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We would like to thank you for your interest and enthusiasm in the 4th AASEC 2019 that will be organized this year by Universitas Pendidikan Indonesia, Universitas Warmadewa and also the other co-hosts.

A total of 1.000 participants have registered to this year's conference, including you. This leads an objective selection of the abstracts to be presented on the conference.

In this occasion, we would like to congratulate you since your abstract is **ACCEPTED** to be presented in the parallel/ round table session of the conference. Authors with accepted abstract(s) are requested to immediatel proceed to payment through BNI bank:

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Thank you and see you in Bali on 24 April 2019.

Don't forget follow our social media accounts and get updates about conference.

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Author: Wilarso (a*), Tri Wibowo (b), Bambang Teguh (b), Mujiarto (c*)
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Mengingat batas akhir unggah bukti pembayaran tinggal lima hari lagi, kami beritahukan kepada ***SELURUH PENULIS YANG TELAH DITERIMA ABSTRAKNYA*** *untuk segera melakukan pembayaran dan mengung bukti transfer melalui akun masing-masing* ***(TIDAK MELALUI EMAIL).***

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Dear Author(s),

Please find the attached file of AASEC 2019's rundown. We would like you to take a careful look at it since we only put ABS codes on every session. Types of presentations (oral, roundtable, and poster) are the committee's decision. See you in Bali on 24 April 2019.

Terlampir Susunan Acara pada AASEC 2019. Mohon diperhatikan dan baca dengan seksama. Kami hanya mencantumkan Kode ABS pada setiap sesi. Ketentuan jenis presentasi (oral, roundtable, atau poster) merupakan keputusan panitia yang tidak dapat di ganggu gugat. Sampai jumpa di Bali, 24 April 2019.

Terima kasih
Thank you

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Dear author(s),

We would like to remind you that the deadline of full paper submission is on **May 12, 2019, at 11.59 PM (Western Indonesia Standard Time)** and **there will not by any time extension**. Please, submit your full paper(s) through your personal account on submission system (http://aasec.conference.upi.edu/2019/submission/), **DO NOT SEND IT BY EMAIL**.

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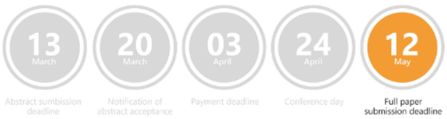
Warm regards,
Committee



Noted with thanks. Thank you for the information. Thank you for informing me.

ABS-902; ABS-1066-Revision

Mujiarto , ST, MT <mujiarto@umtas.ac.id> Rab, 12 Ju
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Salam,
Dear Editor AASEC

Berikut revision ABS-902 dan ABS-1066.

Terima kasih.

Wassalam,
Mujiarto

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Dear Authors,

We would like to inform you the manuscripts of AASEC 2019 are in publication process by IOP which takes time since they are in a quite long line of other conferences' proceedings publication. We do hope that you are patiently waiting and we will keep you updated. Thank you.

Diberitahukan kepada para penulis AASEC 2019, bahwa proses penerbitan proceeding masih menunggu antrean dari conference-conference kami yang juga sedang diproses IOP, proses ini akan memakan waktu yang cukup panjang, dimohon untuk bersabar dan menunggu hasil yang akan di informasikan panitia selanjutnya. Terima kasih.

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Committee

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URL JPCS 1402: https://iopscience.iop.org/volume/1742-6596/1402v

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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 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 45^0 indicated a bending load. Beachmark shows the beginning of the fault, followed by a static fracture. Metallographic and microstructure examination results found too many sulphide 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.

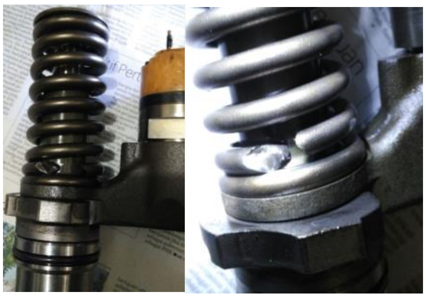
Keywords: Diesel Engine; Exhaust manifold; Glowing; Injector spring; Maintenance management

1.1 Pendahuluan.

Unit pembangkit PLTD adalah pembangkit listrik yang di operasikan oleh PT. X untuk memenuhi kebutuhan listrik di Wilayah Mataram. Kapasitas unit pembangkit 1 x 1200 kW yang dalam operasinya beban dasar (*base load*), dengan total 8 unit dan daya kontrak 7,000 kW atau 7 MW.

