Design & Optimization of Double Girder Electric Overhead Travelling Crane: A Review

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Abstract – Electric Overhead Travelling (EOT) cranes are major material handling equipments in any heavy engineering industry. The main purpose of this review paper is for structural analysis of overhead crane girder using FEM (Finite Element Method). Gantry crane beam was subjected to many types of load. Beam girder is the decisive assembly component of the overhead crane assembly. Existing research was focused to improve the strength structure of overhead crane girder with different types of techniques. These hard work help, to defeat overhead crane girder failure. FEM gives economical solutions for overhead crane girder failure during the loading condition. In the existing studies, analyzers uses various types of approach such as, FEA, FEM, PIM (Precise Integration Method), Micro Structural Characterization, Fractography, Numerical Simulations etc.

Index Terms – Electric Overhead Travelling Crane; Cross-Section of Girder; FEM; Structural Analysis and Von Misses Stress.

1. INTRODUCTION

Crane have been found many applications while the formation of the history of cranes has come across since then. First used of gantry cranes for doing the lifting the work piece from raw material to finished product by using Greek persons. Cranes are mostly used for materials movements in assembly lines, manufacture hall, storage areas, power stations and others place in any industrial plant. In any manufacturing/construction industry, it is required to handle the material at any stage of production, starting from raw materials, intermediate goods or finished products. Mainly they have been used in car factories, heavy industry and shipyards. Design features of gantry cranes very useful the major operational specifications such as motion, weight and load, location, geometric features and environmental conditions. The different range of gantry cranes includes double girder, single girder, double leg, single leg, different load capacities spans and heights. Different cranes are used in industries but gantry cranes are provide an economical way to lift materials anywhere in the manufacturing plant. Analysis has been performed to the gantry crane beam at different cross-section such as I-beam and box type beam and compared which design is better for safety design of crane. For lifting purposes, the dynamic characteristics analysis of crane is important. The present methods are used for calculating the dynamic loads of a crane. The PIM method was proposed by Zhong and improves by many investigators. The differential equation solve with a full precision with the help of computer. PDE are very useful for kinetic analysis as well as optimized control in engineering usually[1]. dynamic loads are calculated in the load-lifting system of the crane by using precise time step integration method.

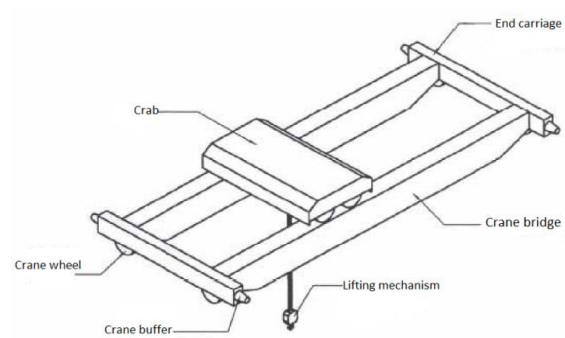

Fig. 1.1 The main component of double girder electric overhead travelling crane

2. FINITE ELEMENT METHOD

FEM (Finite Element Method) is a numerical or computational method that was subdivided a cad model into very simpler parts. Each simpler parts represented by a set of element equations. The next step is to take a system of field equations to be studied where scientifically represented by partial differential equations (PDE). The element equations are linear if the underline PDE is linear and vice-versa. This element equation gives an estimated local explanation of the simpler parts by using a set of simple linear PDEs. When the addition from all basics are considered, it ends up with a large sparse matrix equation system that can be solved by any of a number of well-known thin matrix solvers. In the sense of mathematical language, is to construct integral of inner part of the work piece and set to the zero integral. FEM may be suitable for structural mechanism but not for electromagnetic, and vice versa. It has been performed that the FEM is also suitable for a large class of mathematical physics issue.

3. LITERATURE REVIEW

Literature review is one of the earlier studies. This technique helps us to get the information about previous study of structural analysis of overhead crane girder. A range of literature studies have been done an early phase of project such as scientific journals, textbooks, conference volume article were the main font in job guides.

