The International Conference on Research Perspectives : IoT in Hybrid Grid Integrated Renewable Energy Sources
In association with International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)

A Studies on Static Analysis of Link Chain - A Case Study

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ABSTRACT
Industrial companies, manufacturing factories use chains as the basic equipment to carry the raw material, move equipment one location to another for process. Ships use theses chains link or slings for lifting loads. Bigger link chains are as anchor chains. In this study, 3D modelling and FE analysis were performed taking the two models of a link chain, one non-welded model and another welded model. The static study on these models is done at different load conditions. The stress- strain concentrations and the deflection of the models on loading is observed. This study gives the stress-strain concentration patterns on the model on different loads and observe the locations where the minimum and maximum concentration occurs and where the maximum and minimum deformations take are observed on applying different load conditions. In this paper, we study the stress- strain concentrations, deflection on different load conditions on both non-welded and welded models of a link chain specimen.

Keywords : Chain Link, FE Analysis, Welded, Non-Welded, Lifting Load.

I. INTRODUCTION

Industrial or manufacturing units use chain link for the moving, lifting heavy equipment, loads to different locations for different processes. In ships these chain links are used for carrying containers, using anchor chain to hold the ships from moving. We need to study the effects of chains links when they carry load or when the loads are acting on them. Thus we need study effects of loads, at what loads the maximum yielding it takes etc. A chain consisting of consecutively connected metal rings, is usually used to crane heavy weight materials and hot parts in industry, due to its rigidity and strong resistance to heat and corrosion. In this study, 3D modelling and FE analysis were performed taking the two models of a link chain, one non-welded model and other welded model. Comparison between the two models considering the conditions of different load applications and observing the change in the stress-strain concentrations happening in the models and the deformation on load applications are observed on different load conditions. or this study, model is done using the solid works 3D modelling software and static load analysis is done using solid works simulation software. A chain is a serial assembly of connected pieces, called links, typically made of metal, with an overall character similar to that of a rope in that it is flexible and curved in compression but linear, rigid, and load-bearing in tension. A chain may consist of two or more links. Chain, series of links, usually of metal, joined together to form a flexible connector for various purposes, such as holding, pulling, hoisting, hauling, conveying, and transmitting power.

Fig 1. Chain Link

II. SELECTION OF THE MATERIAL

The chain link is a part of a series of connected links to make sling chain that are used for the lifting the heavy equipment, concrete blocks, containers etc. Chain link in series is connected to form slings of chain, having capability of lifting loads that can be measured in terms of tons. Chain link since used for lifting heavy load, it comprises of material having high strength, resistance to heat and corrosion effects, able to withstand sudden impact variations, long life etc.

For this project, AISI 8622 Steel is used for the study. The purpose of using this material is that it gives high strength, it has resistance to heat property, resistance to corrosion effects. These link chains are used in production factories for lifting heavy goods, since there will be application lifting hot product during the manufacturing products. In shipping industries where there will contact with water, thus corrosion effect might take action. To encounter these effects, the material AISI 8622 steel which is a Grade 80 steel is used in this study.

III. AISI 8622 STEEL SPECIFICATIONS

A. Chemical composition

Compartment	Composition of chemical (%)									
	C	Si	Mn	P	S	Ni	Cr	Mo	Cu	Fe
SPEC (AISI 8622)	0.20-0.25	0.15-0.35	0.70-0.90	Less than 0.035	Less than 0.040	0.40-0.70	0.40-0.60	0.15-0.25	-	Rest
Crane chain	0.244	0.160	0.758	0.011	0.007	0.537	0.332	0.174	0.081	Rest

Table 1. chemical Combination of material

AISI 8622 STEEL (GRADE80) has the above chemical composition, due to addition of the nickel, chromium metal with this, the material gives high strength to the link chain.

B. Mechanical properties of material

PROPERTIES	VALUE	UNIT
Young's Modulus (E)	1.9E+011	Mpa
Poisson's Ratio	0.29	-
Tensile Ultimate Strength	1598.79	Mpa
Tensile Yield Strength	800	Mpa
Density	7800	$\frac{kg}{m^3}$
Thermal Expansion	1.1×10^{-5}	k^{-1}

Table 2. Mechanical properties of material

IV. DESIGN PROCESS

DESIGN and model is done on the solid works modelling software using the standard data for 10mm diameter link chain specifications.

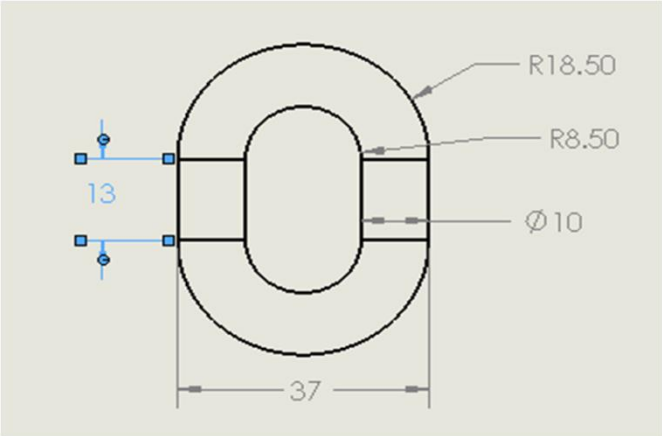

Fig 4. dimension of the model

V. SOLIDWORKS MODEL

The design is done, and the 3D model is created using Solidworks Modelling software. The model is made into equal half sections by cutting the original full

link. This cutting section is made to ease the study process of this project.

