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Studies On Wear Behavior Of Shot Peened EN47 Steel Using Finite Element Method

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Abstract

This paper studies the effect of shot peening on wear life of the EN47 steel used mainly in agricultural applications. To examine wear, pin on disc apparatus is modeled and then finite element analysis is done for EN 47 steel pin and shot peened EN 47 steel pin under pressure ranges from 10 Mpa to 70 Mpa. Maximum and minimum values of von-misses stress and total deformation shows better values for shot peened EN47 steel pin.

Keywords: ***Pin on disc, Finite element analysis, shot peened EN47steel pin.***

1. Introduction

Wear is one of the important phenomenons in Tribology, study of a metal wear help us to predict failure in early stages. Pin on disc apparatus is used to determine wear of materials under non–abrasive conditions. Here pin specimen is pressed against the disk at specific load. Wear results are reported as length change or shape change of pin and the depth change disc in millimeter are determined. Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed. EN 47 steel has high tensile strength and toughness. Typical applications include crank shafts, steering knuckles, spindles, pumps, rotavators and gears.

The quenching and tempering process reduces the wear rate considerably and improved mechanical properties such as hardness, strength and percentage elongation significantly. Shot peening further reduced the wear rate of the EN 47steel if restricted to a certain peening intensity [1]. The finite element analysis made it possible to explain and reproduce phenomena observed during pin on disc experiments, showing that mass losses increased as the normal load increased [2]. Wear profile of pin made of Polyoxymethylene, in sliding contact with rotating disc was performed using finite element analysis under at Different operating conditions of contacts pressure, sliding distances and sliding speeds without considering frictionally induced heat taking into account [3]. The finite element results of deformation and equivalent stress concluded that when the length of the pin decreases the deformation decreasing and equivalent stress is increasing. When the load exceeds tensile yield strength of the material then the material is failed under circumstances [4].

2. Finite element Analysis

The pin on disc model made by using the Ansys workbench. Then static structural analysis is carried out by defining pin material as EN 47 steel, pin holder and disc as stainless steel. Then fine meshing of model results in 62941 nodes and 39079 hex 20 elements to the entire geometries. The meshed view is shown in figure 1. The boundary conditions for pin on disk analysis are followed, pin outer face displacements in the x, y direction is fixed and z direction is free. Likewise for outer face of disc displacement in the x, y direction is free and z direction is fixed. The pressure is applied on the top face of the pin ranges from 10 MPa to 70 Mpa. Along with that a rotational velocity of 50 rad/Sec (3000rpm) is provided for the hollow disc in the z direction, for the rotation of the disc and this is clearly given in Figure 2. When the pressure is applied on the top face of the pin holder, maximum and minimum value of von-misses stress, total deformation are noted and portion of failure noted too.

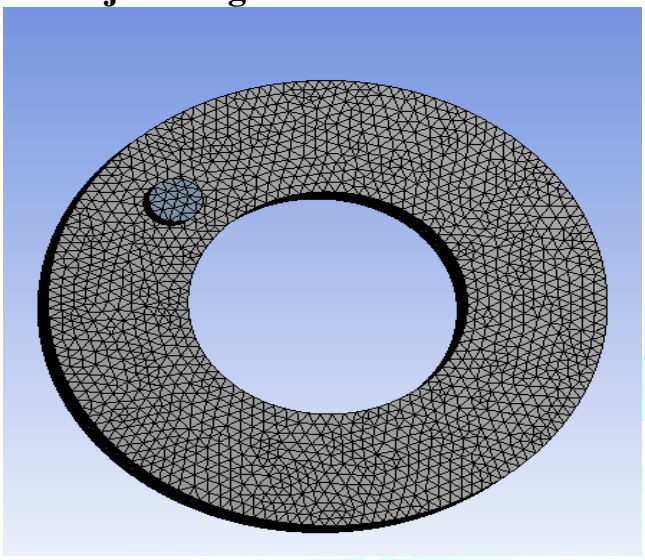

Figure.1. Meshed view of Pin on Disc Assembly

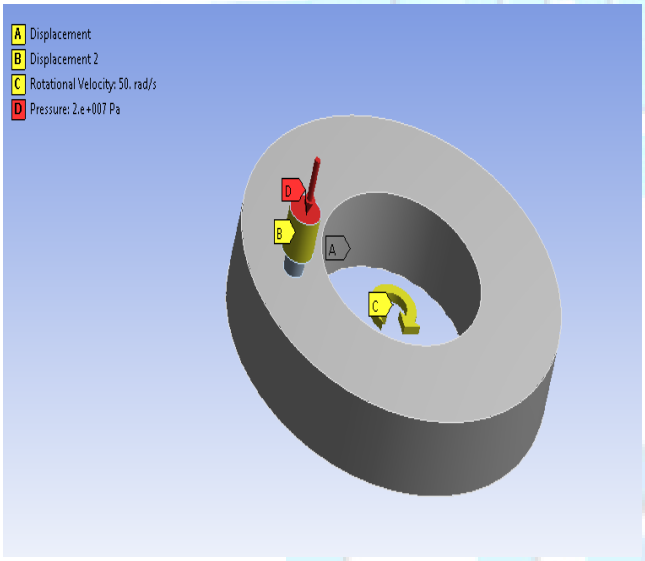

Figure.2.Boundary Conditions of pin on disc analysis.

