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Analysis of injector spring damage to determine maintenance management diesel engine at PLTD Ampenan

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Abstract. The injector spring in cylinder #2 of a diesel engine in Ampenan PLTD which is operated by PT. X damaged. After visual inspection, a helical spring of the injector was broken. The spring broke in the lower part, in winding 2 of the spring. Before the damage was known, with a diesel load of 1100 kW, the exhaust manifold the cylinder #2 was glowing. Root cause analysis of the broken spiral spring was carried out by visual observation, metallography, and maintenance management analysis. Results indicated that the damaged of the broken injector spring based on visual observation of the helical spring was due to alternating bending loads. The fracture angle was at 45° indicated a bending load. Benchmark shows the beginning of the fault, followed by a static fracture. Metallographic and microstructure examination results found too many sulphides possibly making the formation of the onset of the fatigue. To minimize the damage, the sulphide amount of the spring must be reduced, and the spring injector material must be redesigned. Maintenance management must check every time the new spring is received and the cam lobe dimensions and wear of the roller must be lifted every 1000 hours.

1. Introduction

The injector functions for the process of ignition of the fuel, and in the process of fogging the performance of the injector using Mechanical springs are used in the machine to provide flexibility, save or absorb energy [1]. In general, it is classified as a spring wire, a flat spring or a special shape and there are other variances. Round or square wire round helical wire or spring and made to resist tensile, compressive or torsional loads.

When the spiral spring of the injector breaks the pressure on the injector it drops slowly, and the duration of the fuel spraying will take longer, because the pressure inside the injector drops slowly, as a result, it will occur over fuelling and glowing. On 30 minutes prior to the red or glowing damage to the exhaust manifold and then an emergency trip (normal stop) by the operator is explained in Figure 1. Damage to the injector that causes Gen-Set to be inoperable and after checking the injector helical spring is found Broken at the bottom shown in figure 1. After checking, it was found that a broken injector spring at the bottom as shown in Figure 2.



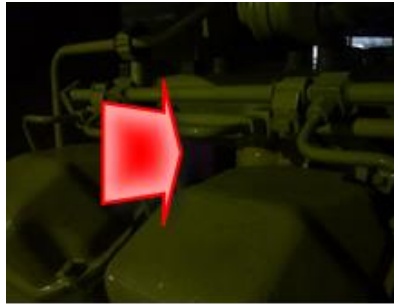


Figure 1. Exhaust manifold glowing.

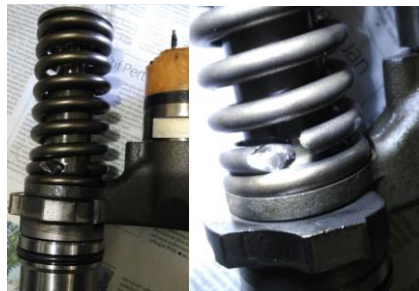


Figure 2. Spring injector broken.

The supply of fuel flows through a high-pressure channel to the injector located on the cylinder head. The function of the injector is to atomize the fuel into the combustion system and how it works the injector has a valve that opens when the fuel pressure is high enough [2]. When the valve opens, the fuel is atomized and sprayed into the combustion chamber. At the end of the spraying, the pressure drops drastically and causes the valve to close again.

The electronic unit injection (EUI) system uses several of the same components as those used by the pump and line systems. The EUI system uses 1. Fuel tank, 2. Primary fuel filter, 3. Fuel transfer pump, 4. Secondary fuel filter, 5. Injector, 6. Return line, which is described in figure 3.

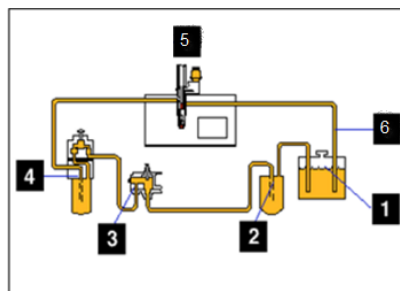


Figure 3. Fuel line diesel engine.

A paper is high-pressure injector damage used on a common rail, an analysis is carried out of the cause of the damage and the results of a microscopic study of damaged components. Tribological damage from high-pressure injectors is local and cavitation holes. Cavitation position is mainly carried out on the valve, where the reduction in the amount of fuel injected [3].

