RESEARCH ARTICLE OPEN ACCESS

Finite Element Based Analysis of the Effect of Internal Voids on the Strength and Stress Distribution Of Component- Review

Sagar S. Awate*, Sandeep S. Kore**
*Department of Mechanical Engineering,Sinhgad Academy Of Engineering, Pune-48
** Department of Mechanical Engineering,Sinhgad Academy Of Engineering, Pune-48

ABSTRACT
Voids are the casting defects and can be source of failure due to action as a stress concentration location. Void is the absence of material where it should be present in metal casting processes. All metal casting contains voids which is inherent to the material and its application. Voids occur for many reasons and in many forms, but it is often the results of gases released from molten metal, or shrinkage of the metal as it cools and solidifies. Voids may go to the heart of casting and infiltrate the entire part. The main objective of the project are to try and develop a model for detection of voids using vibration techniques. Once a void is detected, we should be able to quantify the loss in strength , and based on this data determine if the component will be usable or not. By using FEA modeling of internal void in a component is to be done and using modal analysis technique to determine natural frequency of component. By comparing results with defect free component and checking if there is a co relation between frequency shift and size of the void. By performing structural FEA to determine stress concentration zones and reduction in stress capacity due to void.
***Keywords* –** Defect , Loss in strength , Modal analysis, Natural frequency, Stress concentration

I. INTRODUCTION

In recent years the metal casting processes have been greatly advanced, however porosity, voids in metals, gas bubbles remain an inherent by product of the casting process. Hence study of these casting defects and their effect on the material performance is needed. The various effects can be studied by generating the model of internal void with the help of finite element methods.

II. LITERATURE REVIEW

R. Monroe [1] in "Porosity in castings" studied generation of voids, the effects of different parameters on the void volume with different materials. The main cause of voids being evolution of gases and its entrapment during casting processes, he studied their effects on void volumes. He formulated equations to evaluate volume of voids in the casting. This work can be used to decide the range of void sizes to be analyzed in the current study.

M. Kuna and D.-Z. Sun (1996)[2] presented a paper on 'Analyses of void growth and coalescence in cast Iron by cell models', in which they showed fracture process of cast iron is initiated at the graphite nodules, followed by intensive void growth and coalescence. The three-dimensional cell models turned out that the spatial arrangement of periodic arrays of voids has only weak influence on the deformation behavior, whereas the plastic collapse behavior is strongly affected.

Xiaosheng Gao et al (2005)[3] studied effects of void volume fraction, void shape and void distribution on ductile fracture initiation toughness using finite elements. Their results showed that, besides the initial void volume fraction, other factors also affect void growth mechanism when the initial void volume fraction is large. They also showed that when other parameters are the same, the oblate void grows faster than the spherical void and the spherical void grows faster than the prelate void.

Zhiguang Zhoua et al (2011) [4] presented a paper on "Effect of micro voids on stress triaxiality-plastic strain states of notched steels" in which they modeled round bars with void and without voids with different type of notches to study the stress triaxiality-plastic strain states of notched steels. The results show that the effect of micro voids on stress triaxiality-plastic strain states of notched steels is small until stability limit and become significant gradually after the stability limit.

Q.M. Yu, N.X. Hou, Z.F. Yue (2010)[5] presented paper on 'Finite element analysis of void growth behavior in nickel-based single crystal super alloys'. They found that the stress triaxiality is the main driving force of void growth. When the relative volume fraction of void is the same, the macro-equivalent strain deceases with the stress triaxiality increasing, whichsuggests that low stress triaxiality easily cause ductile crack of the material. The stress triaxiality has noticeable influence on void shape change. At low stress triaxiality, the void deformation exhibits mainly as shape change, and at high stress triaxiality, it mainly exhibits as bulk expansion. They also showed that initial void volume fraction plays an important role in voidexpansion rate, i.e., size effect. The smaller the initial volume fraction is, the higher the growth rate is and also lode parameters significantly affect the void expansion and its shape change.

B. Chen et al[6] studied casted aluminum alloys assuming these voids are cylindrical or spherical and a representative volume element of the material is isolated and investigated. The cylindrical and spherical void-cell models were analyzed making use of a non classical elasto-plastic constitutive relation. The corresponding numerical algorithm and finite element approach were developed and applied to the analysis of the stress–strain and porosity–deformation relationships of casting aluminum alloy A104. The distribution of the porosity of notched specimens under tensile loading was also analyzed and it was found that the largest volume fraction of voids occurs in the region near the notched root and decreases as the distance from the notch root increases.

M. Avalle et al[7] studied the influence of casting defects on static and fatigue strength is investigated for a high pressure die cast aluminium alloy. The effect of porosity and other casting defects on static and fatigue properties of specimens and components obtained by high pressure die casting on a Al–Si–Cu alloy has been assessed. For the three batches of specimens, differing for the sprue–runner design, the influence was straightforward, while no significant variation in the fatigue strength was observed when looking at batches of “acceptable” and “non-acceptable” components, as judged within the foundry quality control. In this case, defects count for their size and location, while quality control often takes no account for component working conditions. The experimental and numerical results point out that, the tensile strength decreases linearly with theporosity range.

III. FEUTURE SCOPE

The previous studies were concentrated mainly on growth of void and stresses developed at the void. The effect of shape of void on fracture initiation is also studied. In present study, firstly the effect of presence of void on the strength of a component is analyzed to find whether the loss in strength can be quantified or not. The vibration characteristics are then analyzed to quantify variations in natural frequency and harmonic response. The study shows that the void can thus be tracked from the vibration characteristics of component and compared with structural analysis to find out the strength loss.

IV. PROPOSED WORK

The proposed work of the project is to study the effects of internal void on the characteristics of the component. FEA is used to analyze the effects structural and vibration characteristics of component. The main objectives are to study the effect of size and location of void on structural integrity of component. To determine the loss in strength of component due to presence of void. To find relationship of size and location of void with the loss in strength of component. To study the effect of void on vibration characteristics of component. To find relationship of size and location of void with shift in natural frequency. To try and develop methodology for detection of void and the resulting loss in strength of component, using acoustic method.

REFERENCES

Journal Papers:

[1] “Porosity in Castings” R. Monroe, Steel Founders’ Society of America, Crystal Lake, Illinoi.

[2] “Analyses of Void Growth and Coalescence in Cast Iron by Cell Models”, M. Kuna and D.-Z. Sun, Fraunhofer- Institute of Mechanics of Materials,Wohlerstrasse11, 79108 Freiburg, Germany.

[3] “On ductile fracture initiation toughness: Effects of void volume fraction, void shape and void distribution”, Xiaosheng Gao, Tianhong Wang, Jinkook Kim, International Journal of Solids and Structures 42 (2005) 5097–5117.

[4] “Effect of micro voids on stress triaxiality-plastic strain states of notched steels”, Zhiguang Zhoua, Hitoshi Kuwamurab, Akemi Nishidaa, Procedia Engineering 10 (2011) 1433–1439.

[5] “Finite element analysis of void growth behaviour in nickel-based single crystal super alloys”, Q.M. Yu, N.X. Hou, Z.F. Yue, Computational Materials Science 48 (2010) 597–608.

[6] “A constitutive description for casting aluminum alloy A104 based on the analysis of cylindrical and spherical void models” B. Chen, X. Peng, J. Fan, S. Chen; International Journal of Plasticity 21 (2005) 2232–2253.

[7] “Casting defects and fatigue strength of a die cast aluminium alloy: a comparison between standard specimens and production components”, M. Avalle, G. Belingardi, M.P. Cavatorta ,R. Doglione, International Journal of Fatigue 24 (2002) 1–9.