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ARB Life Improvement By Improvement in the Current Shot Peening Method

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Abstract— The ARB is widely used in automobiles and one of the major components of suspension system. It needs to have higher fatigue life. The ARB regarded as a safety component as its failure will lead to severe accidents and toppling of vehicle. The purpose of this paper is to predict the methods to improve the fatigue life of ARB by improvement in the shot penning process.
Keywords— ARB, stabilizer bar, Shot peening, measurement of compressive stress, residual stress, fatigue life, X ray diffraction

I. INTRODUCTION

ARB or stabilizer bar is used for preventing vehicle roll and for satisfactory handling characteristics. These are laterally mounted torsion springs which resist the vertical displacement of wheels relative to one another. The ARB only comes into effect when there is some vehicle roll or vehicle is taking a turn.

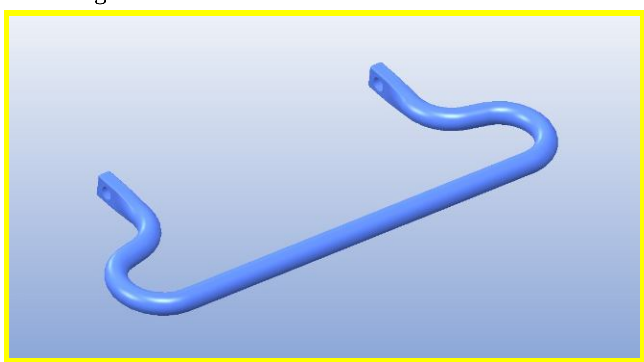

Fig no1: Anti Roll Bar model

Vertical roll rates are not increased when both wheels are deflected simultaneously. However stiffness is increased for one wheel bump. Vehicle suspensions, tuned to give a soft ride with low rate springs, use stabilizer bars to reduce vehicle roll with only a minor deterioration of ride. Heavy vehicles and off road vehicles use stabilizer bar at front for improving the roll resistance.

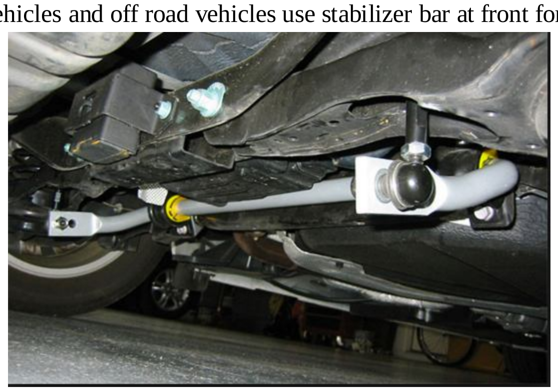

Fig No2: Fitment picture of ARB on vehicle

The common failure modes for ARB are
Breakage from bend radius
Breakage from Eye
Breakage from center

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The primary cause of the failure mode point 1 and 3 are higher stress on the ARB, which is caused due to high speed turning and road irregularities. The usage of ARB material is limited considering material availability for mass production and its cost impact on vehicle and customer. The manufacturing procedure of ARB starts with cutting the required length rod from steel bars which are procured from steel mills. The later procedure is as follows: Heating, forging, punching/machining of eye hole, heating and bending quenching, normalizing, shot peening, assembly, inspection, marking, and packaging and dispatch .Here in this paper we limit our discussion only to ARB life enhancement due to shot peening. Also the optimization of shot peening process to further improve the life of ARB.

II. SHOT PEENING PROCESS

Shot peening is a cold working process that imparts a small indentation on the surface of a part by impacting small spheres or steel wire cut called shot onto the material surface.

