Finite element based analysis of the effect of internal voids on the strength and stress distribution in automobile component-Review

[1]Mr.B.A.Tare, [2]Mr.V.J. Patil

[1]Vice-principal, [2]Lecturer
Department of Mechanical Engineering
DKTE`S Yashwantrao Chavan Polytechnic
Ichalkaranji.

***Abstract*- Generally automobile components are manufactured through casting process because casting process is economical and used for mass production and the part produced which is of high strength. But many defects are produced during casting process. So that casted part faces the stress concentration problem at the location of defect. Void is the one type of defect in the casted part; it is of two types internal void and external void. External void we can detect through naked eye, but for detection of internal void require special equipment, and we cannot find its effect on casted part. In this study we are going to make FEA model to find out the effect of internal void on the automobile component through using Modal analysis technique to determine Natural Frequency of the component.**

Keywords: **Defect, Modal analysis, Natural frequency, Stress concentration etc.**

I. INTRODUCTION:

Casting Voids are casting defects and can be a source of failure and breakage of component due to stress concentration. Void is the cavity in the inner part of metal castings. All metal castings contain voids, which is inherent to the casting process. Reasons for voids in metal casting are high initial gas content, reaction of carbon and dissolved oxygen, mold-metal reactions between evolved mold and core gases at the solidifying casting surface, the result of gases released from the material, or shrinkage of the metal as it cools and solidifies. Voids may go to the heart of a casting and infiltrate the entire part. Because of this the performance life of the component reduces.

Automobile component are mainly produced from the cast iron. The main advantages of using the cast iron are its low price and the ability to make products of a complex shape in a single production step. Cast iron offers a reasonable resistance against corrosion. In general, the mechanical properties are lower than those of cast or wrought steels, especially when loaded in tension. In compression high loads can be supported. The mechanical properties of cast iron depend on the morphology of the carbon. But the main problem of using cast iron for casting process is the defects produced during process. Main defect in casting are shrinkage, porosity and cracks.

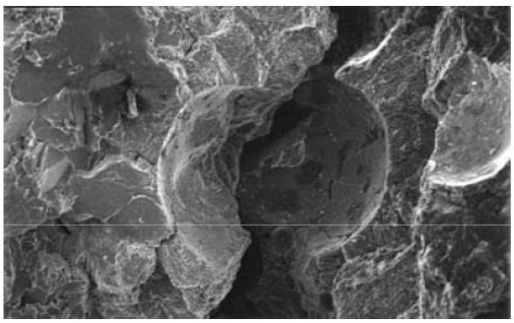


Fig.1: Void resulting in crack in magnesium

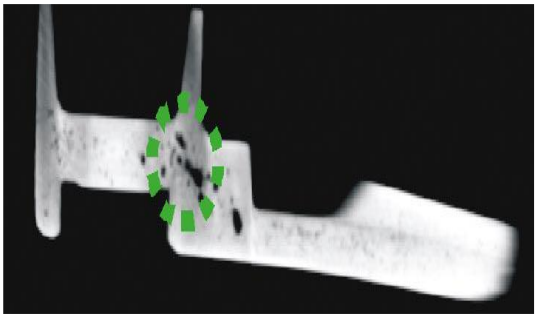


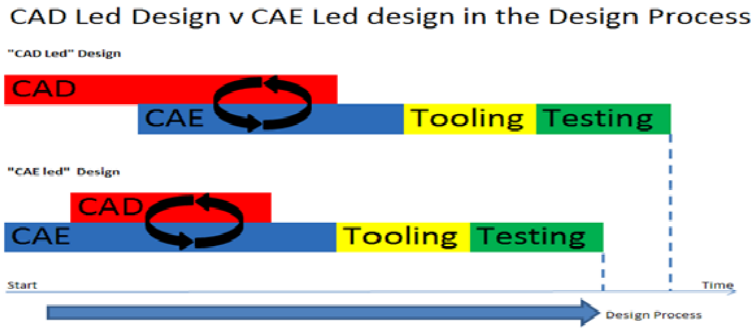
Fig. 2: Void defects in castings

Casting variables are many and recent work has focused on analysis of these variables. The size of the void is often of much less importance than its form and position. A large pore in a low stressed area of the casting may be far less detrimental than a small region of layer porosity in a sharp corner subject to a high tensile stress. However, detection of voids, especially internal voids is still problematic. For detection of these costly techniques such as Tomography, Acoustic Resonance technique, X-ray methods are needed to be employed.

Employing costly NDT techniques is not always a feasible option, considering urgency, economics, and availability. Furthermore, highly skilled technicians are required to interpret.

II. LITERATURE REVIEW

1) Kelvin Lake, Richard Thomas, Martin Gambling, Tony Lawson (2008) - In this paper the applications of FEA techniques in the optimization of large, thin-walled, high-pressure, die cast magnesium alloy components for the automotive industry is discussed and this is compared with CAD. For optimization the technique used are topology, topometry, and shape optimization. By using the CAE it led the design which fits into the product lifecycle, successfully reducing development times and costs.



2) Marco Aloe (2005) – This paper will consider some of the factors influencing the accuracy of a coupled thermal, fluid and stress analysis of casting. Besides the defects related to filling and solidification, there are a number of stress related issues which can affect the final integrity of the die cast component. Factors which are influence the stress behavior and fatigue life of die casting are geometry, thermal history, thermo-mechanical properties of die and casting, external forces and pressures.