One half sections is considered and cut into equal quarter sections and assembling is done and made a weld bead between the two sections to make a welded half chain link. Another half section is considered as non-welded model. Then the two model, are used in the static study process for the comparison of welded and non-welded part for minimum load conditions and observing the difference between values of the two sections of the model.

Fig 6. Non-weld model Fig 5. Link chain solid works model

VI. FEM ANALYSIS

The model of chain link is taken for analysis process using the solid works simulation. The two sections of models are taken and material is applied to the model in the study process. The model is fixed at the top face of the half section of the both welded and non-welded link chains. The meshing is done the models to done on the models using fine meshing property, this meshing gives an effective simulation patterns during the analysis giving accurate load concentrations acting on the models.

The static study gives the stress, strain and displacement plots showing the concentrations of the stress, strain and where the displacement is more are found using this study simulation. The plots help in observing the regions or locations where the concentration is acting maximum and minimum.

The main analysis in this study is on the chain link where the load at safety working limit is taken from the standard loading data for the taken dimension of the chain link and observe the stress acting on the chain link. Chain considered is taken as two section A-A in vertical direction and section B-B in horizontal direction and observing the stress concentration acting the model at safety working load of 31392 N. The FEA stress value at maximum and minimum locations are compared with the numerical calculated values and the error percentage is noted.

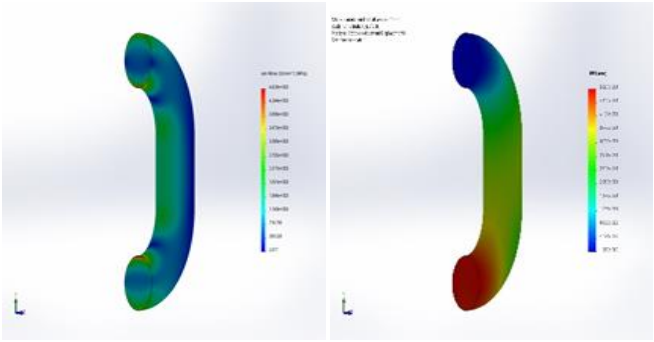

Fig 8. Stress analysis plot Fig. 7 Displacement analysis plot

VII. RESULT & DISCUSSIONS

- The stress concentration acting on the model is maximum along the vertical section A-A where the forces acting vertically downwards.
- The Stress concentration acting on the model is minimum along the section B-B.
- The below results give the theoretical and FEA stress readings at safety working load of force=31392 N.
- The below table 1 shows the comparison between numerical and FEA values and its error percentage.
- Table 2 shows comparison of welded and non-welded models.

Parameter		Welded model		Non-welded model	
	Forces	Minimum stress Mpa	Maximum stress Mpa	Minimum stress Mpa	Maximum stress Mpa
	3000	0.762	586.8	0.8327	580.6
Stress	4000	1.154	779.4	1.397	771.1
	5000	1.312	970.5	2.267	960.1
	3000	1*10^-30	0.457	1*10^-30	0.457
Displacement	4000	1*10^-30	0.604	1*10^-30	0.604
	5000	1*10^-30	0.749	1*10^-30	0.749
	3000	2.454*10^-6	2.439*10^-3	6.56*10^-6	2.46*10^-3
Strain	4000	5.411*10^-6	3.24*10^-3	1.056*10^-5	3.267*10^-3
	5000	9.712*10^-6	4.035*10^-3	1.566*10^-5	4.069*10^-3

Table 4. Comparison of welded and non-welded model

Node	Numerical stress in MPa	FEA values in MPa	Error in %
Node A inner fibre	2134.03	2232	4.3893
Node A outer fibre	1190.16	1471	19.0917
Node B inner fibre	1027.17	1037	0.9479
Node B outer fibre	461.41	522.67	11.7205

VIII. CONCLUSION

This research deals with a stress analysis for a chain link plate. The stress analysis was performed by Finite element method, and some methods were considered with the suppression of the stress distribution. The main conclusions are as follows.

1) The design proposal for the use of a chain link symmetrically constrained at center will yields a desired stress. Although welded and non-welded comparison was made to understand the residual stress effect on the chain link
2) residual stress is algebraically added to which causes maximum stress at inner fiber in A-A cross section which is corelated in finite element method
3) the non-welded chain link will exhibit better results in terms of stress distribution across the curved beam compared to welded section due to influence of residual stresses during temperature rise in welding process.

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