The diesel engine used in trucks has problems when serviced. Inspection shows that four exhaust valves and intake valves and two exhaust valves and inlet valves are cracked. Fractographic studies show that fatigue is the main failure mechanism for all four valve springs. Under the action of the maximum nominal voltage, fatigue cracks begin in coil spring wire 1.3-1.5 from the top end of the

spring. This region is also a location that is damaged by contact friction. The fracture of the intake valve and exhaust valve stem also indicate possible fatigue failure as a result of valve spring failure [4].

Most recent diesel engine failures have occurred in modern diesel engines, which can be directly blamed on the quality of the fuel used. Due to poor fuel lubrication, as well as some particle contamination, the injector fails prematurely, causing bad combustion and engine damage, damage caused by fuel quality damage to the injector tip, abrasive on the plunger and barrel [5].

The deflection in the spring decreases with less stress when changing certain parameters. The spring index will affect deflection and stress. When the number of turns increases, the deflection decreases, and the pressure also decreases. This effect is not possible without changes in wire diameter because the wire diameter has an influence on deflection and pressure. Therefore when the wire diameter increases the deflection and the pressure also decreases. This happens because of the achievement of a better spring index [6].

Spring is a mechanical shock absorbing system. Mechanical springs are defined as elastic objects that have the main function to bend or twist the load and to return to their original shape when the load is released. Researchers for many years have provided various research methods such as Theoretical, Numerical and Experimental. The researchers used theoretical, numerical and FEM methods. This study concludes that the Finite Element method is the best method for numerical solutions and calculates fatigue stress, life cycle and helical compression spring shear stress [7].

The helical compression spring is commonly used in diesel engine fuel injection systems, where it undergoes cyclic loading for more than 10 cycles. To predict the possible position of failure in the helical compression spring, which is used in the fuel injection system, along with the inner spring, finite element analysis is carried out, using ABAQUS 6.10. Simulation results show the behaviour of pressure oscillations along the length on the inside. It is ensured that oscillations are caused by bending associated with compression. It was also revealed that bending was caused by the geometry of a spring. The shear stress along the spring is found to be asymmetrical and with local maxims at the beginning of each middle coil. Asymmetry is caused by a coiled-coil smaller than 360 degrees.

2. Methods

2.1. Remove cover cylinder head and visual inspection

In a visual inspection of a spiral spring injector, A \emptyset wire diameter 7.0 mm and \emptyset 48 mm spring circumference has a broken first circle.

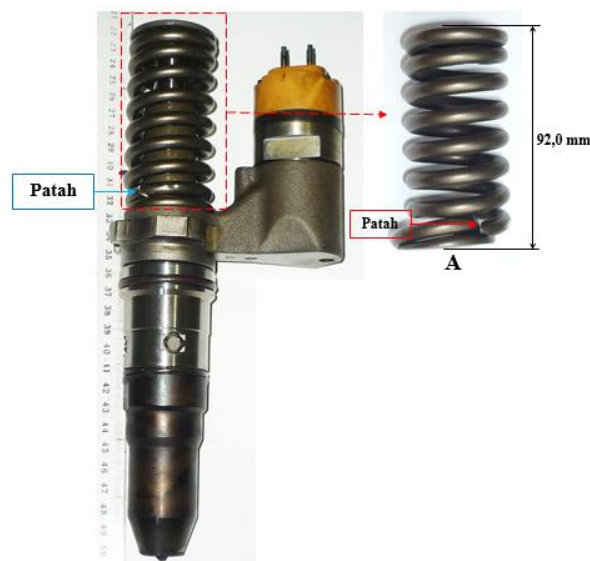


Figure 4. Macro photo injector.

2.2. Visual observation

Photo macro image 8 on the injector spring the broken center point is a load bearing area and includes a fairly high center of stress concentration, it can be seen from the circumference area of the fracture there is a defect between the spring and spring wear.

