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Design and Analysis of Crane Hook – A Review

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ABSTRACT

Crane hooks are stressed by repeated loading and unloading, which eventually causes them to fail. These are the causes of crane hook fatigue. To avoid failure, the crane hook stress is investigated and reduced to the maximum stress possible in comparison to the current (trapezoidal) crane hook. Crane hook stress can be reduced by altering the shape of the crane hook in comparison to a standard crane hook. The hook's cross section was used as a major parameter in this study to optimise its design for a given weight. The fatigue life of the crane hook will be extended as a result of the reduced stress (have better life comparing with standard crane hook). Crane hooks have four cross-sectional shapes: rectangular, round, square, and oblong.

Keywords: Crane hook, Repeated loading, Optimization, Simulation, Solid works

INTRODUCTION

Cranes are classified as weight-handling equipment (WHE). They are intended for heavy lifting and excavating in a variety of terrain and weather conditions with the appropriate attachment. A crane is a piece of equipment that can horizontally raise, lower, and move a load, including the crane's supporting structure and foundations as well as the load itself. Crane configurations are available in a variety of shapes and sizes to accommodate a wide range of industrial and construction operations. Cranes are distinguished primarily by their carriage and boom type. [4] A variety of cranes are frequently used in the construction industry. Overhead cranes, mobile cranes, tower cranes (telescopic and gantry), telescopic mobile cranes, and loader cranes are among the most common crane types. The hoist is either in a permanent equipment building or on a trolley that travels horizontally across tracks depending on the type of girder. It is also referred to as a gantry crane (twin-girder). To support the crane's frame, the gantry system is made up of equalised beams and wheels that run perpendicular to the trolley's travel path. An above-the-head crane's hoist and trolley assembly, also known as a "suspended crane," works similarly to that of a gantry crane, with the exception that one or two fixed beams allow it to only travel in one direction, which are typically found in the factory's assembly area, either on the side walls or on elevated columns.The tower crane is a more modern, updated version of the balancing crane. Tower cranes, which are anchored to the ground and can also be mounted to the side of a structure, provide the best combination of height and lifting capacity in skyscraper construction. Construction workers use mobile cranes to complete their tasks because they can traverse an area without the need for a permanent runway and rely solely on gravity for stability.

LITERATURE REVIEW

Following is a list of researchers who has worked in area of optimization of crane hook parameters to avoid crane hook failure.

E.Narvydaset.al[1],We investigated the circumferential stress concentration features of lifting hooks with shallow notches of trapezoidal cross-section using finite element analysis (FEA). Previously, stress concentration features were commonly used to evaluate the strength and durability of structures and machine components. The FEA results were used, and a general equation was selected to meet their requirements. As a result, formulas for the rapid engineering assessment of stress concentration factors that do not necessitate the development of finite element models are developed.

MamtaR.Zade.etal.[2]Stress and fatigue tests were performed on crane hooks made of various materials during the study. When compared to rectangular, circular, and triangular cross sections, trapezoidal cross section hooks are preferred. The trapozoidal cross section is chosen for extrastatic structural investigation using various materials. The analytical technique is used in the development of the hook. After the analytical technique is completed, the hook is designed and modelled in modelling software (CATIA). Furthermore, the FEA is performed with ANSYS. Workbench for project work. We can better understand how FEA works by comparing its results to those of other materials such as aluminium alloy, structural steel, and wrought iron. The material for the crane hook is chosen based on the structural study findings.

M. Shaban et. al [3], ABAQUS software was used to study the stress distribution of the crane hook in its loading condition, and a solid model of the crane hook was generated. Using a 3D model of a crane hook, a real-time arrangement of stress concentration is obtained. The shadow optical method is used to assess the accuracy of the stress distribution configuration on an acrylic model of a crane hook (Caustic method). The crane's geometry is changed after identifying the stress concentration area to increase working life and reduce letdown rates. The overall goal of the project is to develop a finite element analysis (FEA) approach for stress measurement by evaluating the results. Accurately estimating stresses and their magnitudes, as well as their likely locations, is an important part of minimizing hook failure.

RashmiUddanwadiker[4],The crane hook's stress was assessed using the finite element method, and the results were confirmed using photo elasticity. The birefringence property is used in the photo elasticity test. Two phases of analysis were required to evaluate the stress pattern within the hook under loaded conditions. The first step was to perform a FEM stress analysis on a rough model, followed by a photo elastic experiment to validate the results. Second, assuming the hook is a curved beam and confirming this with an actual hook finite element model. When the ANSYS results were compared to the analytical calculations, it was discovered that the results were within a tiny percentage error of 8.26 percent. On the basis of the stress concentration area, form alterations were madetothehook in orderto boostitsoverall strength and durability.

SpasojeTrifkovic'et.al[5],The stress condition in the hook is investigated in this study using both approximate and precise methods. They first assumed the hook material was a straight beam, then a curved beam, and computed stresses in various hook material locations. Analytical techniques, including the use of FEM, were used with computers.