Salah satu Gen-Set mengalami kerusakan injector yang menyebabkan Gen-Set tidak bisa beroperasi dan setelah dilakukan pengecekan ditemukan pegas spiral injektor patah di bagian bawah yang ditampilkan gambar 1

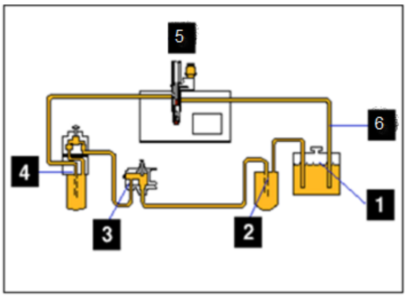
Pada saat pegas spiral injektor patah tekanan di injektor turunnya lambat, dan durasi penyemprotan bahan bakar akan lebih lama, karena tekanan didalam injektor turunnya lambat, akibatnya akan terjadi *over fueling* dan glowing, sesuai dengan gambar 1



Gambar 1. Pegas Injektor Patah (*Sumber: Dokumentasi kerusakan komponen*).

Suplai bahan bakar mengalir melalui saluran bertekanan tinggi menuju injektor yang terletak di kepala silinder. Fungsi dari injektor adalah untuk mengabutkan bahan bakar ke dalam sistem pembakaran dan cara kerja injektor mempunyai katup yang membuka pada saat tekanan bahan bakar cukup tinggi (supply, 2010). Ketika katup membuka, bahan bakar dikabutkan dan disemprotkan ke dalam ruang pembakaran. Pada akhir penyemprotan, tekanan turun secara dratis dan menyebabkan katup menutup kembali.

Sistem eletronik unit injection (EUI) menggunakan beberapa komponen yang sama seperti yang dipakai oleh sistem *pump* dan *line*. Sistem EUI menggunakan, *1. Fuel tank, 2. Primary fuel filter, 3. Fuel transfer pump, 4. Secondary fuel filter, 5.Injector, 6. Return line*, yang dijelaskan pada gambar 3.



Gambar 2. Fuel Line Diesel Engine (Sumber: Dasar-Dasar Diesel Engine-Caterpillar)

2 Tinjauan Pustaka.

Menurut berbagai sumber analisis terhadap kerusakan helica spring sebagai berikut:

Kerusakan injektor bertekanan tinggi yang digunakan pada common rail, analisis yang dilakukan tentang penyebab kerusakan dan hasil penelitian mikroskopis komponen yang rusak. Kerusakan tribological ari injektor tekanan tinggi bersifat lokal dan lubang kavitasi. Posisi kavitasi terutama dilakukan pada katup, dimana pengurangan jumlah bahan bakar yang di injeksikan(Ignaciuk & Gil, 2014).

Mesin diesel yang digunakan pada truk mengalami masalah saat di servis. Inspeksi menunjukkan bahwa empat katup buang dan katup intake serta dua katup buang dan katup masuk retak. Studi fraktografi menunjukkan bahwa kelelahan adalah mekanisme kegagalan utama untuk semua empat pegas katup. Dibawah aksi tegangan nominal maksimum, retak kelelahan dimulai pada kawat pegas kumparan 1.3-1.5 dari ujung atas pegas Wilayah ini juga merupakan lokasi yang aling rusak karena gesekan kontak. Fraktur katup intake dan batang katup buang juga menunjukkan kegagalan kelelahan mungkin sebagai akibat kegagalan pegas katup(Yu & Xu, 2009).

Sebagian besar kegagalan diesel engine baru baru ini terjadi ada diesel engine modern, yang dapat langsung disalahkan pada kualitas bahan bakar yang digunakan. Karena pelumasan yang buruk dari bahan bakar, serta beberapa kontaminasi partikel, injektor gagal sebelum waktunya, menyebabkan pembakaran yang buruk dan kerusakan mesin, kerusakan yang disebabkan oleh kualitas bahan bakar terjadi kerusakan pada tip injektor, abrasif pada plunger, dan barrel (Wielligh, Burger, & Vaal, 2004).