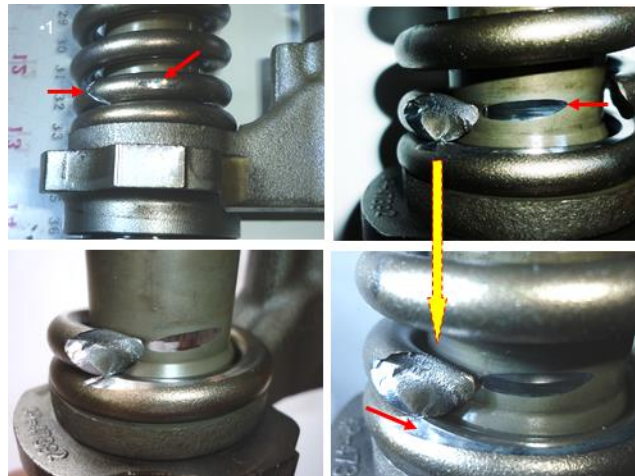


Figure 5. Photo macro on the injector fracture surface.

Figure 6 spiral spring circle 2 is the beginning of a fracture which first occurs the bending load thinning, while the shape of the fault has a 45° angle is a static fracture, while the 7 benchmark image on the injector spring fracture.

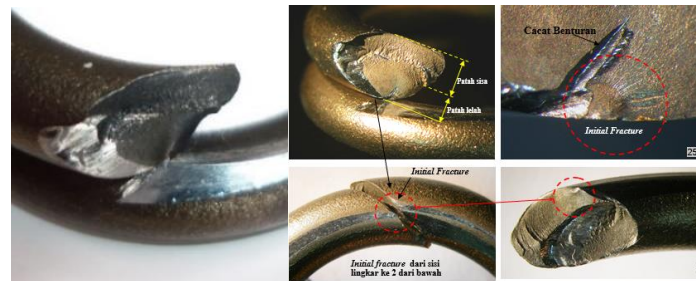


Figure 6. Early broken.

2.3. Metallographic testing

Metallographic testing Figure 7 describes a benchmark that occurs in a spiral spring, that a benchmark indication is a form of fatigue in the injector spring.

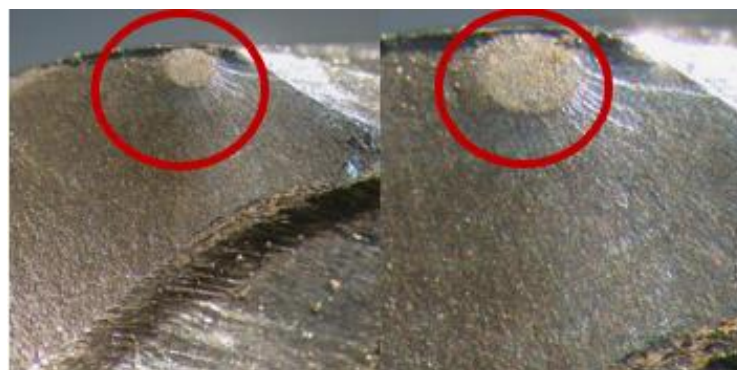


Figure 7. Benchmark injector spring fault.

2.4. Microstructure testing

Figure 8 with 100x magnification and 500x there are secondary cracks due to dynamic loads. The secondary crack is caused when a break occurs and is not the cause of damage.

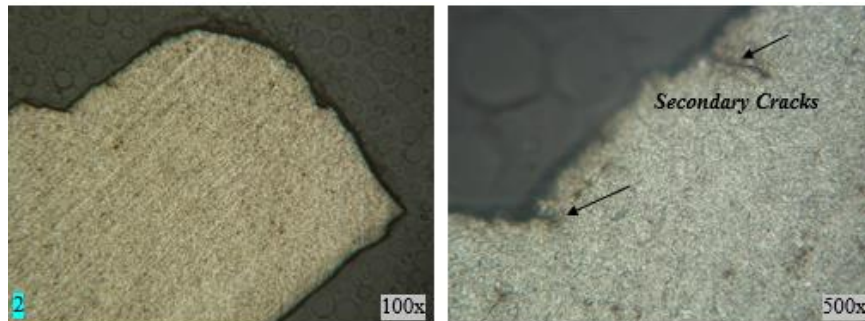


Figure 8. No.2 100x and 500x magnification.

Figure 9. No. 3 in the edge area deformation of the structure due to the shot pining of the production process, the process will improve the performance of the spiral spring. While the number 4 microstructure is a marten site tamper and there is manganese sulphide. Where manganese sulphide is formed during the manufacturing process.

