Finite Element Analysis of a Developed Fixture for Shot Blasting and Zinc Coating Operation

Mr. Rahul Jadhav
Department of Mechanical Engineering
Government College of Engineering
Aurangabad (MH), India

Prof. Kushal Wasankar
Department of Mechanical Engineering
Government College of Engineering
Aurangabad (MH), India

Mr. Sanjeev Punase
Department of Manufacturing Engineering
Endress + Hauser Pvt. Ltd
Aurangabad (MH), India

***Abstract*—In many manufacturing industries, fixtures have a direct impact upon product manufacturing quality, productivity and cost. Fixture Design is a crucial task which needs the experience of designers, try-error process, understanding of products and manufacturing. The main goal of this paper is to reduce the operator fatigue by implementation of fixture.**

Keywords—Fixture Design; fixture model; Analysis.

I. INTRODUCTION

Fixture Design is complex, time consuming and also iterative process. The design of fixture can takes longer time to complete. Fixture reduces operational time, Scrap, increases productivity and gives high quality of operation. Fixture also eliminates the frequent checking, individual marking, positioning. Fixture design is an important manufacturing activity which affects the quality of parts produced. The Semi-automation or automation of fixture design activities in manufacturing is an important research area, which is as a crucial design manufacturing link, especially in a modern manufacturing environment.

Shot blasting is a popular industrial method for smoothing rough surfaces or roughing up smooth surfaces by using pressurized abrasive streams. Shot blasting is a process by which abrasive particles are made to impinge on a component to clean or modify its surface properties. A pressurized air is used to propel the blasting material (often called the *media*). In the shipbuilding and ship repair industry, abrasive blasting is the most common surface preparation technique used to remove old paint and other surface materials such as rust, mill scale, dirt, and salts. Abrasive blasting might be conducted during vessel fabrication (e.g., on piping, steel plates and steel members used in structural assemblies, and other miscellaneous materials) and during maintenance and repair operations that include blasting and painting the ship's hull, and interior tanks and spaces.

Zinc coating is accomplished by feeding zinc powder or wire into a heated gun, where it is melted and sprayed onto the part using combustion gases and/or auxiliary compressed air to provide the necessary velocity. Prior to metalizing, the steel must be abrasively cleaned.

In this paper, we have studied the ergonomic consideration during the blasting operation and zinc coating operation."Ergonomics (or human factors) is the application of knowledge of human characteristics to design of the systems."

II. LITERATURE REVIEW

Following are some literature reviews concerning the ergonomics and fixture design:

A.S. Jackson et al. [1] have studied the Physical work capacity (PWC) by two ways: fat free Weight and Isometric strength. Upon arrival at the laboratory, height and weight were measured on a calibrated physician's balance beam scale. Skin fold fat thickness was measured with a skin fold caliper (Lafayette Instrument Co., Lafayette, IN, USA) that exerted constant pressure and conformed to established standards (Keys, 1956). The men's skin fold sites were: chest, abdominal, and thigh, and the women's sites were triceps, supra ilium, and thigh. These skin fold test procedures are fully described in other sources (Baumgartner and Jackson, 1995; Jackson and Pollock, 1985). Body density was estimated from published generalized sum of skin fold equations (Jackson and Pollock, 1978; Jackson et al., 1980). The Sift equation (Siri, 1961) transformed body density to percent body fat. Body weight (Wt) and percent body fat (Pfat) was used to compute fat-free weight (FFW) using the following equation (Baumgartner and Jackson, 1995; Ross and Jackson, 1990):

$$FFW = WT - [W_t \times (Pfat/100)] \quad (1)$$

R.S. Bridger [2] presented the research on physical anthropology in general and hominid evolution in particular is of interest since comparative analysis of the anatomy of early hominids, Homo sapiens and modern great apes can help specify the adaptations required for the adoption and maintenance of the upright posture and, indeed, clarify what is meant by the term posture as it is used in Ergonomics. The holding a weight close to the body is advisable to minimize the moment about the lumbo-sacral joint. There would appear to be theoretical support for the notion that the C.O.G. of the body plus load should not be raised when an object is carried or held because an increase in the height of the C.O.G. increases the load on the muscles (such as the gluteals), which stabilize the trunk and may increase postural sway and hasten the onset of fatigue. It may be hypothesized that the C.O.G. of the load should be no higher than the hips, particularly when walking or standing on uneven ground.

K.C. Parsons [3] has studied the vibration relates to the health, comfort, performance and human response. There are levels of vibration that can cause physical damage to the body; for example, those found in aircraft in severe turbulence, long-term exposure of tractor operators to vibration, or vibration to the hand from some vibrating tools. For e.g. Blasting operation. The term vibration discomfort is used in studies of human response to vibration. It is clear that there has been a great deal of work on the effects of light, noise, vibration, and thermal environments on the health, comfort, and working efficiency of the workers.