It is repeated for the same model from 10 MPa to 70 MPa in steps of 10 MPa, it results in the seven analysis. When the initial setup is analysed, we got from the analysis that some portion of the pin showing the maximum equivalent stress. We assume that portion is worn out. Then removing those elements, we have no provision for measuring the length of the failed elements of pin by this software. So it is necessary to make 5 models, then all these results in 35 experiments.

3. Results and Discussions

Using the ANSYS Workbench software, along with the boundary conditions, 10 MPa pressure is given, then we got a value for this pressure, von-misses stress contour & deformation obtained at a length of EN47 steel pin without shot peening 2.54mm, 10MPa, and 50 rad/sec is given in the figures, fig. 3.1, 3.2. At the tip of the pin is having the maximum stress value and the maximum deformation is obtained at the portion where the pin holder and the pin is bonded. At the maximum pressure of 70 MPa, the value of maximum equivalent stress as 186.32 MPa and maximum deformation as 11.78 µm

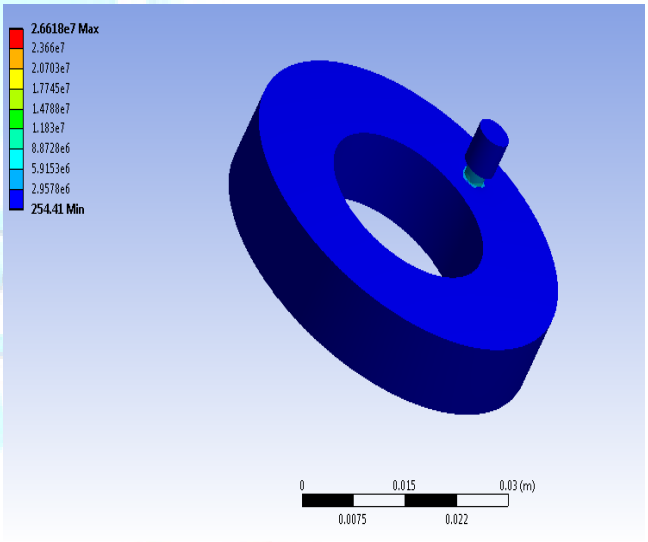

Figure.3.1. Von- Misses stress of EN47 steel pin without shot peening for 10 Mpa Pressure

Along with the boundary conditions, 10 Mpa pressure is given then we got a value for this pressure, the values are noted. Assumed that 0.5 mm of the length of the pin is worn out, and the model used here is having the length of the pin as 2.00mm. The value means the equivalent (von-Mises) stress and deformation. Then the maximum and the minimum value is noted and the portion where it's value is obtained, like that 1.50mm, 1.00mm and 0.5mm length was given as the length of the pin and the values of these 35 analyses were done. While considering that, about 2.00 mm of the length of the pin is worn out, and the model used here is having the length of the pin as 0.50 mm. The value means the equivalent (von-Mises) stress and deformation. Then the maximum and the minimum value is noted and the portion where it's value is obtained, i.e. some portion of the pin showing the maximum equivalent stress. Then the stress contour stress & deformation

obtained for EN47 steel with shot peened 2.54mm, 10MPa, and 50 rad/sec is given in the figure 3.3. Here also the tip of the pin is having the maximum stress value and the maximum deformation is obtained at the portion where the pin holder and the pin is bonded and especially in the face of the pin where pin holder and the pin is bonded as earlier. At maximum pressure of 70 MPa, we got the value of maximum equivalent stress as 186.32 MPa and maximum deformation as 2.57 µm.

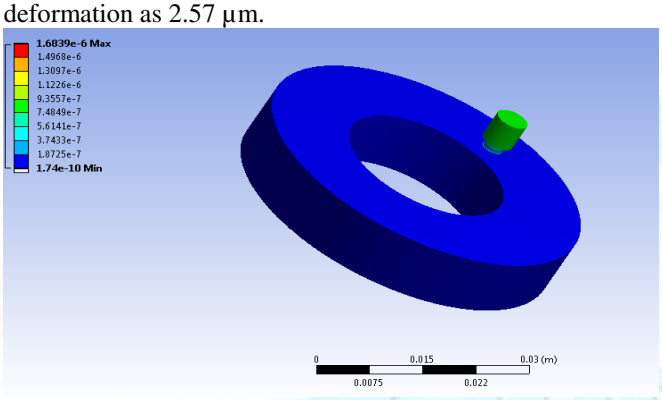

Figure.3.2. Total Deformation of EN47 steel pin without shot peening for 10 Mpa Pressure