Lendutan pada pegas berkurang dengan berkurangnya tegangan saat perubahan parameter tertentu. Spring index akan mempengaruhi lendutan dan stres. Ketika jumlah belokan meningkat, defleksi berkurang dan tekanan juga berkurang. Efek ini tidak mungkin terjadi tanpa perubahan diameter kawat karena diameter kawat memiliki pengaruh pada defleksi dan tekanan. Oleh karena itu ketika diameter kawat meningkatkan defleksi dan tekanan juga berkurang. Ini terjadi karena pencapaian indeks pegas yang lebih baik (Thakare & Kadlag, 2017).

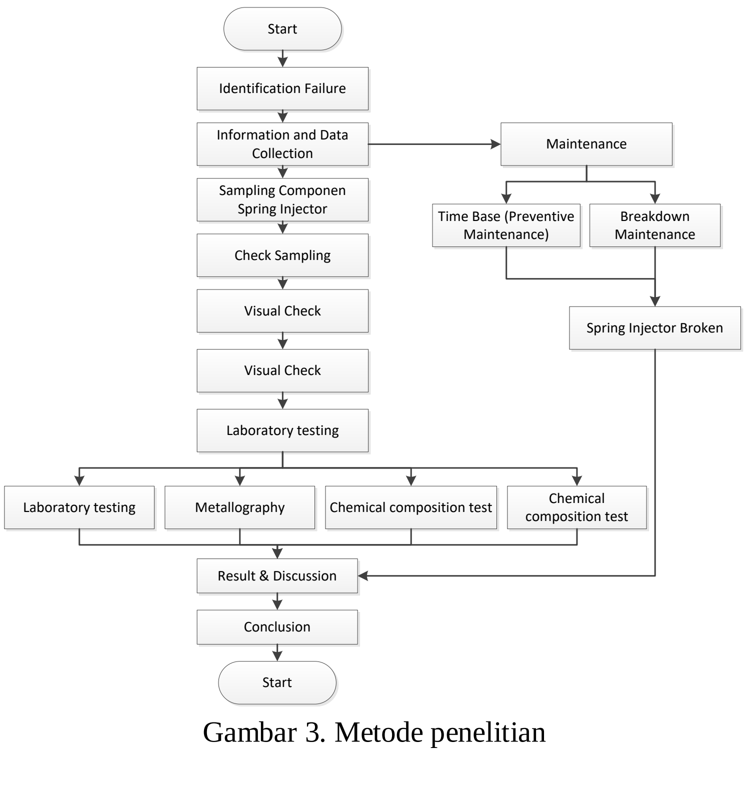
Pegas adalah sistem peredam kejut mekanis. Pegas mekanis didefinisikan sebagai benda elastis yang memiliki fungsi utama untuk membelokkan atau memutarbalikkan beban, dan untuk kembali ke bentuk aslinya ketika beban dilepaskan. Para peneliti selama bertahun-tahun telah memberikan berbagai metode penelitian seperti Teoritis, Numerik dan Eksperimental. Para peneliti menggunakan metode Teoritis, Numerik dan FEM. Penelitian ini menyimpulkan metode Elemen Hingga adalah metode terbaik untuk solusi numerik dan menghitung tegangan lelah, siklus hidup dan tegangan geser pegas kompresi heliks (Rathore & Joshi, 2013)

3 Metode

Dalam melakukan penelitian pegas injektor patah menggunakan metodologi kualitatif, yang dilakukan oleh peneliti diantaranya:

1. Melakukan observasi lapangan terhadap kerusakan komponen injektor.
2. Melakukan pemeriksaan visual pegas injektor patah, terhadap operasional.
3. Melakukan pengambilan sampel uji pada pegas injektor.
4. Pemeriksaan laboratorium fractografi pada sampel uji untuk mengetahui kerusakan pegas injektor yang patah.
5. Pemeriksaan metalografi pada sampel uji untuk mengetahui mikrostruktur pada pegas injektor.
6. Pemeriksaan uji kekerasan sampel uji terhadap kualitas material.
7. Pemeriksaan komposisi kimia terhadap kualitas material.
8. Pemeriksaan terhadap laju korosi pada material pegas injektor.
9. Pemeriksaan data pemeliharaan *preventive maintenance* dan *breakdown maintenance*.