A. Wisner [4] has studied ergonomic considerations are related to the occasionally excessive physical strength limits of many populations in industrially developing countries. Efforts to be made, loads to lift and distances to cover over bad ground have moderate or dangerous effects according to the physical capacities of the persons in question. Highlighted as such, the actual workers' capacities have a significant effect on production and economic development. The preservation and increase of these capacities may be obtained in accordance with specific ways and means.

The formalization of the fixture design process based on functional requirements allows developing a more integrated approach to the problem of fixtures design. The basic steps, and fundamental input to any implementation aiming to automate such process, start with the fixture design Process, and continue with the definition of the fixture Knowledge Units: fixture requirements, fixture functions, part definition, machining operations, functional design rules, detail design rules, fixture resources, and fixture validation. To validate the methodology, and based on the developed models, a prototype knowledge-based application has been implemented in a commercial CAD/CAM system (CATIA V5) [5].

Hui Wang et al. [6] have studied the fixtures impact upon product manufacturing quality, productivity and cost. The current design and automation theories and technologies are still not mature. Most current commercialized fixture design tools in manufacturing are traditional geometric based, for instance, the tooling and fixture design functions in some CAD systems, e.g., Unigraphics and Pro/Engineer, the software by some fixture components manufacturers.

Ernest Y.T. Tan et al. [7] has developed the Finite Element Model (FEM) which is able to determine in detail what are the reaction forces, workpiece displacement, deformation in workpiece and fixtures. The main drawbacks of FEM are: the need to determine accurate inputs and longer time for constructing the model and running the simulation.

III. Fixture Model

A. *Modeling of fixture:*

Fig. 1 shows the fixture model is modulated in CATIAV5R18. Fixture is capable to hold the maximum weight upto 30 Kg. It consists of main parts like Base plate (Trolley Base), Round plate, vertical column, Ribs, Ring lock, Outer pipe, Support bracket, First swell arm with bearing housings, Second swell arm with bearing housings, Hinge bracket, Support bracket of balancers etc. The material used for fixture is Mild Steel EN8.

At free end of fixture, Support bracket of balancer holds the spring balancer. Here the one hook of spring balancer engages with the support bracket of balancer and other end hold the guns individually.

Fig.1. Fixture Model

B. *Physical Constans of Material:*

Type of Material: MS EN8.
Modulus of Elasticity (E) = 202 GPa.
Modulus of Rigidity (G) = 78.5 GPa.
Poisson's ratio (μ) = 0.292
Density (ρ) = 7850 Kg/m^3

These are the some physical constants which are useful to analyze the fixture model.

IV. Analysis of Fixture Model

RADIOSS 12.0 is a state-of-the-art finite element solver uniting implicit and explicit integration schemes for the solution of a wide variety of engineering problems, from linear statics and linear dynamics to complex nonlinear transient dynamics and mechanical systems. This robust, multidisciplinary solver enables designers to maximize performance related to durability, crash, safety, manufacturability, and fluid structure interaction, in order to bring innovative products to market faster. Basically, RADIOSS is a finite element solver for linear and non-linear problems.

Fig.2 represents the meshing of fixture model. The meshing process is performed with the help of HYPERMESH.

