ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017

Impact of shot peening process on the Fatigue life of a Dissimilar Metal Welded Joint

Harish.A
Department of Mechanical Engineering,
B.N.M.Institute of Technology,Bangalore,India

Abstract: A dissimilar welded joint finds its prominence in high temperature applications and has better corrosion resistance. Whereas the welding process induces residual tensile stresses that are detrimental to fatigue life. Tensile stresses act to stretch or pull apart the surface of the material. With enough load cycles at a high enough tensile stress, a crack is initiated. Significant improvement in fatigue life can be obtained by modifying the residual stress level in the material. The intent of this project is to measure fatigue life and surface hardness of butt welded joint with dissimilar materials. The surface modification method employed is shot peening method which is simple, yet effective to improve the fatigue life of the joint. In this study an investigation is carried out into the effect of shot peening upon improvement in the fatigue strength and hardness of the welded joint.

Keywords: Welded joint,hardness,Fatigue life,Shot peening

I. INTRODUCTION

The welded joints may be of similar or dissimilar metal type. The similar metal welds are used in applications where the temperature remains constant throughout. Whereas problems like corrosion arise under high temperature applications. Thus in order to tackle this we make use of dissimilar metal welded joints. Dissimilar metal joints are used in various engineering applications such as steam power plants, pressure vessels, nozzles, nuclear power plants, coal fired boilers and automobile manufacturing. Dissimilar metals welded joints are mainly used in high temperature application.

Shot peening is a cold working process used to increase the fatigue properties and hardness of metal components. During the peening process, the surface of the component is bombarded with small spherical media called a shot. Overlapping dimples develop a uniform layer of residual compressive stress in the metal. Hence the cracks will not develop in a compressively stressed zone. Since nearly all fatigue failures originate at the surface of a part, compressive stresses induced by shot peening provide considerable increase in part life. When controlled properly, all the surface area which is susceptible to fatigue crack initiation, is encapsulated in a uniform layer of high magnitude compressive stress. An added benefit of this method is the increase in hardness of the weld. It also helps to reduce any porosity present, allows the system to work under higher stress levels, and produces a uniform textured surface and so on. Since the welded joints need to withstand high stresses and loads, modification processes like shot peening helps us to reduce the tensile stresses, which in most of the cases is the root cause for the failure of the joint. The main objective here is to increase the fatigue life of the system. The Residual stresses play an important role in deciding the fatigue life. Residual stresses tensile in nature reduce the fatigue life whereas residual stresses compressive in nature increase the fatigue life. During heating, the compressive residual stresses are developed in the region of base metal which is being heated for melting due to thermal expansion. This expansion is restricted by the low temperature surrounding base metal. Once the melting starts these compressive stresses gradually reduce. During cooling as the metal starts to shrink, tensile residual stresses develop and their magnitude keeps on increasing until the room temperature is attained. Thus the residual stresses are a part of any welded system. When we apply bending or torsion loads the tensile stresses are very high at the surface of the material. The failure of the weld by the tensile stresses takes place by crack nucleation and their propagation under tensile loading conditions, therefore presence of tensile residual stresses in combination with external tensile loading reduces the fatigue life. While compressive residual stresses under similar loading conditions reduce the net stresses and so discourage the failure tendency. Hence, compressive residual stresses are induced intentionally. There are various methods through which we can induce the compressive stresses into the system. One such method is the shot peening method

II. EXPERIMENTAL DETAILS

In this work, a mild steel plate and stainless steel plate of thickness 4 mm is used. The chemical composition of Mild steel and stainless steel is shown in Table 1 and Table 2 respectively. A single V-joint with bevel angle 35 degrees and root face 3 mm is prepared. The plates are butt-welded

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE)
Vol 2, Issue 5, May 2017

by shielded metal arc welding process with E-6013 electrode, ensuring good surface finishing conditions. In order to join MS to SS, Stainless steel 304L wire is used as filler material

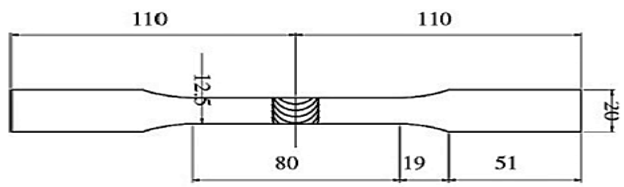


Fig 1: Dumbbell Specimen prepared for experimental testing

C	Mn	Si	P	S	Fe
0.05-0.18%	0.7-0.9%	0.40% max	0.04% max	0.04% max	Balance

Table 1: Composition of Mild Steel

C	Mn	Si	P	S	Cr	Mn	Ni	N	Fe
<0.03%	<2.0%	<0.75%	0-0.045%	<0.03%	18-20%	2-3%	8-12%	<0.1%	Balance