Adapun dalam diagram alir dalam melakukan analisa pada pegas injektor sebagai berikut:



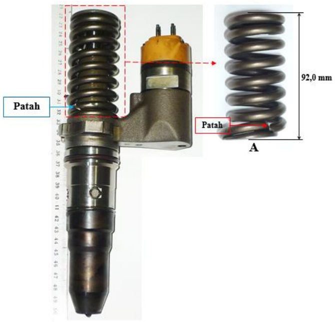
Gambar 3. Metode penelitian

4 Analisa

Dalam penelitian kerusakan pegas injektor dilakukan beberapa pengujian, agar hasi dapat menentukan akar penyebab kerusakan.

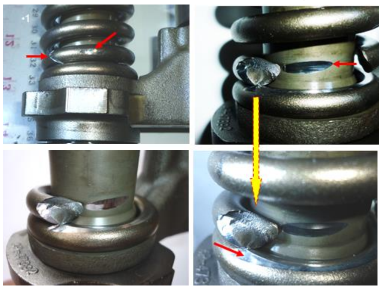
Pemeriksaan visual.

Dalam pemeriksaan visual pada injektor Pegas spiral A diameter kawat Ø 7,0 mm dan Ø lingkar pegas 48 mm mengalami patah dilingkar pertama



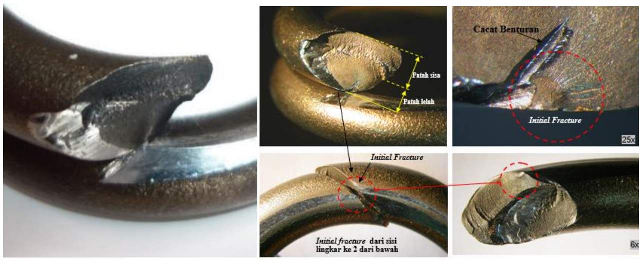
Gambar 4. Photo makro injektor

Photo makro gambar 8 pada pegas injektor titik pusat patah merupakan daerah tumpuan beban dan termasuk pusat konsentrasi tegangan yang cukup tinggi, hal tersebut dapat dilihat dari daerah lingkar lokasi patah adanya cacat himpitan antar pegas dan cacat aus pegas.

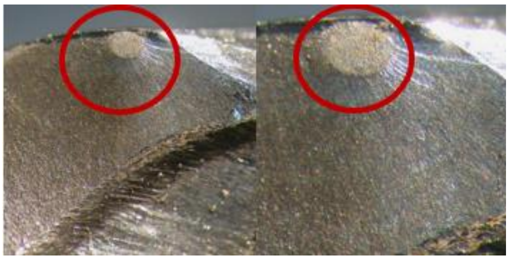


Gambar 5. Photo makro pada permukaan patahan injektor

Gambar 6 pegas spiral lingkaran 2 merupakan awal patah yang terlebih dahulu terjadi penipisan beban bending, adapun bentuk patahan mempunyai sudut 45^o merupakan patah statik, sedangkan gambar 7 beachmark pada patahan pegas injektor.

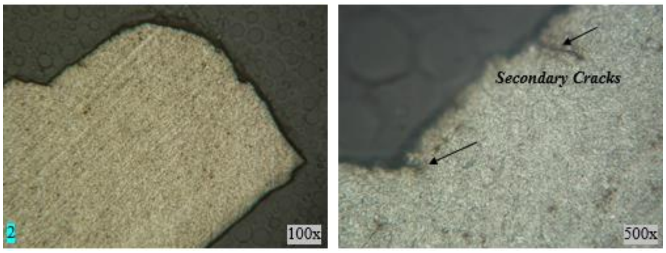


Gambar 6. Awal patah



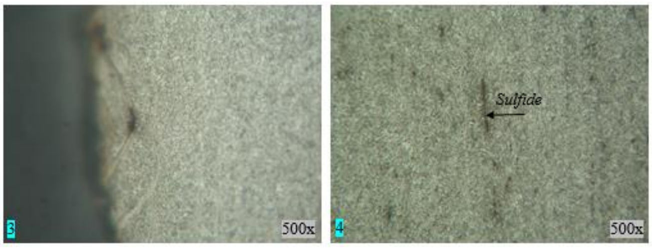
Gambar 7. Beachmark patahan pegas injektor

Gambar 14 dengan pembesaran 100x dan 500x terdapat *secondary cracks* akibat beban dinamis. Adapun *secondary crack* ini disebabkan saat terjadi patah dan bukan penyebab kerusakan



