ISSN XXXX XXXX © 2019 IJESC

Research Article Volume 9 Issue No.3

A Review Paper on Crack Analysis of Process Equipment

Sandip Kumar[1], Padmakar. T Raut[2], J. K. Patil[3]
Lecturer[1, 2], HOD[3]
Department of Mechanical Engineering
Bharati Vidyapeeth Institute of Technology, Navi Mumbai, Maharashtra, India

Abstract:
Process equipment is a very integral part of the industry. Any defect or crack on the surface of process equipment like pressure vessel can lead to a fatal accident during operation, so it needs to be crack analysis. Many designers have done a lot of research in this area. The present work has done to review the methods and techniques to analyze the process equipment like pressure vessel. Hence procedure could be developed to analyse or to test process equipment like pressure vessel on the basis of operating parameters by using techniques like SIFs by validate the results with the FEA results.

Keywords: pressure vessel, SIFs, and FEA

1. INTRODUCTION

Industries have to deal with different toxic gases as well as chemicals for different applications so they have many process equipments like pressure vessel [1]. Generally, there is huge difference in internal and external pressures of the pressure vessel. If pressure vessel fails or get explode, it may cause a huge damage to human life and property [2]. The failure of the pressure vessel starts from a small crack may remain present during manufacturing processes or due to material deficiency on the surface and due to different operating parameters. So it becomes mandatory for the pressure vessel manufacturer and user to test the process eqipments before operation.

2. OBJECTIVES

I. To understand the importance of process equipments.
II. To understand the methods for analysing process equipments.

3. LITERATURE REVIEW

The field of fracture mechanics has prevented a substantial number of structural failures. We will never know how many lives have been saved or how much property damage has been avoided by applying this technology. Designers are always interested to know whether a crack is likely to grow or not if the geometry of crack, loads and other boundary conditions of a structural component are known. Therefore parameter is available to measure crack effectiveness or crack extension force. This chapter depicts attempt towards research work carried out in the area of analysis and feature driven optimization of thin walled pressure vessel, it is found that an evolutionary research has been done and keeps on expanding in this topic. A quite good amount of research work is found available on various areas of pressure vessel analysis and optimization.

J.Reynen[1],in 1976 states that in order to assess the safety of pressure vessel components, the analysis should take into account cracks. Fracture mechanics provide an adequate tool to deal with such situations. He also characterizing the different modes of cracks in a material by local stresses e.g. mode I, mode II and mode III. He said every material has different value of resistance to deformation also known as material toughness. The stress intensity factor "K" is a measure of material toughness. According to LEFM, if a material is loaded beyond this material toughness then the material gets brittle cracked.

S.Sugawara[2],in 1986 evaluated the J-integral of a crack in pressure vessel under thermal loadings. He says to assure the safe design of reactor vessel. In reactor vessel there is cyclic loading and by virtue of which different kind of cracks are formed and they can be very fatal as per as safety is concerned. In reactor vessel sometimes stainless steel cladding will form around the inner surface of the reactor vessel and it has some effects on the performance as well as on the life the reactor vessel, so we analyzed the values of J-integral of reactor vessel with or without cladding and their values will be compared so we can prepare a better design to safeguard it from any accidents.

R. L .Wilson, S.A. Meaguid [3], in 1994 published a research paper and he said the papers we have examined so far have straight horizontal and vertical cracks but what would be the effect if we have an angled crack. This paper is concerned with the arbitrary located and oriented angled crack in discs. All major forces causing the crack in the disc has been considered like boundary loading, body forces and thermal stresses.

Wai tuck chow and Satya N. Atluri [4], evaluated in 1996 most of the equipments are made of composite laminated materials and they are also exposed to different loadings. They may cause fracture in the material. A mutual integral method is used to calculate the mixed mode stress intensity factor for different cracks and loadings.

R. Singh [5], used a new methodology in 1998 here in this paper, it is mentioned that except the general procedure of analyzing a cracked problem a new methodology called Universal crack closure integral (UCCI) based on the Irwin's original CCI to solve it in a better way. We can also analyze 3D components by using the same methodology

A. Nachum [6],[7], in 2000,2001 published his study on internal cracks analysis on pressure vessel in an overstrained

cylindrical pressure vessel due to only auto frettage level in part-I and in part-II it is due combined effects of auto frettage and internal pressure. He said reactor vessel, chemical pressure vessel and gun barrels are few examples of thick walled pressure cylinders. This cylinder bears high internal pressure, pressure fluctuations, thermal shocks, corrosive environment etc. all leading to the formation of crack in the body of pressure vessel. It's mandatory to increase the maximum allowable pressure and to reduce the susceptibility to crack. In the second paper of the A. Nachum in 2001 he gone somewhat ahead in the study on this topic and he combined the auto freightage with the internal pressure of the pressure vessel.