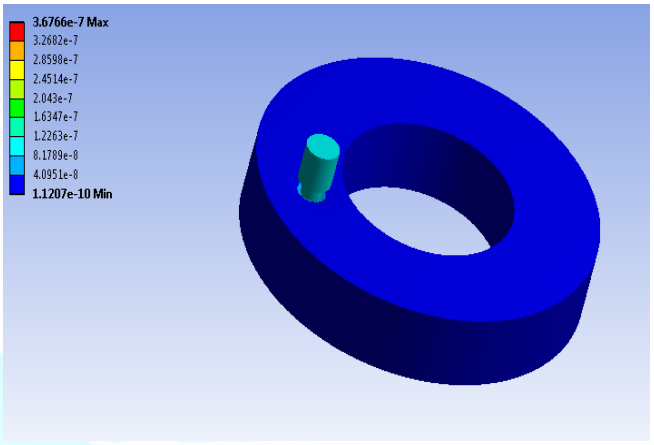

Figure.3.3. Total Deformation of EN47 steel pin with shot peening for 10 Mpa Pressure

In comparison of 6150 steel pin without shot peening and with shot peening, the analysis shows that 6150 steel with shot peening shows better results than without. The analysis results of wear simulations are tabulated in table 1 and table 2.

Table 1. Maximum equivalent stresses and deformations obtained for the model when length of 6150 steel pin (without shot peening) and pressure varied from 2.54mm to 0.50mm and 10 to 70 MPa respectively at 50 rad/sec

Length of Pin (mm)	***Results***	***Pressure (Mpa)***						
		10	20	30	40	50	60	70
2.54	Equivalent Von misses (Mpa)	26.61	53.23	79.85	106.47	133.09	159.71	186.32
	Total Deformation (µm)	1.68	3.36	5.05	6.73	8.41	10.12	11.78
2	Equivalent Von misses (Mpa)	23.48	47.67	72.89	99.43	122.78	143.88	168.45
	Total Deformation (µm)	3.16	5.98	7.02	8.78	9.96	11.25	13.76
1.5	Equivalent Von misses (Mpa)	21.32	43.21	64.51	86.74	112.41	130.69	153.46
	Total Deformation (µm)	4.72	9.43	12.43	15.56	17.87	19.91	20.84
1	Equivalent Von misses (Mpa)	19.87	40.9	61.53	84.21	105.87	127.66	146.93
	Total Deformation (µm)	6.26	10.13	13.51	15.17	18.49	20.10	22.16
0.5	Equivalent Von misses (Mpa)	18.63	35.83	54.12	83.19	102.34	121.98	140.62
	Total Deformation (µm)	7.92	12.56	15.89	17.97	19.15	22.53	24.48

Table 2. Maximum equivalent stresses and deformations obtained for the model when length of 6150 steel pin (with shot peening) and pressure varied from 2.54mm to 0.50mm and 10 to 70 MPa respectively at 50 rad/sec

Length of Pin (mm)	*Results*	*Pressure (Mpa)*						
		10	20	30	40	50	60	70
2.54	Equivalent Von misses (Mpa)	26.61	53.23	79.85	106.47	133.09	159.71	186.32
	Total Deformation (µm)	0.36	0.71	1.1	1.46	1.83	2.2	2.57
2	Equivalent Von misses (Mpa)	23.48	47.67	72.89	99.43	122.78	143.88	168.45
	Total Deformation (µm)	0.52	0.89	1.26	1.54	1.92	2.33	2.61
1.5	Equivalent Von misses (Mpa)	21.32	43.21	64.51	86.74	112.41	130.69	153.46
	Total Deformation (µm)	0.65	0.97	1.34	1.67	1.98	2.42	2.71
1	Equivalent Von misses (Mpa)	19.87	40.9	61.53	84.21	105.87	127.66	146.93
	Total Deformation (µm)	0.74	1.04	1.41	1.74	2.05	2.56	2.79
0.5	Equivalent Von misses (Mpa)	18.63	35.83	54.12	83.19	102.34	121.98	140.62
	Total Deformation (µm)	0.82	1.09	1.49	1.81	2.12	2.65	2.91

4. Conclusion

The experimental setups are modeled in Ansys workbench part modeler who is very essential for these analyses. It is successfully imported into ANSYS Workbench. When the pressure increases from a value of 10 Mpa to 70 MPa, the corresponding maximum equivalent stresses are increased, at the same time some portion of the bottom face of the pin results the maximum value. Found out that some elements of the pin will fail first. When the pressure increases from a value of 10 MPa to 70 MPa, the corresponding maximum deformations are increased, at the same time some portion of the top face of the pin results the maximum value. When the pin starts wearing out, then the maximum value of the equivalent stresses are increased, it may due to the decrease in area. When the pin starts wearing out, then the maximum value of the deformation are decreased, it may due to the decrease in length. What we observed is based on deformation the EN47 steel without shot peening shows poor results on compared with shot peened one. So the shot peening process will increase the wear life of steel. In the future the same work is preceded by experiments in order to find tribological characters and fatigue properties.

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