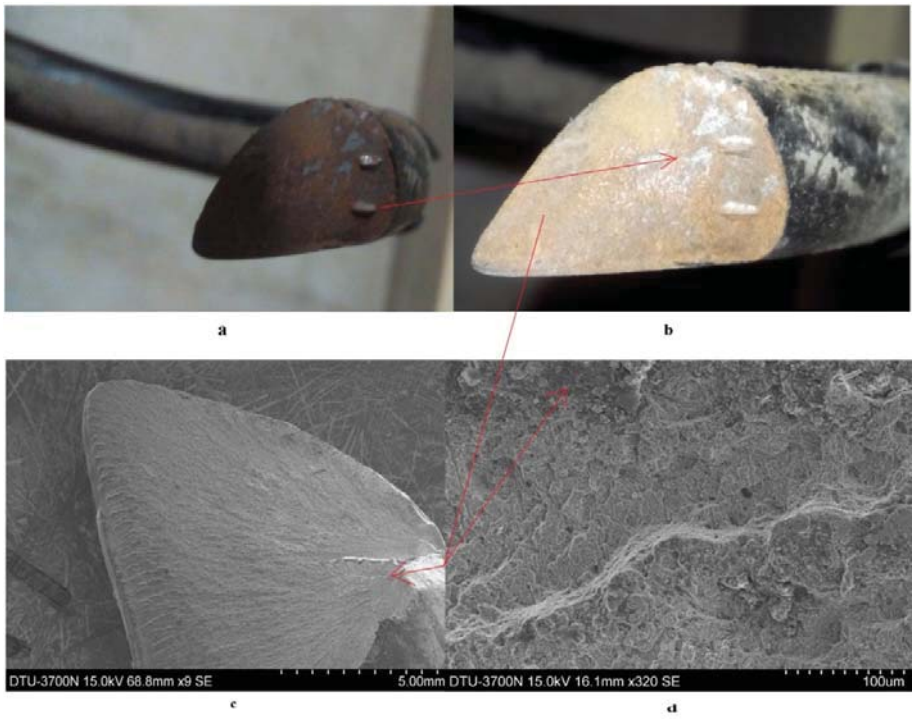

Figure 4: Corrosion in Coil Spring

Figure: 4 ‘a, b, c, d’, shows the corrosion and decarburization in suspension coil spring due to poor maintenance and environment condition, in figure ‘a’ clearly shows more corrosion on coil they are as well as seen in figure ‘b’ and these cold stone easily shown in figure ‘d’ in darker in SEM image. These corrosive particles cause premature failure in suspension coil spring. However the modern coating technology is able to prevent corrosion in coil spring and also improve service life of coil.

IV. CONCLUSION

This paper have metallurgical analysis to find reason behind the premature failure of suspension system have been performed. Normally in raw material defect such as inclusion, decarburization causes imperfection are observed which conclude in this work one may be that defects in raw material inclusion, decarburization are the major reason behind premature failure. Internal cracks and holes also played a major role in the premature failure of the suspension system. However the material property change due to over tempered of the coil spring causes loss ductile property. In coil metal fracture spaceman brace due to corrosive for poor maintenance or coating. So imperfection in coil spring found to premature failure caused various type of directs.

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