IJARSE
ISSN 2319 - 8354

IMPLEMENTATION OF VIBRATORY STRESS RELIEF FOR DOMESTIC LPG CYLINDER USING ELECTRO-DYNAMIC SHAKER

Ms. A. A. Patil[1], Dr. S. S. Lakade[2]

[1]PG student, Mechanical Design Engineering, [2]Head of Mechanical Department,
Pimpri Chinchwad College of Engineering, Pune, (India)

ABSTRACT

Stress relieving process plays an important role in manufacturing of Liquid Petroleum Gas cylinders. Paper describes techniques and parameters of VSR for LPG domestic cylinder where process cost, dimensional stability and durability are the essential features. A setup is designed for the process and an Electro-Dynamic shaker has been used to provide vibrations. Residual stress change is found with the help of X-ray Diffraction method. ANSYS is used for the calculation of natural frequencies. It has been proven that the process gives stabilization results comparable with thermal stress relief treatment, whilst being quicker and cheaper. The technique offers many advantages without alteration in dimensions and processes such as welding, deep drawing, bending etc involved in manufacturing.

***Keywords:* ANSYS, Electro-Dynamic Shaker, Thermal Stress Relief, Residual Stresses, Vibratory Stress relief, X-ray Diffraction**

I. INTRODUCTION

Over the last few decades, vibratory stress relieving has evolved from a little known art into an indispensible basic process, which is now a well tried and established alternative to thermal treatment for the treatment of casting, fabrications, component requiring intricate machining operations and non-ferrous metals[4]. Particularly, during this dissertation work an innovative step for stress relieving in LPG cylinders by vibration instead of annealing process is carried out. Although total stress relief is almost impossible to obtain by using any commercial process, vibratory stress relieving can stabilize and stress relieve the component at any stage of manufacturing or machining process without changing the materials metallurgical condition, without scaling or discoloration and without any distortion at low cost and with minimal time restraints to the manufacturer.

Work done up till now in the field of vibratory stress relieving technique is mostly concerned with the huge (thousands and tones of weight) component. The method used for such purposes is use of eccentric motors directly attached to components to provide vibration but this method will not be appropriate for the small (say up to 50kg) and complicated structure. At the same time, for such components thermal stress relieving technique will not be economical therefore for such components a setup is need to be developed, by which a component can be easily vibrated for required frequencies to release induced residual stresses. For this work LPG cylinder is taken for vibratory stress relief rather conventional method of annealing process. An electro-dynamic shaker has been used to provide necessary vibrations. To measure the stress relief residual stresses are measured before and after the VSR process. ANSYS as well as electro-dynamic shaker used to calculate the natural frequencies.

II. HISTORICAL OVERVIEW

During World War II, Germans were facing severe shortage of large size castings and turned to fabrication methods to meet their demands. However, because of the absence of proper heat treatment facilities, these components could not be stress relieved because of their large sizes. The Germans soon discovered that their fabrications transported via truck between their shops displayed superior dimensional stability as compared to those fabrications that were processed in the same or adjacent workshops. As war progressed, this method of '*transport after fabrication'* became the standard method for processing of large size fabrications.

After this observation, they made transportation after fabrication a standard procedure. There was also a well-known experience by the US navy in 1943, when they observed that the jigs and fixtures were stress relieved and more stabilized due to the movement of ship in sea when they were transported in them [5].

Almost two centuries ago hammer relaxation techniques were used to stress relieve metal pieces, in which repeated hammer blows were applied to produce high amplitude, gradually decaying vibrations.

III. VSR – MECHANISM AND TYPES

In the VSR process, the component is isolated from extraneous forces or vibrations using anti-damping mechanisms such as rubber cushions. This setup is then subjected to controlled vibrations, which may be imparted to the system using an eccentrically loaded variable motor along with a speed controller, which is used to scan the active frequency in real time.

Depending upon the size of the components, there are two types of setups to impart vibrations to the component. If the structure is sufficiently large, the vibrator can be clamped directly onto it. The motor is then energized to vibrate the component. In the case of smaller components, the stressed body can be placed upon a table, which is isolated with anti- damping mechanisms and the vibrator is then attached to the table top [5].

