FAILURE ANALYSIS OF DIFFERENTIAL GEAR

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Abstract

In order to move the vehicle, the rotating force generated in the motor by increasing the required amount depending on the front or rear-wheel drive must be transmitted to the wheels. Vehicle movement in all of these systems enables the transmission Powertrain is called. In motor vehicle driveline clutch mechanism with the mechanical movement as energy, gear boxes, hinge mechanisms, shafts, differential, axle systems with wheels are expressed transmitting system. Powertrain for working under severe conditions some damage and malfunction may occur. Power of the most important parts in the driveline is one of the differential gear.

In this study; BMC 935 trucks belonging to the spider and the spider shaft of the differential gear box damage were investigated. According to information received from the service, which is 138,000 miles spider, and the spider shaft broken, the damage has occurred. Differential gear unit and the shaft breaks the chemical composition spider, optical microscope, hardness and applying the failure analysis, the obtained results were evaluated in accordance with literature data.

Keywords: BMC 935 Trucks, Differential Gear Box, Gear Rosary, Microstructure, Failure Analysis.

1. INTRODUCTION

Engineering and mechanical power transmission gears, offering a combination of cost advantages, like clockwork precision devices, automotive, machine tools, aircraft and space technology is used in many large areas [1].

The important features are requested from gearwheel material like surface hardness, fracture toughness, fatigue resistance, resistance to impact loads, wear and corrosion resistance [2].

Forces pushing the wheel to bend the teeth, the tooth root and the curvature of the tooth root and tooth profile causes maximum stress at the intersection. Cracks, who was forced to pull the tooth root curvature starts from the side, in the direction parallel or perpendicular to the tooth gently until completely break leads to progress. Cross-section gradually decreases, fewer cracks in the cycle of each load, and a certain period continues to travel further gear is subject to breakage [3, 4].

Under high pressure in the load again after many teeth formed on the surface or below the surface constituted by the combination of small cracks develop and become detached as a result of material particles of gears pitting occurs [3].

In motor vehicle driveline clutch mechanism with the mechanical movement as energy, gear boxes, hinge mechanisms, shafts, differential, axle systems with wheels are expressed transmitting system.

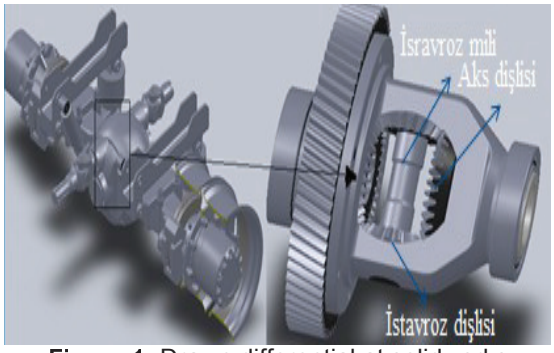


Figure 1. Drawn differential at solidworks

If the last piece of the driveline are differential (Figure 1). The task of differential during cornering, wheel of a vehicle cornering, the outer part of the circle inside the wheels remaining on the remaining wheels are forced to rotate faster than. These wheels, their commitment to protecting the interior and the car's turning circle required in order to draw more need to go a long way. Which case during cornering is seen through (Figure 2). This movement in turn providing diversity scheme is called the differential gear box (Figure 3).

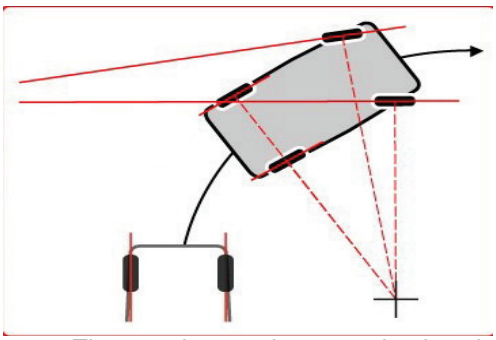


Figure 2. The way that you have to take the wheels during cornering

The investigations on damaged gears; two months after a study damaged a spur gear damage analysis studied the damage and the cause of the wrong cementation process from implementation stated that [5]. In the sprocket teeth of a spur gear system, hardness, wear, and on the effects of the reduction in thickness of the oil film under conditions of accelerated tests have performed experimental studies [6]. Metallurgical properties of the helical idler gear a diesel engine made from 20CrMnTi steel and causes of breakage was investigated [7]. While in another study of diesel trucks damaged crankshaft pulley hardness, the results of