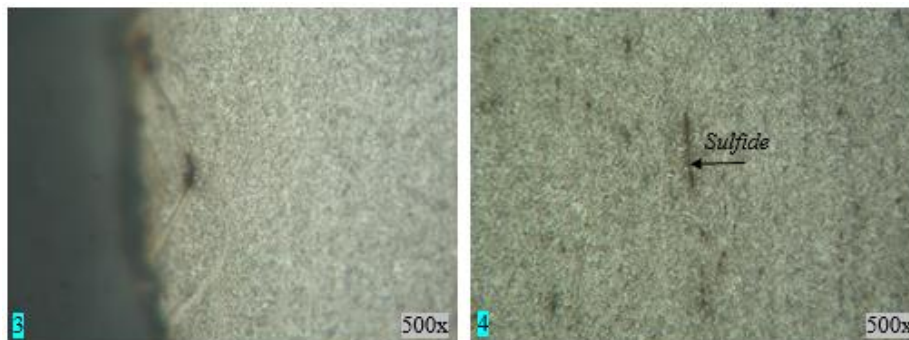


Figure 9. No 3 and No 4 Sulphide at helical compression spring.

2.5. Testing of chemical composition

The chemical composition of spiral 1 spring contains low alloy steel where the values of C 0.609 and Fe 98.8 are described in table 1 and the composition is homogeneous and there is no correlation with the spiral spring damage. As for low carbon steel, the chemical composition C: 0.05-0.35%, Mn: 0.25-0.90%, medium carbon steel Chemical composition C: 0.36-0.65%, Mn: 0.70-0.90%, high carbon steel carbon values above 0.65-1.6% , Mn 0.65-0.90% is brittle, toughness drops, hardness and strength increase.

Table 1. Chemical composition.

No	Element	Result (wt %)		No	Element	Result (wt %)	
		Spiral Spring 1				Spiral Spring 1	
1	Fe	98.8		10	Al	0.0010	
2	C	0.609		11	V	0.0932	
3	Si	2.15		12	Ti	0.0018	
4	Mn	0.753		13	S	0.0047	
5	Cr	1.03		14	P	0.0077	
6	Ni	0.257		15	Co	0.0015	
7	Mo	0.0181		17	Nb	0.0447	
8	Cu	0.0060		18	W	0.0400	
9	Pb	0,0222					

2.6. Testing for material hardness

Testing injector springs using 1 sample and 3 (three) points to compare the points of each sample and compare the material hardness of the values obtained from the testing of the material hardness and in table 2 with an average value for samples A: 592, sample B: 595, sample C: 576 is homogeneous.

Table 2. Test results for hardness of injector spring materials.

No	Value Hardness, HV		
	Sample A	Sample B	Sample C
1	593	612	576
2	593	593	585
3	567	585	567
4	541	592	567
5	567	593	576
6	693		576
7			585
8			576
9			576

3. Results and discussion

From this discussion, the damage of the broken injector spring is caused by:

- Metallographic results indicate a benchmark in the form of a fault, which indicates fatigue fracture (fatigue fracture). The initial form of initial fracture from the fracture of the injector
- Secondary cracks on the fault surface as a result of overloads
- Chemical composition of injector spring with low alloy steel with Cr 1.03%, and Mo content of 0.753%, that spiral spring material is low alloy steel with high C content. The spring elasticity is quite high
- The spiral spring material hardness 1 average value of point A: 592, point B: 595, point C: 576, while the spiral spring 2 the average value of point A: 576, point B: 586, point C: 561
- Sulphide content in spiral 1 microstructure is seen in a large amount of material, possibly making early fatigue
- The wear of cam lobes and roller lifter injectors will cause an abnormal height of the injector, and if each PM interval is found an abnormality of altitude will have an impact on the performance of the injector spring and can cause damage to the spring spiral injector broken.

4. Conclusions

Sulphide content in spiral spring microstructure is seen in the whole material quite a lot, possibly making the formation of early fatigue, with an indication of the beach mark in the form of a fatigue fracture in the injector spring.

Acknowledgments

Thank you, I convey to Mr. Bambang Teguh Prasetyo, Mr. Tri Wibowo, Mr. Koswara, and Mr. Mujiarto and all colleagues who have helped this research. I hope that what has been conveyed is useful for others and the gentlemen all make it easy, carry out their efforts and be protected by the Almighty God. Success for all.

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