Two major hypotheses are used to explain the mechanism stress relief using vibratory techniques. One hypothesis draws an analogy between vibratory and thermal methods by relating it to atomic displacement that builds up the crystal lattice:

"The low—frequency vibrations are supposed to impart sufficient energy to the atoms to enable them to take up new positions. This theory based on internal friction can presumably be applied to materials that display a pronounced tendency towards natural aging [5]."

The second hypothesis related stress relief with the process of plastic deformation:

"During vibration treatments, the combined residual and cyclic stresses exceed the yield point of the material, resulting in residual stress reduction by plastic deformation [5]."

The three main types of VSR processes used are Resonant-VSR (R-VSR), Sub-Resonant VSR (SR-VSR) and Sub-Harmonic VSR (SH-VSR). The only common denominator between the three processes is that in each method, the component to be treated is isolated from the surroundings and is then subjected to cyclic vibrations, the effect of which is monitored in real time [6].

International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue 08, August 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

IV. ANALYTICAL APPROACH

In this section, analytical process has been discussed. Firstly, two samples taken from LPG cylinder for vibration testing. One sample was used for the measurement of residual stresses using X-ray diffraction and on other sample Resonance vibration testing was done. Success of the technique initially was calculated by measurement of residual stress change in sample. As the residual stresses within sample was calculated before and after the vibration test. Fig.1 shows the sample taken for testing of residual stress.

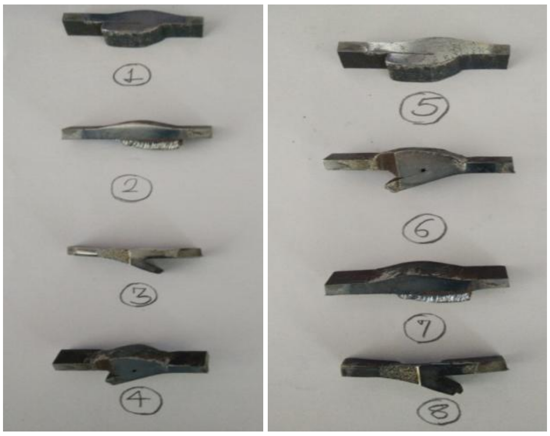

Fig.1: Sample for Residual Stress

X-ray Diffraction (XRD) is a high-tech, non-destructive technique for analysing a wide range of materials, including fluids, metals, minerals, polymers, catalysts, plastics, pharmaceuticals, thin-film coatings, ceramics, solar cells and semiconductors. Throughout industry and research institutions, XRD has become an indispensable method for materials investigation, characterization and quality control. Example areas of application include qualitative and quantitative phase analysis, crystallography, structure and relaxation determination, texture and residual stress investigations. Measurements were done in Metallurgy Department, IIT Powai. Fig.2 shows X-ray diffraction equipment.

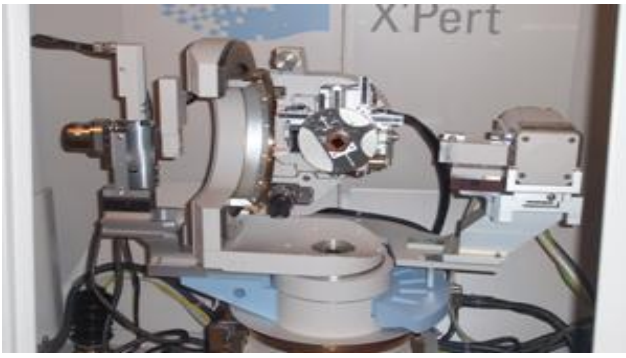

Fig. 2: X-ray Diffractometer.

Before and after vibration testing sample checked for stresses and the result is presented in tabular format as below:

Table I Residual Stresses

Sample No.	Residual stresses before VSR (MPa)	Sample No.	Residual stresses after VSR (MPa)
1	-732	5	-338
2	-735	6	-340
3	-731	7	-335
4	-729	8	-330

From the table 1 it can be seen that residual stresses were relieved. Now for LPG cylinder Natural frequencies were calculated using ANSYS as well as on Electro-Dynamic Shaker. LPG cylinder model was developed in ANSYS, commercial finite element analysis software, for modal analysis. Figure 3 shows meshed model of cylinder.