Pu H. et al [1]. Developed a dynamic model for load lifting system of the overhead crane. Direct precise integration method has been planned for calculating the dynamic loads of the system during lifting products. They have discussed the dynamic characteristics of the general crane and advanced crane which were used the traditional step speed regulation, variable frequency speed control technique respectively. The dynamic characteristics of the load-lifting system of the general crane and advance crane were calculated by the high precision time step PIM. The results showed that the advanced crane has much lesser dynamic loads as compared the general crane in the same case.

Wu X. et al [2]. Optimized the general structure and hoisting mechanism of large quenching crane for structure and technical requirements. They had designed and calculated for structural features of the quenching crane-related to technical documents, specific national standards, and main technical parameters. They have found that this development of large quenching crane to meet the development needs of venture production. It has provided the guideline and reference for the future design of similar cranes.

Alicia et al [3]. analyzed of the total plate girder to determine their shear failure mechanism. It was observed that the shear-induced at plastic hinges only develop at the end of panels due to the shear deformation near abouts supports. It was shown that the simple shear panels, in the form of detected plates do not accurately represent the failure mechanism of web plates. The concluded that the detached plate's simulation does not represent the true behaviour of plate girder web panels. It was found that the shear- induced plastic hinges occur only in the flanges of end panels after the deformation of partially inclined yield zones in webs. They do not occur in mid panels.

Zambian et al [4] carried out failure analysis of a shaft used in a bridge crane. It has been different types of analysis such as chemical analysis, fractography, hardness measurements, micro structural characterization and finite element simulation. The analyzed the different factors which produced fatigue failure such as oxides, microspores, manganese sulphide. It was found that the stereography examination revealed in the presence of beach and ratchet marks on the surface and the fractography examination shows striations, and shaft fractured by fatigue. The study found the length of MnS inclusions above the value of critical inclusion size parameter that produced a drastic decrease in fatigue life.

Chauhan N. & Bhatt P.M [5] analyzed the stress condition in the power structure of overhead crane for increasing its toughness has been made by using the NX NASTRAN. The estimation of stresses state are pointed out at the critical areas and measures, which are imposed in order to increase the stiffness of the power of structure for the overhead equipment, were performed. They obtained EN-22 material is most excellent from another two materials and trapezoidal sections is finest than the round and rectangle section. They found that the stress and deflection are less in the EN-22 material than forged steel and Steel-20.

G.Martin L.M. et al [6] reduced the ultimate strength of steel I-girders when the loads were applied at an eccentricity relative to the centre of the section. The effect of patch load length had investigated using a substantially larger data set that was available in the past. It was observed that the length of patch loading has an effect on ultimate strength for ratios $t_f / t_w \leq$ 1.5. Ultimate strength had obtained through the pondered least square method that resulted in the definition of a penetration coefficient k. It was found that the effect of the patch load has a significant influence on the strength reduction coefficient for small ratios of flange thickness to web thickness t_f / t_w.

Sowa L. et al [7] to evaluate of the stress state at the critical areas of gantry crane. Strength parameters of designed structures were analyzed using advanced software with high efficient possibilities of modelling. The mathematical model and numerical simulations of mechanical phenomena in the gantry crane beam are presented. The influence of changing the loading force position on generate the equivalent stress in the crane beam was evaluated. It was observed that the Huber-Misses equivalent stresses in the all crane beam about I-beam cross-section was less than the strength of beam material. It should be noted that results of numerical simulations are compatible with the results found in literature of the subject. It was found that recommended reducing stresses near the end of the crane beam by improving structure gantry crane.

Sankar et al. [8] reduced the structure mass of overhead crane subjected to heavy stresses on its structure, by using the modern computer modelling and simulations methods and applications. The structural mass reduction are designed and verified by structural static stress simulations. The modern computer modelling and simulations methods also increase the life of span of a real-world double girder overhead equipment. The several checks go mainly through horizontal, stress and vertical deflection analyses of the crane bridge. The models static structural response preserves the response of the original crane structure. Results obtained using analytical and the software-oriented results 5.6% and 5.4% respectively. The new designs suggest that succeed to reducing the model crane.