Table 2: Composition of Stainless Steel

The Test specimens of plate thickness 4 mm × width 20 mm × length 110 mm as shown in fig 1 were employed and were subjected to butt welding under the following welding conditions: welding current 180 A, arc voltage 21 V, welding speed 1100 mm/min and weld width 3 to 4 mm, while the plate was restrained and continued to be restrained for 30 min following the completion of welding. Hardness is the ability of the material surface to resist abrasions, scratching and cutting. Here we make use of Rockwell hardness testing equipment to find the hardness. Rockwell hardness tester presents direct reading of the hardness number on a dial provided in the machine. There are many scales having different combinations of load and size of indenter. Here the indenter has a diamond cone at the tip and applied force is of 150 kgf. In this test we make use of scale 'A' and a diamond indenter. To start off, the specimen is first placed on the anvil surface. Then the indenter ball is brought in contact with the specimen surface. Pull the load release lever and wait for 15 seconds and a load of 60 kgf is applied by means of this load lever. Note down the reading and repeat the experiment at different points on the specimen surface. The value of hardness is the average of these values obtained.

The fatigue test is conducted here using a rotating fatigue testing machine TM7001. The fatigue specimen is gripped on to a motor at one end to provide the rotational motion. Whereas the other end is attached to a bearing and also subjected to a load or stress. When the specimen is rotated about the longitudinal axis, the upper and the lower parts of the specimen gauge length are subjected to tensile and compressive stresses respectively. Therefore, stress varies sinusoidally at any point on the specimen surface. The test proceeds until specimen failure takes place. The number of cycles for which the specimen withstands the load without any failure is noted down. This cycle is known as fatigue strength of given specimen. The revolution counter is used to obtain the number of cycles to failures corresponding to the stress applied. At the fatigue endurance limit, there will be a certain value of the cyclic stress where specimen failure will not occur. This cyclic stress level is called the fatigue strength.

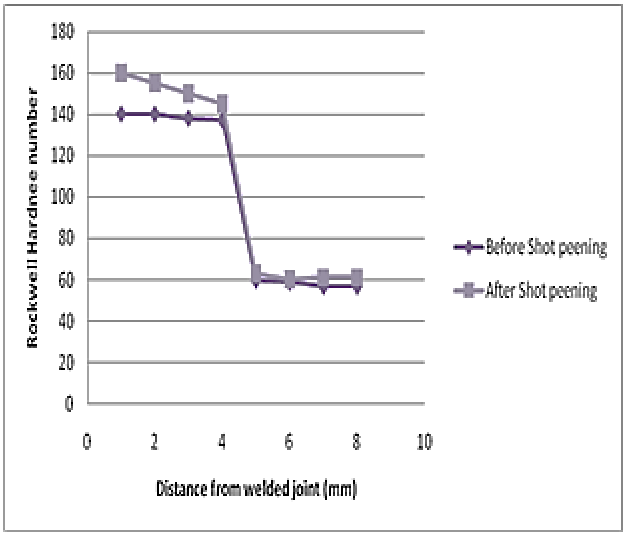
The specimen on which Shot peening is to be performed is placed on the machine fixture and S330 type shot ball of diameter ranging from 0.7 to 1.20 mm is made to strike with velocity of 47 m/sec at an angle of 45 ° on the specimen for 25 sec at an intensity of 0.53 mm.

III. RESULTS AND DISCUSSION

The shot peening method is employed as it helps the welding joint in many ways. This method introduces compressive stresses onto the surface of the joint. From the graphs plotted above it can be observed that the hardness and the fatigue life of the joint have improved significantly. When the hardness increases the resistance offered to wear increases. One of the main reasons for fatigue failure is due to the lack of plasticity. That is why compressive stresses are introduced. The metal surface is shot with high velocity particles so that a layer of plastically compressed material is formed to a certain depth. This reduces the magnitude of tensile stresses and also cracks don't initiate in a plastic environment.

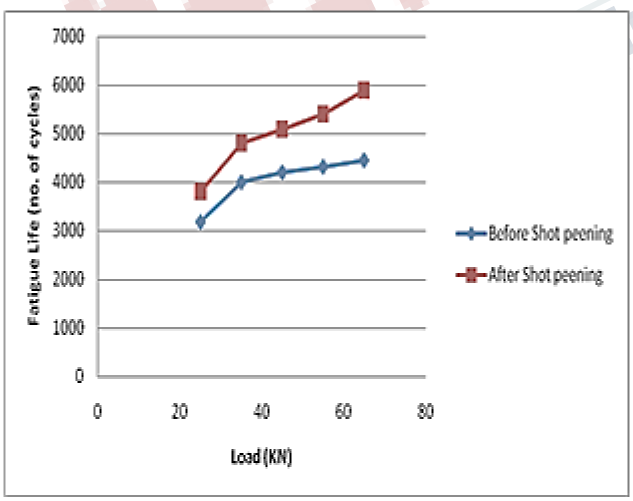
In Graph 1 it can be observed that the value of hardness has increased after the shot peening process. This is because of work hardening. The hardness increases because of plastic deformation. At a distance of 1mm from the welded joint the hardness value has increased from 140 to 159.Similarly this increase can be noticed at all the points.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 5, May 2017