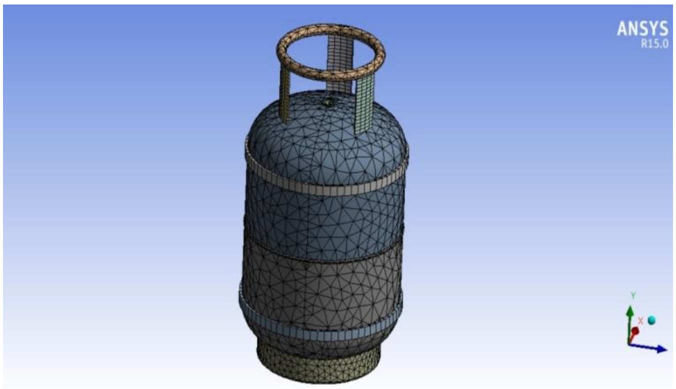

Fig.3: Meshed Model of Domestic LPG cylinder Using ANSYS

V. EXPERIMENTATION

Electro-Dynamic shaker is used to provide vibration. The shaker is essentially an electro-magnetic assembly comprising of an electro-magnetic circuit consisting of a stationary (field) coil and a moving (drive/armature) coil which is a part of "Head" that vibrates. A concentrated magnetic field/flux is generated in the small air gap of the magnetic structure by feeding DC current to the field coils. When AC power is fed to the 'Drive armature coil' the head (moving platform) vibrates simulating the nature of signal being fed to it based upon Fleming's left hand rule.

The vibrations on the moving platform can be transferred to the specimen/object which can be mounted on this platform for the test. The drive coil suspension system offers high lateral stiffness for the loads and ensures low transverse motion.

Fixture is designed and fabricated for sample as well as for cylinder as shown in the figure 4 and 5.

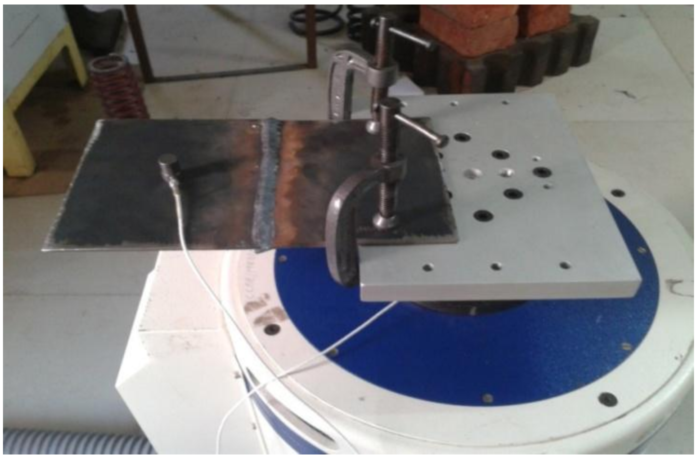

Figure 4: Sample Mounted for Vibration Test on Shaker Table.

Vibration testing on sample was done at following specifications: Frequency- 252.08Hz Displacement-5mm Acceleration-2g Time – 10min.s

Figure 5: LPG cylinder mounted for vibration test on shaker table.

Vibration testing on sample was done at following specifications: Frequency-2065.04Hz Displacement-5mm Acceleration-2g Time – 20min.s

IV. RESULTS

After vibration testing cylinders were taken to Om cylinders, sinner, Nashik. According to Bureau of Indian Standard testing was done on cylinders. Mainly two testing were done and compared results with annealed cylinders.

Acceptance test and Burst test were done. In acceptance test, tensile test is done by preparing specimen as shown in figure 6.

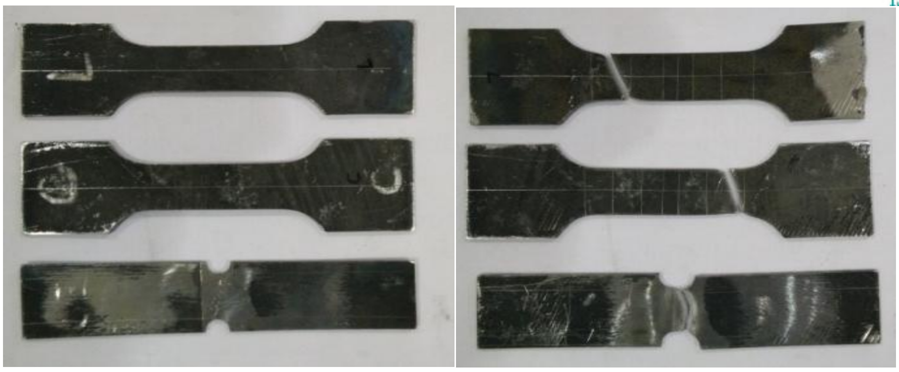

Figure 6: Samples after and before Acceptance test.