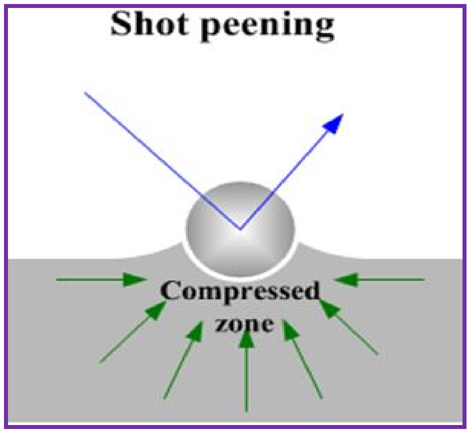

Fig No 3: Steel Ball Impact on Surface in Shot Peening

The material directly beneath it is subjected to high compressive forces from the deformation and tries to restore the outer surface to its original shape. By overlapping the surface indentations, a uniform compressive layer is achieved at the surface of the material. The compressive layer squeezes the grain boundaries of the surface material together and significantly delays the initiation of fatigue cracking. As a result, the fatigue life of the part can be greatly increased.

A graph for high carbon steel component with and without shot penning is shown below.

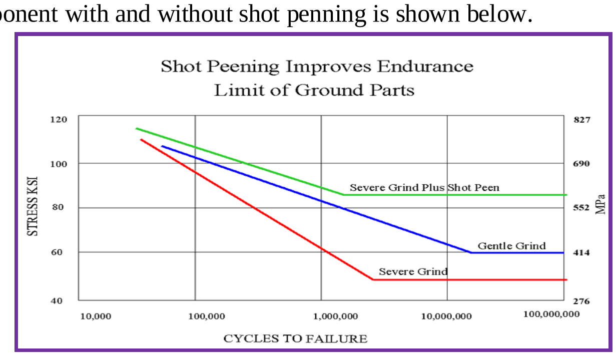

Fig no 4: Stress v/s cycles of life

Shot penning benefits:

Shot penning improves all the below mentioned factors

Enhances fatigue strength

Improves ultimate strength

Prevents cracking due to wear

Prevents hydrogen embrittlement

Prevents corrosion

III. CURRENT SHOT PENNING PROCESS AND MEASURING METHOD

Below mentioned parameters were studied (which are having a proportionate relation with the intensity of shot penning).

Size of shot

Hardness of shot
Coverage of shot penning
Angle of impingement
Exposure time
Measurement of Shot Penning

In the current shot penning method ARB were shot peened by cut wire shots. The cut wire shot have more impact strength and the compressive stress induced is more than that induced due to steel balls. Sometimes two stage peening is done to improve the penning intensity. The cut wire shots are made from carbon steel material having hardness in the range of 45 HRC.

The requirement of shot penning coverage is it should be minimum 90 percent. As the ARB is round shape the coverage is not uniform all round. The ARB was hung vertically on a rotating table. In the current process the shots were fired at 45 deg. to the ARB surface to have maximum impact. The coverage area and shape of the sample determines the exposure time.

The intensity shot penning is currently measured by Almen strip of thickness as per A or C scale. The Almen strip is placed in the ARB conveyor and exposed to steel shots. To prevent movement the almen strip is supported in a fixture with two points or four point support. Due to penning the flat strip deforms and takes the shape of cambered surface. The camber in the Almen strip is measured and compared with the acceptance limit given on the ARB drawing.

This method is not accurate method of measuring the residual stress as it indirectly indicates the residual stress. Also it involves the human error in placing and measuring the camber of the strip. Also the ARB exposed surface to penning is round surface where as the almen strip surface is flat surface. So the result measured from the almen strip is not accurate. To measure the residual stress directly on the rod the more accurate method available is by X-ray diffraction method.

IV. PROCESS IMPROVEMENT AND TESTING

Preliminary study is focused on the existing component and high stress zone and residual stress is measured for existing ARB. One ARB assembly which is used in commercial vehicle is selected for analysis. Some samples of this ARB which are manufactured with the existing process are taken for analysis. Also the subject ARB model is given for CAE analysis and area of high stress are identified.

Fig No 5: Stress Pattern in ARB

One high stress location is identified for compressive stress analysis. Two such samples are prepared by cutting pieces from steel bars at the above location. The compressive stress due to shot penning will increase from the surface of ARB to the center .To determine the pattern of compressive stress increase we have to take measurement at different depths. The measurement was taken at 5 different depths to identify the location of highest residual stress and impact of current shot penning process on the ARB.