microscopic and SEM observations and the results were evaluated [8]. The chemical composition, hardness, metallographic examination results of helical gears made from AISI 8620 steel of a bus are examined in terms of fatigue damage [9]. Material structure of damaged two helical gears are examined and the results are evaluated by microscopic and SEM analysis [10].

Figure 3. Differential gear box

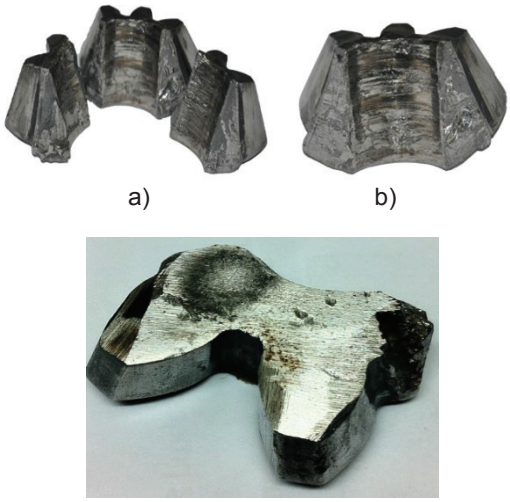
Figure 4. Axle and spider gear group

(Figure 3) and (Figure 4) show the differential gear boxes, axles and the spider gears. In this study, as seen in (Figure 5), the chemical composition, optical microscopy, hardness and damage analysis of broken, damaged spider and shaft on the study was conducted.

Figure 5. Broken spider gear and shaft

2. Material and Method

2.1. Spider Gear Failure Analysis



a) b) c)

Figure 6: The broken spider gears (a,b,c)

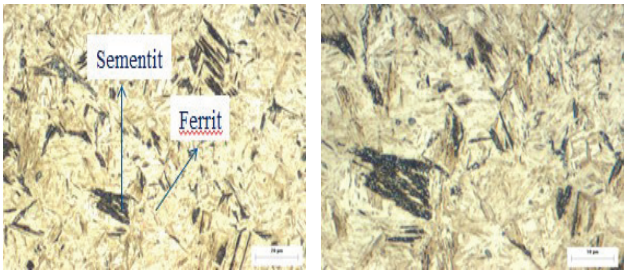
(Figure 6a, 6b, 6c) show broken spider gears which is used in the chemical analysis. Materials of broken spider gear and shaft which were applied for the detection and microstructure were examined. AISI 4145H alloy steel was determined after examinations of the spider gear about kind of material (Table 1). Hardness value was measured as 641.67 HV (Vickers) (Table 2).

Table 1: Spider gear spectral analysis

Damaged Spider Gear		AISI 4145H	
Fe	97,0	**Fe**	96,4 - 97,7
C	0,306	**C**	0,420 - 0,490
Si	0,164	**Si**	0,150 - 0,300
Mn	1,20	**Mn**	0,750 - 1,20
P	0,0173	**P**	≤0,0350
S	0,0287	**S**	≤0,0400
Cr	1,08	**Cr**	0,750 - 1,20
Mo	0,0124	**Mo**	0,150 - 0,250
Ni	0,0436	**Ni**	

Table 2. Spider gear mechanical properties

	Hardness (HV)
Damaged Gear	641,67
AISI 4145H	510



a) b)

Figure 7. Spider gear microstructure appearance: a) 500x, b) 1000x

Cementite and ferrite structures are seen through (Figure 7). The damaged structure is a part perlite and cross our gear. Eutectoid pearlite structure is a mixture containing 0.8% C and 723 C are formed by slow cooling. Ferrite and cementite in the form of a very thin layer or lamellar is formed from the mixture.