3) Si-Young Kwak, Jie Cheng , Jeong-Kil Choi (2011) - This paper shows that the Shrinkage cavity may be detrimental to mechanical performances of casting parts. First Al alloy wheel impact test was computationally analyzed for both the wheel models with and without shrinkage cavity defects. Based on shrinkage cavity data obtained from industrial CT (Computerized Tomography), the shrinkage cavity defects were modeled with SSM (Shape Simplification Method), which reconstructs shrinkage cavity defects to hollow spheroid primitives. After this the impact simulation was conducted. The results shows that under impact test condition, the wheel considering shrinkage cavity defects fracture because the high stresses are developed at that region while the wheel without shrinkage cavity defects survive.

4) R.Hardin , C.Beckermann (2002) - In this paper the radiography technique is used for determination of steel casting soundness as Non destructive examination (NDE) and mechanical testing for structural performance prediction .But the contradiction between the above two method is present if one pass then other fails. To avoid this the FEA and simulation method are used for analysis of the structural service performance of steel castings and predict the defects in the casting.

5) R.Hardin, C.Beckermann (2012) - In this paper, a combined experimental and computational study is performed to investigate the effect of internal shrinkage porosity on the mechanical behavior of cast steel under static loading. 1) Steel plates containing porosity are cast in a sand mold, machined, and tensile tested until fracture.2) Radiographic imaging is used as a NDE to detect the porosity field in the test specimens. 3) The measured porosity field is then used in a finite-element stress analysis of the tensile tests. 4) The local elastic properties are reduced according to the porosity fraction present and porous metal plasticity theory is used to model the damage due to porosity. Good agreement between measured and predicted stress-strain curves is obtained. The computational model proposed in this study allows for a detailed evaluation of the effect of porosity, including its size, shape and location, on the mechanical performance of a steel casting.

6) Marco Aloe (2008) - In this paper, Cast irons defect is predicted by using the FEM software ProCASTTM.FEM model gives accurate shrinkage, porosity prediction by taking into account density variation through microstructural information as well as the mechanical properties at ambient temperature such as yield strength, tensile strength, elongation and hardness.

7) Vivek Hari Sankaran (2011) - In this paper the Acoustic resonance as NDT method used for cracks and other internal defects testing . The method is designed for rapid detection of cracks and other internal material related

flaws, with time per part typically being less than a second. When a part is impacted, or dropped onto a suitable surface it resonates at frequencies specific and unique to each part which are the natural modes. These modes are affected by cracks and other internal material related defects causing a change in the resonant frequencies. This resonance can be captured using a simple microphone to obtain the resonance spectrum which is used to classify the parts. This method combines the apriori knowledge of the frequency of the modes obtained using FEA of 3D model of component and combines it with an expert system.

8) K. E.A.Van Den Abeele, P. A. Johnson, A.Sutin (2000) – In this paper the Nonlinear elastic wave spectroscopy (NEWS) method is discussed. NEWS is NDT technique used for predicting the damage in materials. This technique finds the material is linear or nonlinear. If material is nonlinear, a wave can distort, creating accompanying harmonics, multiplication of waves of different frequencies, and, under resonance conditions, changes in resonance frequencies as a function of drive amplitude. In undamaged materials, these phenomena are very weak. In damaged materials, they are remarkably large. The sensitivity of nonlinear methods to the detection of damage features (cracks, flaws, etc.) is far greater than that of linear acoustical methods (measures of wave speed and wave dissipation).

9) Luiz Henrique Dias Alves (2010) - In this paper Taguchi method is used for process Improvement, modeling and optimization of voids related to the solidification in steel casting process. Taguchi method gives the ideal condition to minimize the occurrence of defects. Paper shows that increasing the S/N ratio means improving the final product and minimizing variability.

10)W. Beres, A.K. Koul (2002) - This paper presents the results of finite element based stress and fracture mechanics analyses carried out on the compressor disc of a jet engine using two and three dimensional models. The FE based analytical results, in terms of stress intensity factors, are compared using results obtained on the basis of metallurgical analysis. The results obtained formed the basis for performing damage tolerance analysis for the compressor disc.

11)A E Ismali, A K Ariffin, S Abdullah, M L Ghazali (2012) - This paper numerically discusses the stress intensity factor calculations for surface cracks in round bars subjected to combined loadings.The whole Finite element model is constructed, then both tension and torsion loading are remotely applied to the finite element model and SIF`s are determined. Comparison is made between the combined SIF`s obtained using the equivalent SIF method and finite element analysis (FEA) under similar condition.

III. PROBLEM DEFINITION

Automobile component casted from the cast iron but it is mainly affected by the voids created during casting process because of various gases produced during casting process if void is very large then part gets rejected.We have to detect the voids produced in the casting then determining stress concentration zones and reduction in stress capacity due to the void after this, checking if there is a co-relation between the frequency shift and stress capacity to avoid the rejection of the component.

IV. OBJECTIVES AND PROPOSED WORK

- To try and develop a model for detection of voids using vibration techniques.
- Once a void is detected, we should be still able to quantify the loss in strength, and based on this data determine if the component will be usable or not.
- FEA objectives are as Follows:

- Modeling and Internal Void in a component
- Performing FEA and using Modal analysis technique to determine Natural Frequency of the component
- Comparing the results with a defect free component and checking if there is a co-relation between the frequency shift and size of void
- Performing a Structural FEA and determining stress concentration zones and reduction in stress capacity due to the void
- Checking if there is a co-relation between the frequency shift and stress capacity

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