Gambar 8. No.2 Pembesaran 100x dan 500x

Gambar 15. no 3 di daerah tepi terjadi perubahan bentuk (*deformation*) struktur akibat shot pining proses produksi, proses tersebut akan meningkatkan performa pegas spiral. Sedangkan no 4 struktur mikro berupa martensit tamper dan terdapat mangan sulfida



Gambar 9. No 3 & No 4 Sulfide at helical Spring

Kandungan komposisi kimia pada pegas spiral 1 mengandung *low alloy steel* dimana nilai C 0,609 dan Fe 98,8 yang dijelaskan pada tabel 4.2 dan komposisinya homogen dan tidak ada korelasinya terhadap kerusakan pegas spiral. Adapun low carbon steel, komposisi kimia C: 0.05-0.35%, Mn: 0.25-0.90%, *medium carbon steel* komposisi kimia C: 0.36-0.65%, Mn: 0.70-0.90%, *high carbon steel* nilai karbon diatas 0.65-1.6%, Mn 0.65-0.90% bersifat getas, ketangguhan turun, nilai kekerasan dan kekuatan meningkat.

Tabel 1. Komposisi Kimia

No	Unsur	R e s u l t (wt %)
		Pegas Spiral 1
1.	Fe	98.8
2.	C	0.609
3.	Si	2.15
4.	Mn	0.753
5.	Cr	1.03
6.	Ni	0.257
7.	Mo	0.0181
8.	Cu	0.0060

9.	Al	0.0010
10.	V	0.0932
11.	Ti	0.0018
12.	S	0.0047
13.	P	0.0077
14.	Co	0.0015
15.	Nb	0.0447
16.	W	0.0400
17.	Pb	0,0222

Hasil pengujian kekerasan material pegas 2 di posisi A dengan nilai rata-rata 576, posisi B 586, posisi C 581, perbedaan di setiap titik pengambilan sampel uji dengan nilai yang homogen dan tidak ada keterkaitan dengan kerusakan pegas.

Tabel 2. Hasil Pengujian Kekerasan Material Pegas Spiral 1

No	Nilai Kekerasan, HV		
1	Sample A	Sample B	Sample C
2	593	612	576
3	593	593	585
4	567	585	567
5	541	592	567
6	567	593	576
7	693		576
8			585
9			576
10			576

5 Kesimpulan.

Dari pembahasan tersebut kerusakan pegas injektor patah disebabkan oleh:

Kerusakan pegas spiral injektor 1 dan 2 yang mengalami patah berdampak terhadap tidak beroperasinya unit pembangkit dan kejadian kerusakan tersebut sering terjadi pada unit pembangkit diesel engine.

- Dari visual inspeksi pada pegas spiral 1 patah terjadi di lingkaran kedua dari bawah dan penipisan pada permukaan pegas dan pembanding kerusakan pada pegas spiral 2 dibagian lingkaran ketiga.
- Hasil metalografi terindikasi beachmark pada bentuk patahan, yang mengindikasikan patah lelah (*fatigue fracture*).
- Bentuk dari initial fracture awal dari patahnya injektor.
- Secondary crack pada permukaan patahan sebagai akibat beban overload.
- Hasil pengujian komposisi kimia kandungan Fe 98.8, Cr 1.03, C 0,609, bahwa material pegas spiral *low alloy steel* kandungan C tinggi. Elastisitas pegas tersebut cukup tinggi.
- Hasil pengujian kekerasan material pegas spiral 1 nilai rata-rata titik A: 592, titik B: 595, titik C: 576, sedangkan pegas spiral 2 nilai rata-rata titik A: 576, titik B: 586, titik C: 561.
- Kandungan sulfide pada struktur mikro pegas spiral 1 dan 2 terlihat pada keseluruhan material cukup banyak, kemungkinan membuat terbentuknya awal patah fatigue
- Keausan cam lobe maupun roller lifter injektor akan menimbulkan abnormal ketinggian injektor, dan jika setiap interval PM ditemukan abnormality ketinggian akan berdampak pada kinerja pegas injektor dan bisa mengakibatkan kerusakan pegas spiral injektor patah.