Takuma Nishimura et al. [6] Researchers investigated damage factors for crane hooks in order to recognise the load situation's trend. The loading conditions are thought to have contributed to the crane-hook damage. They used finite element modelling to investigate the relationship between the load condition and material deformation. As a result of their efforts, the load condition is located between the most downward and tip-end locations, the load direction is in the direction of gravity, and the tip-end stress is minimised. It is necessary to create a load-deformation database that contains the relationship between the crane hook's load condition and its deformation using numerical computation.

E. Narvydas.et al. [7] The amount of tension was determined by focusing on shallow notches and the smooth lifting hook. Furthermore, he believed that the stress concentration factor was especially important when assessing machine durability and components. The obtained result is used in conjunction with a generic stress concentration factor equation that does not necessitate the use of FEM. Stress concentration factors at the shallow notches of trapezoidal cross-section lifting hooks were determined by fitting the prescribed general equations to the FEA data and comparing the results to the shallow notches and smooth trapezoidal cross-section hooks investigated in this study. Furthermore, the difference between the results of the fitted equations and the FEA findings was around 3%.Theliftinghooksmustbemadeofductilematerial,accordingto his designguideline,in order to avoidbrittle failure.

TripathiYogesh .et al. [8] A FEM analysis was performed to investigate the stress distribution of a crane hook in its loaded state, for which a solid model was created using CATIA and analysis was performed using ANSY 14.0. For the outcome's validity, the stress in the hook is compared to the Winker- Bach theory. The Winkler-Bach stresses for curved beams are compared to the results obtained using ANSYS software. The results are quite close, with a percentage error of 10.36 percent. And his research concluded that the entire study is an effort to build a Finite Element process based on SOLIDWORKS SIMULATION for the measurement of stress with Winkler- Bach theory for curved beams by validating the results.

Y. Torres.et al. [9] The cause of the crane hook breaking while in operation has been established. In these studies, researchers compared UNE 58-509-79 to UNE 1677-1 and 1677-5, as well as the experimental outcomes of these standards. The method also includes a visual and microscopic examination of the hook's temperature history and chemical makeup. Finally, to reduce or eliminate hook failures, they've decided on the following solutions. Electric melting furnaces and oxygen converters must be used to create the steel product. Additional studies show that aluminium should be largerthan0.025percent,nitrogenshouldbelessthan0.0075percent,andsulphurcannotexceed 0.03 %.

PrashantR.etal.[10]has conducted structural analysis and crane hook performance improvement research in addition, compare the crane hook manufacturing process. Because forging produces crane hooks that are significantly stronger than casting, forging is preferred over casting. Forging is less expensive than casting. The reason for this is that residual strains remain as a result of the non-uniform solidification process when molten metal solidifies. As a result, casted crane hooks are unable to withstand massive tensile strains. And making a decision lowers the cost of materials while increasing the stress level.Finally, based on the stress analysis results, it was discovered that the cross section of the maximum stress area. The amount of stress that occurs can be reduced by increasing the area on the inner side of the hook at the maximum stress region. According to an analytical calculation, increasing the thickness by 3 mm reduces stresses by 18%. As a result, it is possible to modify the design by increasing the thickness of the inner curve, which significantly reduces the likelihood of failure.

Amandeep Singh. Et al. [11] Using the study's data, multiple options for a 30 tonne capacity are determined by varying the lengths of two parallel sides of the cross-section. As a result, it is less difficult to make and less expensive. We taught 24 candidates to lift 30 tonnes by varying the cross sectional dimensions of the hook based on weight, maximum stress, and total deformations. This assessment is used to select the top three candidates from among the 24 applications received. A fatigue study is performed on these most capable individuals. AISI 4340 150. Aside from the mechanical properties of AISI 4340 150, there are also fatigue metrics. According to the results of a fatigue study conducted on the candidate, Candidate No.3 had the best fatigue life of any of the other two, with a minimum fatigue life of 8.805E7repeats. Candidate No. 3 was chosen as the best candidate after this model was compared to a genuine crane hook.

Jayesh Rajendra Chopda.et al. [12] The lifting capability of the working load was set to 50 kN for the purposes of this study. All of these are critical components of EOT development, analysis, and optimization. The crane hook is now in position. It was decided to model the system in ProEngineer and then analyse the results in ANSYS. Shape optimization is a technique for completing optimization assignments. Furthermore, stress concentration affects cross-sectional dimensions. The geometry of the crane hook varies depending on the cross-section form. Twelve sections are built and used to change the size. There are six iterations total, with each iteration occurring at a different point on the hook. Item 6 is thenpicked as the most efficient one, based on the comparison of all other iterations to this basecase (the typical hook).

CONCLUSION

The results of each updated modelling crane hook must be compared to the results of a standard crane hook in order to decide whether the maximum Von-Misses stress and total deformation of models -1 and -2 are raised. The standard crane hook, which is included in both the model-1 and model-2 crane hook variants, is less fatigue resistant. The maximum Von-Misses stress is decreasing as overall deformation increases. The fatigue-resistant crane hook has a much longer life span than standard crane hooks.

The model-2 crane hook was then chosen as the best crane hook model. We can obtain the following conclusion using the model-2 crane hook analysis, which meets the thesis's main goal.

According to the manufacturer, the fatigue life of the Model-2 crane hook is superior to that of the standard crane hook and has been increased by 22.78 percent when compared to the standard crane hook.

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