Junbo Zhou[8],in 2004 he said the basic cause to get the material fractured is because of two reasons one the excessive pressure at weak metallurgical zones i.e. around welding zones, necking etc. and the manufacturing malfunctions during manufacturing of the pressure vessel, like during the process of manufacturing some of the heat treatment processes are not done properly so material becomes weak at some reasons and results in micro cracks ,malposition and slip etc. Because of segregation of Cr on crystal boundary, a micro-couple cell would be formed and resulted in an inter-crystalline corrosion. The segregation was caused during welding and the area influenced by the heating was at a transition temperature. He used different techniques for the analysis of metallurgical structure of the material like Metallurgical microscope, scanning electron microscope, scanning Auger energy spectra and X-ray diffraction method etc.

J.A. Wang, K.C. Liu [9], in 2004 introduces a new approach to evaluate fracture toughness of structural materials. He said there are number of methods to analyze the failure of the material but every method has some deficiency. To overcome these deficiencies he introduces a new approach called "spiral notch torsion test" (SNTT) to calculate the fracture toughness of the material and to standardize the fracture toughness testing. By using these we can analyze a wide variety of material for the fracture toughness.

S. Stoychev, D. Kujawski [10], has evaluated in 2007 the Crack tip stresses and their effect on stress intensity factor for crack propagation .In this paper, analytical and numerical simulations of the crack tip stresses are presented. 2-D FEA results are calculated and they are compared and discussed in terms of crack tip compressive residual stress. The fatigue crack growth (FCG) behavior depends upon two fracture mechanics parameters fatigue damage and crack tip stretching. If we using them separately so we get incomplete information. So to get the complete information we have to use combined loading. The unified approach however is a conceptual approach. So in this paper they evaluated composed fatigue crack driving force, which provides a tool for practical implementation of the unified approach. Durability and strength evaluation of notched and cracked structural elements requires calculation of stress intensity factors for cracks located in regions characterized by complex stress fields. This is particularly true for cracks emanating from notches and other stress concentration regions that might be frequently found in mechanical and structural components. A major achievement in the theoretical foundation of LEFM was the introduction of the stress intensity factor K (the demand) as a parameter for the intensity of stresses close to the crack tip and related to the energy release rate (Bazant and Planas 1998). Inglis (1913) studied the unexpected failure of naval ships, and Griffith (1921) extended this work using thermodynamic criteria. Using this work, Irwin (1957) developed the concept of the stress intensity factor.

4. CONCLUSION

According to research done by many researchers as discussed above, it is clear that the process equipments like pressure vessel are very critical. While designing them and before manufacturing they needs to be tested and analysed in all respect. Engineered by safety factor, many testing are carried out like fracture analysis, non-destructive testing, ultrasonic testing, radiography and hydro test which involves water. It could also be tested pneumatically by using air and any other gas.

5. REFERENCES

[1]. M.Perl, A. Nachum,"3-D stress intensity factors for internal cracks in an overstrained cylindrical pressure vessel-part II: the combined effect of pressure andautofrettage" Journal of Pressure Vessel Technology, Vol.123/135, 2001.

[2]. J.A. Wang, K.C. Liu,"A new approach to evaluate fracture toughness of structural materials", Transactions of the ASME,534/vol.126,2004

[3]. S. Stoychev, D. Kujawski," Crack tip stresses and their effect on stress intensity factor for crack propagation", Engineering Fracture Mechanics 75, 2007.

[4]. Ma Youli,"Evaluating stress distributions and stress intensity factors of a crack under mixed–mode conditions in aluminum alloy", International Conference on Measuring Technology and Mechatronics Automation, 2010

[5]. NidhiDiwedi, Veerendra Kumar, AshwaniShrivastava, Rajinareliya,"Burst pressure assessment of pressure vessel using finite element analysis: A review" Journal of Pressure Vessel Technology, Vol.135/044502-1, 2013.

[6]. Rafael G. Savioli, Claudio Ruggieri, "Experimental study on the cleavage fracture behaviour of an ASTM A285 grade C pressure vessel steel" Journal of Pressure Vessel Technology, Vol.137/021206-1, 2015.

[7]. Christopher J.Evans, Timothy F.Miller," Failure Prediction of Pressure Vessels using Finite Element Analysis" Journal of Pressure Vessel Technology, vol.137/051206-1, 2015.