6 Daftar Pustaka

Ignaciuk, P., & Gil, L. (2014). Damages To Injectors in Diesel Engines. *Advances in Science and*

Technology Research Journal, *8*(21), 58–61. https://doi.org/10.12913/22998624.1091880

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ANALYSIS OF INJECTOR SPRING DAMAGE TO DETERMINE MAINTENANCE MANAGEMENT DIESEL ENGINE AT PLTD AMPENAN

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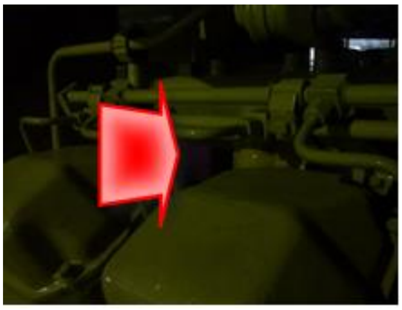

Figure 1. Exhaust manifold glowing

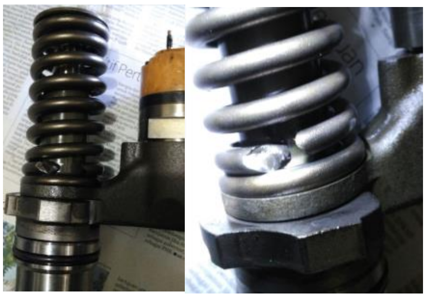

Figure 2. Spring injector broken

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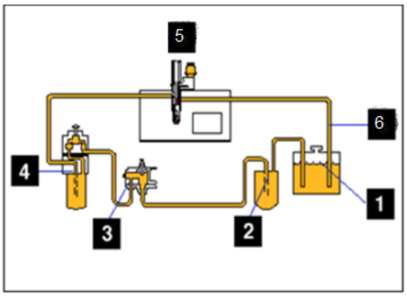

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Spring is a mechanical shock absorbing system. Mechanical springs are defined as elastic objects that have the main function to bend or twist the load and to return to their original shape when the load is released. Researchers for many years have 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 behavior 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.

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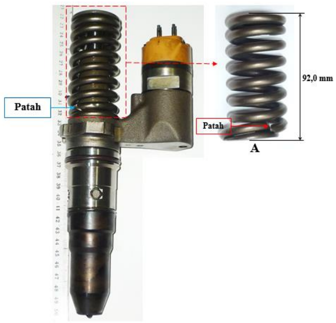

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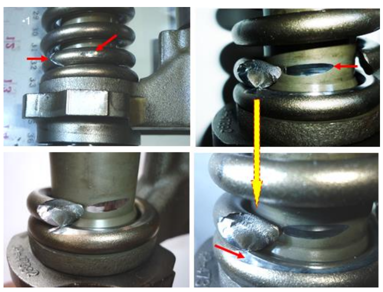

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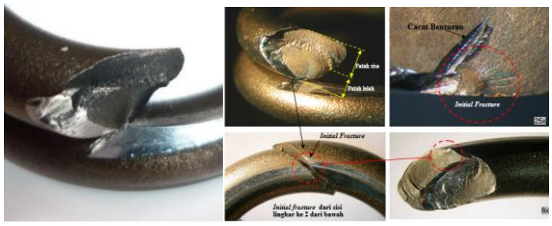

Figure 6. Early broken

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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.

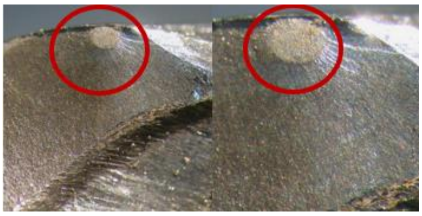

Figure 7. Benchmark injector spring fault

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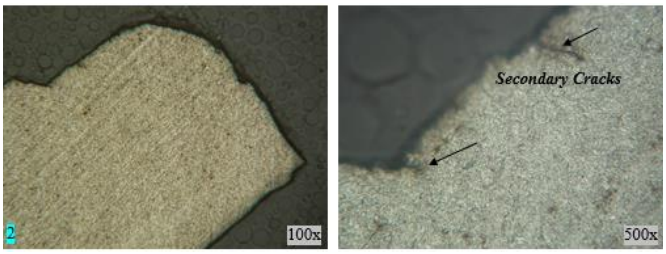
Figure 8 with 100x magnification and 500x there are secondary cracks due to dynamic loads. The secondary crack is caused when a break occurs and is not the cause of damage.