Details of requirement of measurement are mentioned below:
No. of location fixed for measurement: one
No. of readings to be taken at each location: 3 readings.
Depth of measurement: Residual stress to be measured at 5 different depths as given below.
On surface
At 0.03mm below surface
At 0.05mm below surface
At 0.1mm below surface

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At 0.2mm below surface

Different depth were achieved by removing material by electro corrosion method. For ease of identification all the reading on the sample manufactured by existing method is denoted as Reading 1. Residual stress on the cut piece is measured on X-Ray diffractometer.

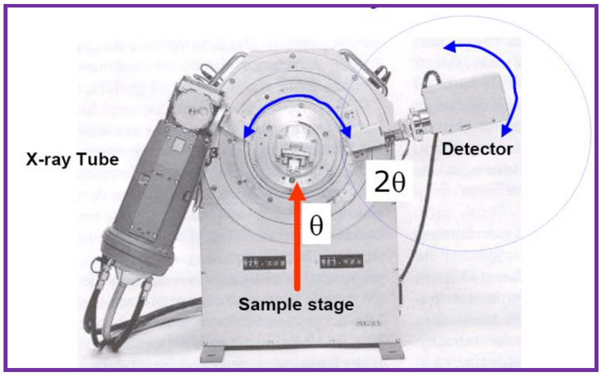

Fig No 6: X-ray Diffractometer

Location	Residual stress (Mpa)	
	Sample 1	Sample 2
On surface	-387	-373
0.03mm below surface	-557	-480
0.05mm below surface	-694	-600
0.1mm below surface	-609	-678
0.2mm below surface	-368	-678

Table no 1: Residual stress measurement (Reading 1)

Negative sign indicates the stress are compressive in nature. Here the intensity of the shot penning is measured on the surface and some distance beneath the surface to understand the peak value and its location. Also the average value of shot penning can be predicted on the surface and can be linked to life enhancement of ARB. From the measurement it was found out that the compressive stress is not adequate at the surface. The minimum stress for sample one and two comes below 400 Mpa. Requirement of compressive stress at the surface is 500 Mpa (min).

To increase the compressive stress on the ARB the shot penning process is studied again. Considering the constraint of the existing machine below mentioned changes were suggested to the ARB supplier.

Increasing the velocity of shot

Sieve analysis of the shot size before feeding them to machine.

Increasing the exposure time of the ARB to steel shots

Measurement of shot peening by X ray diffraction method

It was found that it is very difficult to increase and control the velocity, so this option is discarded. Due to continuous usage of steel shots the size of steel shot detoriates over time. So the sieve analysis is required before feeding of shots for penning. Also required volume of new shots were added to have same intensity of coverage. Also different exposure time were checked to arrive at optimum exposure time. Different iterations were done manipulating above parameter and measurements were taken after each iteration for arriving new value of above parameter. After the modification in the process parameters two sample cut piece of the ARB were taken after shot penning and given for residual stress measurement. Also the reading on the sample manufactured after process modification is mentioned as Reading 2.

Location	Residual stress (Mpa)	
	Sample 1	Sample 2
On surface	-548	-516
0.03mm below surface	-603	-582
0.05mm below surface	-637	-608
0.1mm below surface	-656	-621
0.2mm below surface	-490	-392

Table no 2: Residual stress measurement (Reading 2)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Comparing both the result, it is clear that the compressive residual stress at surface is increased by approx. 10 percent, which will improve the fatigue life and ultimate strength of the ARB. Some ARBs were manufacture by the improved process and fitted on vehicle for further trial. Also new method of measurement of shot penning is added as a periodic checking parameter for ARB manufacturing.

V. CONCLUSION

The process control for shot penning can not only be ensured by Almen strip measurement, some alternate method of measurement is require at supplier end for direct co relation of shot penning with compressive residual stress.

With improvement of exposure time, addition of sieve analysis process the residual stress on the ARB surface increases.

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