Results of Acceptance test are tabulated as below:

Table III Results of Acceptance Test

Particulars	**W(Std.)**	**W(VSR)**	**C(Std.)**	**C(VSR)**	**L(Std)**	**L(VSR)**
Yield Strength Mpa	---	---	276	390	279	534
Ultimate Tensile Strength MPa	448	487	404	539	389	534
%elongation	---	---	20	4	25	26

Where, W - welded sample

C – along circumference sample

L - along length of cylinder

Std. – Annealed sample

VSR – Vibratory Relieved sample

In Burst test water is filled in cylinder and continued to do so until the cylinder bursts and pressure noted for accepted pressure level. Result of burst test showed as below:

Table III Results of Burst Test

Particulars	**BT (Std.)**	**BT (VSR)**
BT Pr.(Kg/cm2)/MPa	90	124
Hoop stress (MPa)	554	755
Initial volume (By weight)	33.730	33.700
Expansion volume (By weight)	7.45	2.80
Volumetric expansion	30.98	8.31
Burst without fragmentation	Yes	Yes

VII. COST FACTOR FOR PROCESS

For Thermal Process

Oil required per cylinder: 800-900ml

Cost of oil: 40rs per liter

Time required per cylinder in furnace: 40min.s

Cost per cylinder: 40-50Rs

For VSR process

Time required: 15-20min.s

Electricity required: 3-4units

Cost per cylinder: 15-20Rs

VIII. CONCLUSION

1) VSR proves to be effective avoids the disadvantages of thermal stress relieving. As from the result it shows that 53.74% stress relief is achieved.
2) The level of energy induced in the metal is also dependent upon the current supplied. By varying the input current the process of stress relieving will be optimized.
3) Optimization of parameters of VSR will help in improving the efficiency of VSR for stress relieving of machine tool structures.
4) The potential saving in time, equipment and energy costs are substantial; the freedom from many of the side effects accompanying thermal stress relief.
5) X-ray diffraction method can be used for the measurement as it can be available with required accuracy.

IX. ACKNOWLEDGMENT

Authors are thankful to Dr. A. M. Fulambarkar, Principal, Pimpri Chinchwad college of Engineering, Pune (MH) India, for his kind support.

REFERENCES

[1] Walker, Waddell & Johnstone. ‘Vibratory stress relief – An investigation of the underlying process.’ Proceedings Institute of Mechanical Engineers vol209, pp51-58 1995

[2] ‘Vibratory stress relief: A fundamental Study of its effectiveness.’ By R. Dawson, D. G. Moffat Journal of Engineering Materials and Technology, Vol. 102, April 1980

[3] ‘Study of Vibratory stress relief of fabricated machine tool structure’ By Bukka V.M. , Dr. S. S. Lakade

[4] ‘Vibratory Stress Relieving- an effective alternative to thermal treatment for component Stabilization?’ By R. A.Claxton, Journal of heat treatment of metals, 1991.2 P.53-59

[5] ‘Numerical analysis of retained residual stresses in C(T) specimen extracted from a multi-pass austenitic weld and their effect on crack growth’ By O. Muránsky a, M.C. Smith , Engineering Fracture Mechanics 126 (2014) 40–53

[6] Development of a finite element simulation framework for the prediction of residual stresses in large welded structures By Ayjwat A. Bhatti , Zuheir Barsoum, Mansoor Khurshid, Computers and Structures ,133 (2014) 1–11

[7] 'Vibratory stress relief and modifications in metal to conserve resources and prevent pollution' by William Hahn, 2002

[8] 'Residual stress measurement using X-ray diffraction', A Thesis by Osman Anderoglu, Texas A&M University.

[9] C. Mel Adams, Bruce B. Klauba, ―Productive Applications of Mechanical Vibrations

[10] J S Hornsey, R A Claxton, ―Vibratory Stress Relief – Recent Developments

[11] R.T. McGoldrick, Captain Harold E. Saunders, ―Experiments in stress relieving castings and welded structures by vibration