2.2. Spider Shaft Failure Analysis

Images of the spider shaft fractures is also observed at (Figure 8). The first sign of the cross shaft fractures associated with physical observations, it is exposed to extreme fatigue and shaft diameter as a result of the decrease in strength has been made in reducing effects observed on.

a) b)

Figure 8. Broken Spider Shaft (a, b)

The materials used in the star wheel shaft for detecting the applied chemical analysis and microstructure were examined. Examination of differential spider shaft material steel is AISI 4145H were observed (Table 3).

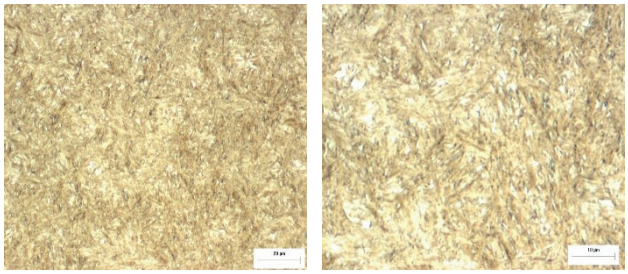
Table 3. Spider shaft spectral analysis

Damaged Spider Shaft		AISI 4145H	
Fe	97,1	**Fe**	96,4-97,7
C	0,302	**C**	0,420-0,490
Si	0,350	**Si**	0,150-0,300
Mn	1,07	**Mn**	0,750-1,20
P	0,0176	**P**	≤0,0350
S	0,0254	**S**	≤0,0400
Cr	0,954	**Cr**	0,750-1,20
Mo	0,0103	**Mo**	0,150-0,250
Ni	0,0386	**Ni**	

Hardness value was measured as 708,4 HV (Vickers) (Table 4).

Table 4. Spider shaft mechanical properties

	Hardness (HV)
Damaged Spider Shaft	708,4
AISI 4145H	510



a) b)

Figure 9. Spider shaft microstructure appearance: a) 500x, b) 1000x

3. Results and Discussion

Spider gear and spider shaft damage of differential gear box of a truck were investigated. Damage has occurred because of breakage of spider gear and spider shaft.

Metallographic studies and analysis result has been found that damage caused by fatigue. Fatigue crack began due to friction of spider gear with spider shaft.

Often used on slippery ground excavation of truck formed continuous loading and unloading on its spider gear and spider shaft. Therefore, spider gear and spider shaft have been broken because of fatigue.

4. References

[1] Isel, B., Gear pitting test device for developing and to investigate the effect of oil temperature, Master's Thesis, Afyon Kocatepe University Institute of Science, Turkey, 2007.
[2] Can, A.Ç., Design of Machine Elements, Birsen Publishing, İstanbul, 2006.
[3] Kızılaslan, K., Isel B., Yavuz İ., Damage to the types of gears, Electronic Journal of Machine Technology, 7, 119-129, 2010.
[4] Basaran, B., Experimental Investigation of Pitting Formation in Helical Gears, Master Thesis, Gazi University, Institute of Science, Ankara, 2001.
[5] Jonk, J., Slabbert, G.A., Analysis of a failed spur gear from a Vibro-Hammer, Engineering Failure Analysis, Volume 34, Pages 511-518, 2013.
[6] Amarnath, M., Sujatha, C., Swarnamani, S., Experimental studies on the effects of reduction in gear tooth stiffness and lubricant film thickness in a spur geared system, Tribology International, Volume 42, Pages 340-352, 2009.
[7] Yu, Z., Xu, X., Failure analysis of an idler gear of diesel engine gearbox, Engineering Failure Analysis, Volume 13, Pages 1092-1100, 2006.
[8] Yu, Z., Xu, X., Failure investigation of a truck diesel engine gear train consisting of crankshaft and camshaft gears, Engineering Failure Analysis, Volume 17, Pages 537-545, 2010.

[9] Asi, O., Fatigue failure of a helical gear in a gearbox, Engineering Failure Analysis, vol. 13, Pages 1116-1125, 2006.
[10] Fonte, M., Reis, L., Freitas M., Failure analysis of a gear wheel of a marine azimuth truster, Engineering Failure Analysis, Volume 18, Pages 1884-1888, 2011.