Graph 1: Effect of shot peening on Hardness

Let us look at some of the variations in the Graph 2.The value of fatigue life before shot peening at load 35kn is found to be 4000 cycles and after shot peening the fatigue life is increased to 4800.This increase in fatigue life can be found at different load conditions. Thus hardness and fatigue life has increased significantly after shot peening.
The shot peening method is employed as it helps the welding joint in many ways. The experimental results have also shown that the Residual stress before shot peening was found to be 3.75Psi while after shot peening was found to be -910.8Psi.



Graph 2: Effect of Shot peening on Fatigue life.

The microstructure of different specimen by using Scanning electron microscope (SEM). Images and X-ray diffraction pattern are shown and discussed as below:

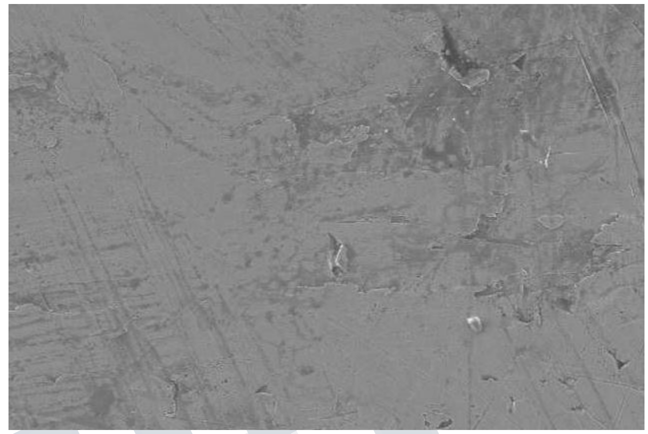


Fig 2: Microstructure of MS to SS specimen before shot peening

It is observed from Fig 2 and Fig 3 that the toughness of surface increases after shot peening process. Fig 2 Fig 3shows the microstructure of MS to SS specimen before and after shot peening simultaneously. It is observed that the first fig has smooth surface than second one which shows that the roughness increases after shot peening

IV. CONCLUSIONS

Conclusions are drawn based on the results obtained from experimental methods are summarized as follows:-
1. The welding processes create residual tensile stresses; which is detrimental to fatigue life these stresses can be reduced through shot peening process.
2. With the shot peening treatment the welded joint fatigue strength is significantly improved.
3. With shot peening treatment the welded joint surface hardness is significantly improved.

V. REFERENCES

[1] Mark S. Molzen and Doug Hornbach, Evaluation of Welding Residual Stress Levels Through Shot Peening and Heat Treating.

[2] Sylvain Chataigner, Lamine Dieng, Kevin Guit and Michel Grasset, Improving welded joint fatigue life using shot peening or grinding, France, Jan 2013.

[3] M Hasegawa and H Suzuki, Improvement of the fatigue strength of aluminum alloy welded joints by high hardness and large specific gravity shot peening, Welding International, Volume 19, 2010.

[4] Manoj Saini, Navneet Arora, Chandan Pandey and Husain Mehdi, Mechanical properties of bimetallic weld joint between sa 516 grade 65 carbon steel and SS 304 l for steam generator application, 2014.

[5] Xiaohua Cheng1, Henry J. Prask, Thomas Gnaeupel Herold, Vladimir Luzin4, and John W. Fisher, Neutron Diffraction Measurements for Residual Stresses in AL-6XN Stainless Steel Welded Beams.

[6] M.H. (Johnny) Johnson, Fatigue life improvement Techniques for welds, Process Barron Alabama.

[7] Vinod M. Bansode and N. D. Misal, Fatigue life estimation of a butt welded joint by s-n approach, College of Engineering, Pandharpur, India, 2012.

[8] Baptista R., Infante V., and Branco C.M., Experimental and Numerical Analysis of Fatigue Life Improvement Techniques in Welded Joints of Stainless Steels, Lisbon, Portugal.

[9] B. Mvola, P. Kah and J. Martikainen, Dissimilar ferrous metal welding using advanced gas metal arc welding processes, Finland, 2014.

[10] N. S. Rossini, M. Dassisti, K. Y. Benyounis and A. G.Olabi, Methods of Measuring Residual stress components Ireland