Kulshresta et al. [9] customized a concept of overhead gantry crane, which are usually definite for ISRO under n number of constraint. It was developed the safest particular design part of an overhead crane beam that undertakes the stresses during loading, unloading and transverse movement of the test load and the deflection. FEA gives the accurate analysis results of design for the particular part of a customized gantry crane. It also provides all detail related about the gantry crane beam. The design criteria depends not only the study by FEA but also all possible constraints were taken in mid and a final conclusive way was achieved, and ultimately the deflection received was well within the scope of the design and at rated load too. Finally, they were concluded that the developed gantry crane is useful for customized with unlimited constraints and this activity off course provide a second opinion to all of the manufactures and overcome the disadvantages of general gantry manufacturing.

Sharma et al. [10] discussed the design of the hoists generally conform to (Indian Standards) IS-3177.The stress and deflection were calculated at critical points (mid section of the beam) using ANSYS and optimized the different input parameters. After studied different design of hoist model of EOT crane, the Trapezoidal section showed less stress. They concluded that using more number of ropes fall divides the load that shows less tension. It was observed that with increase in rope lose increase the rope length by that time, it is not economical. By increasing the drum length, volume setup also increases. It was concluded that to overcome the volume setup uses the double winding of rope on the drum can be adopted it depends on motor power required on lifting speed and load applied. Gearbox is used for power transmission between the angular speed of drum and motor.

Chopda et al. [11] discussed about Modelling, Design, Analysis and Optimization of EOT Crane hook. Design of hook depends upon load lifting capacity, which may be ranging from 10 KN to as per requirement. Working load capacity of 50 KN was used. Cad model created using Pro-E and for analysis ANSYS was used. They optimized the dimension as per stress pattern and saving in the material has been carried out without disturbing the stability and safety, as per IS code 3177. They concluded that volume is reduced by 34.00 %, stress is increased by 40.00 % and deflection is increased by 3.00 %. The stress and deformation was increased but still safe to carry load within permissible limits.

Patel et al. [12] the Design, analysis and Optimization of the overhead bridge crane girder for the 75-ton capacity was experimentally carried out by changing the dimensions of section of overhead crane girder. Girder of 750 x 450 I section was used. They optimized the weight of section from different size I section (740 x 440, 730 x 430, 720 x 420, 710 x 410, 700 x 400). After analysis they found that, the von-misses stress and the deformation was matched with, the data generated through the ANSYS data. It was noticed that optimized design had a possibility to reduce the weight by 9.35% by increase the performance parameter by 16.50% and all the performance parameters was within its allowable limit.

Paresh [13] discussed the design and analysis of major component of 120 tonnes capacity of EOT crane. EOT crane design has been done in accordance to the various relevant IS codes IS3177, 1S 807. He analysed different type of components of overhead crane like that drum size sheave, structure of girder, lifting hook. 3D Modelling and analysis of the major components has been carried out using Cre-O software and ANSYS. All results were within the limit.

Patel [14] reviewed the structural analysis of overhead crane girder by using numerical technique. Gantry crane girder was subjected to different types of load. Girder acts as critical assembly component of overhead crane. The Current research has been carried out to improve the strength of the structure of overhead crane girder. These efforts reduce the chances of failure of overhead crane. The FEA technique with different types of approaches was used. FEA is essential tool for helping us to determining the cause of problems and recommends the solutions. For structural failure analysis (Finite Element Analysis) FEA should be used as a standard tool.

Zhou [15] established the single-girder crane cad model for each style (I beam and rectangular beam). The stress values at stress concentration points of upgrading structures and existing structure was compared. For fatigue strength analysis stress method and S-N curve method was used where easily occurs fatigue failure. It was observed that the fatigue analysis gives the minimum number of effective cycles ($N=3.73\times10^5$). It was also observed that the design specifications are well of single girder crane. It will provide some design idea for main-beam design and improvements.

4. CONCLUSION

According to the application, structural features of the electric overhead material handling crane girder was calculated correlative between the technical documentation, design standards, and main technical input/output parameters of EOT crane girder. At current, the crane has been in the perfect solution in all of industries related to material handling process such as steel industries, automobile industries, heavy industry and various types of workshop or station which are transform material from one place to another.

The major category of researchers used hoisting capacity, thickness, load and crane span as input parameters are easily controlled and mostly influenced by FEM analysis.

The output from research done, the output parameters such as, Von misses stress, factor of safety and deflection of girder had found to be depending upon the types of material, cross-section, span length, thickness of plate, and loading capacity. For future design of similar crane provided guideline& reference. The paper has some functional value.

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