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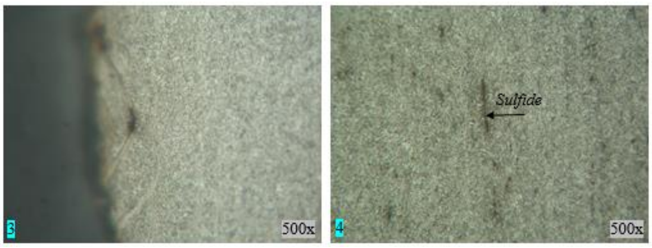

Figure 9. No 3 & No 4 Sulfide at helical compression spring

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	Unsur	R e s u l t (wt %) Pegas Spiral 1	No	Unsur	R e s u l t (wt %) Pegas Spiral 1
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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
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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.

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

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- Sulfide content in spiral 1 microstructure is seen in a large amount of material, possibly making early fatigue
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Sulfide 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.

5. Acknowledgment

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.

6. References

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To cite this article: W Wilarso *et al* 2019 *J. Phys.: Conf. Ser.* **1402** 077043

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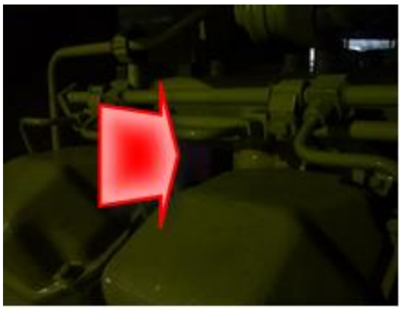

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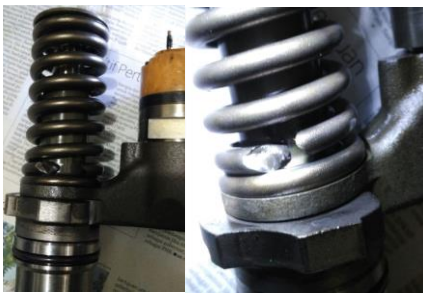

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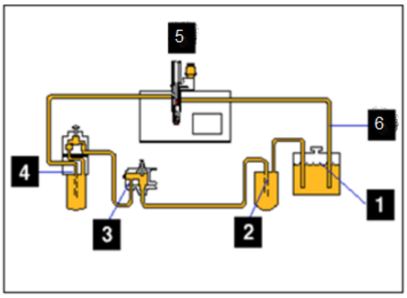

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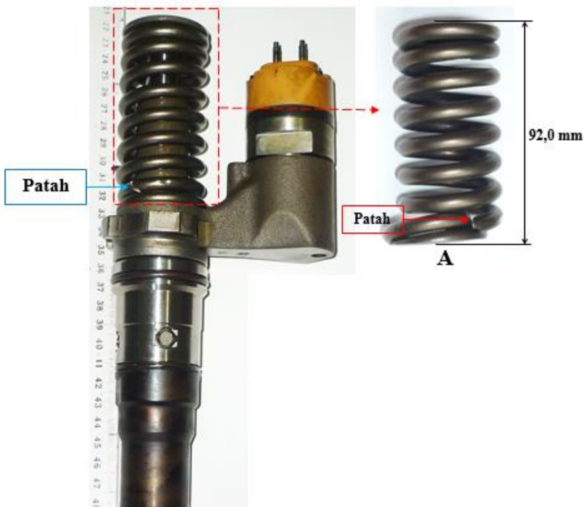

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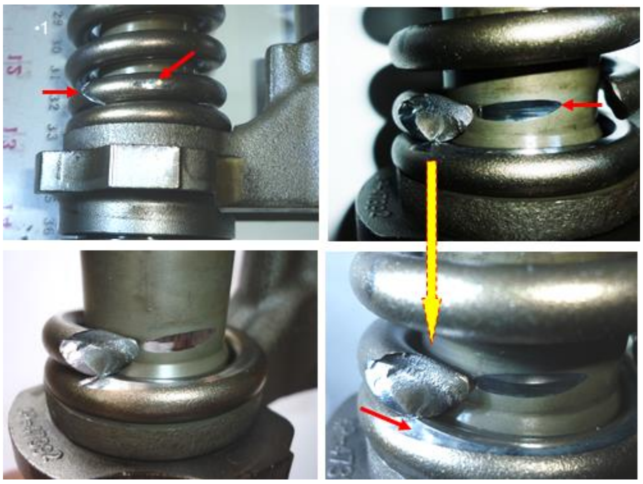