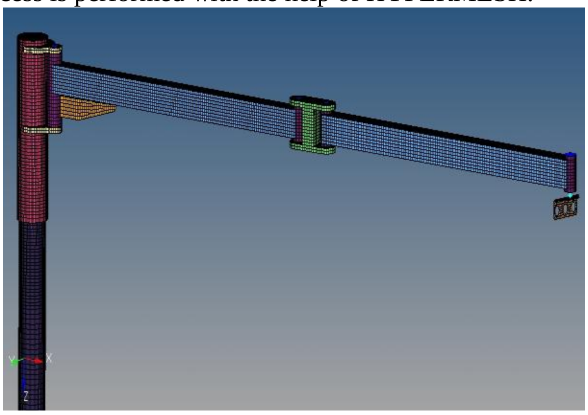

Fig.2. Meshing of Fixture Model

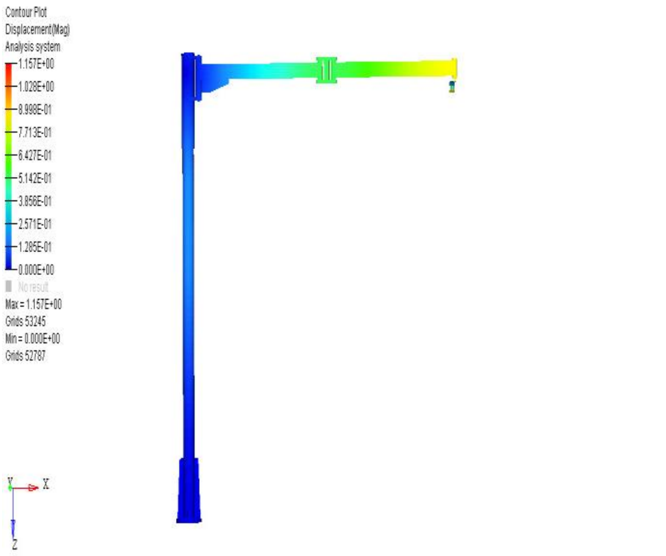

Fig. 3 Determination of displacement in Fixture Model

Fig. 3 represents the determination of displacement in fixture model. The maximum displacement in fixture model is 1.16 mm. Means, there is no fatigue failure in fixture model.

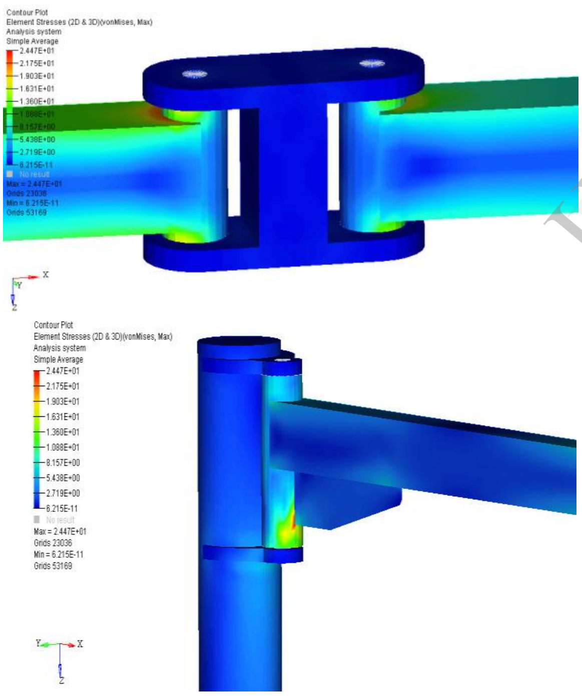

Fig. 4 Determination of VonMises stresses

Fig. 4 depicts the determination of VonMises stresses in fixture model. The Maximum VonMises stress is about 2.44 N/mm^2.

The finite element model information is as follows:

Number of nodes: 36203
Number of elements: 33764
Number of rigid elements: 33
Number of rigid element constraints: 2682
Number of degrees of freedom: 199982
Maximum 1-D element stress is 0.834 N/mm^2 in element 43925.
Maximum 2-D element stress is 27.0 N/mm^2 in element 21716.
Maximum 3-D element stress is 4.25 N/mm^2 in element 42089.

V. CONCLUSIONS

It is concluded that, the Fixture model is capable to hold the guns individually. After analyzing the fixture model, the maximum displacement in fixture is 1.16 mm. It means that the fixture is safe. By introducing such mechanism, now operator fatigue is reduced and also there is increase in productivity.

REFERENCES

[1] A.S. Jackson, G. Borg , J.J. Zang, K.R. Laughery, and J. Chen, "Role of physical work capacity and load weight on psychophysical lift ratings," Rice University, Houston,TX, USA, 20,1997, pp.181-190.

[2] R. S. Bridger, "Some fundamental aspects of posture related to ergonomics," UCT Medical school observatory 7925,Cape Town, South Africa, 8, 1991, pp.3-15.

[3] K.C. Parsons, "Enviornmental ergonomics: a review of principles, methods and models," Loughborough University, Leicestershire, LE11 3TU,UK, 31, July 2000, pp. 581-594.

[4] A. Wisner, "Variety of physical characteristics in industrially developing countries- Erginomic consequences,"Elsvier Science publishers B.V. Amesterdam, 4, 1989, pp. 117-138.

[5] R. Hunter, J. Rios, J.M. Perez, A. Vizan , "A Functional approach for the formalization of the fixture design process," Department of Mechanical and Manufacturing Engineering, Universidad Plitecnica de Madrid, Spain, 46, 2006, pp. 683-697.

[6] Hui Wang, Yiming (Kevin) Rong, Hua Li, and Price Shaun, "Computer aided fixture design: Recent research and trends," Computer Aided Manufacturing Laboratory, Worcester Polytechnic Institute, USA, 42, July 2010, pp. 1085-1094.

[7] Ernest Y.T. Tan, A Senthil Kumar, J.Y.H. Fuh, and A.Y.C. Nee, "Modeling, Analysis, and Verification of Optimal Fixturing Design," IEEE Transactions on Automation science and Engineering, 1,October 2004, pp. 121-132.

[8] K. Mahadevan, and K. Balaveera Reddy, " Design Data Hand book," 3rd Edition,CBS Publishers,1987.