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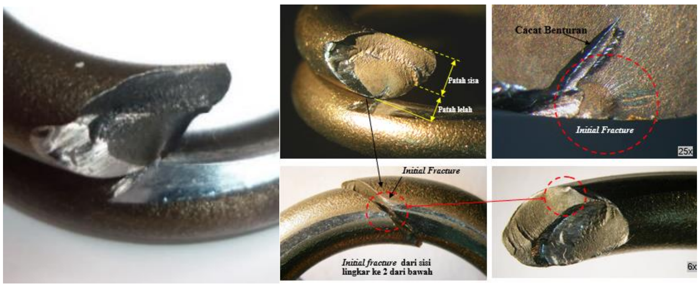

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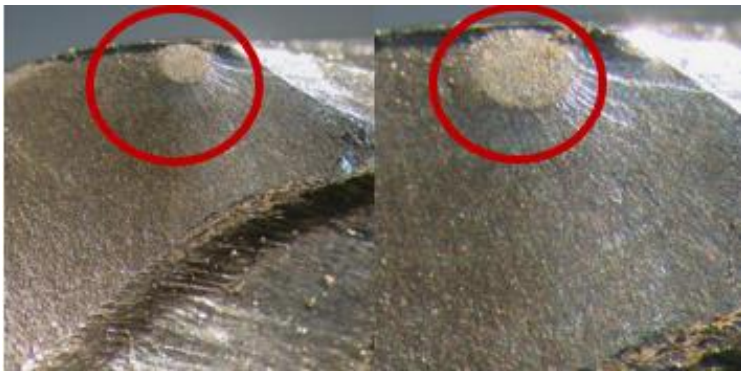

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Journal of Physics: Conference Series **1402** (2019) 077043 doi:10.1088/1742-6596/1402/7/077043

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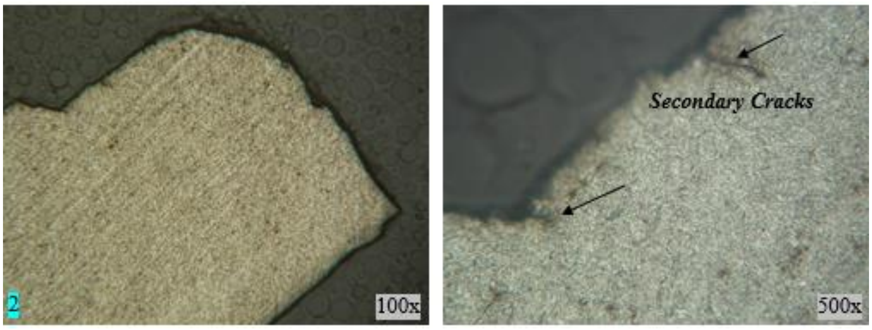

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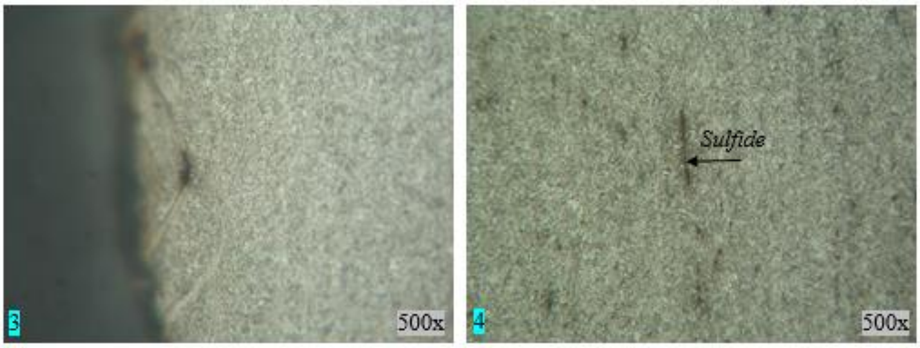

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Sulphide content in spiral spring microstructure is seen in the whole material quite a lot, possibly making the formation of early fatigue, with an indication of the beach mark in the form of a fatigue fracture in the injector spring.

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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