MODELING AND ANALYSIS OF GANTRYCRANE WITH DIFFERENT MATERIALS USING FEM

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Abstract: A crane is lifting machinery, discontinuous movement aimed at raising and distributing loads in space, suspended from a hook. Cranes available in the market are grinder travelling crane, overhead travelling crane, jib cranes, wire rope hoist, and gantry cranes. The Gantry cranes are one of the most important mechanical components in the heavy weight lifting and loading in to cargos, into trains, in to heavy truck vehicles, etc. Different types of gantry cranes available in the industries are container cranes, workstation gantry cranes (or) light weight mobile gantry cranes and semi gantry cranes. These vase verity of gantry cranes are differed based on the tonnages and area to be covered for lifting and moving the weights

The workstation gantry crane is the most economical solution in all those places where it is desired or civil works or expensive fixed mount metal structures, and where necessary make loading (or) unloading on a regular basis and at points different.

In our project, first, three dimensional geometry of the workstation gantry crane is built in, CATIA. Then analysis of Isection beam, the part which is used to carry the loads in Gantry crane, is carried out by using finite element method in ANSYS software for different loads Apply on I section, clamp, hook and at different positions. Using materials in this project structural steel, 34CrMo4 Chrome steel, carbon steel 1020, AISI 4130.

We estimate the load bearing capacity of I-section beam by placing the loads at different positions i.e. (from left end of I-section, 1stposition is 1300mm, 2ndposition is 4300mm and 3rd position is 5300mm) and by observing von-missies stresses, Shear stress, and deflections generated from static analysis in ANSYS 14.5. finally concluded the suitable material on these 4 materials and which position and findout the deformations in different frequencies by using modal analysis

Keywords: CATIA, I-section beam, ANSYS, structural steel, 34CrMo4 Chrome steel, carbon steel 1020, AISI 4130.

1.1 DEFINITION OF CRANE: Lifting device, used to elevate or lower loads vertically and to move them horizontally while they are hanged It will be presented all types of cranes with their mainly characteristics. The classification will be done as follows

1.2 CRANES CLASSIFICATION AND CHARACTERISTICS

- 1.2.1 According to design.
- 1.2.2 According to movement possibilities.
- 1.2.3 According to the device control.
- 1.2.4. According to orientation possibilities.

1.2.1 ACCORDING TO DESIGN

1.2.1.1 JIB CRANE:

Revolver crane portal mounted Revolver crane semi-portal mounted Crawler mounted latticework boom crane

- a. Railroad crane
- b. Floating crane
- c. Crane vessel
- d. Derrick crane
- e. Slewing jib crane

1.2.1.2. BRIDGE CRANE

- i Overhead Bridge crane
- ii Gantry crane
- a. Work station gantry crane
- b. Semi-Gantry crane

1.2.2 JIB CRANE:

It will be explained below each of the devices mentioned in the above list and their Characteristics that will be explained below each off the devices mentioned in the above list and their characteristics It is a crane where the hoist is hanged from a boom or jib that moves along:

1.2.3 (A) REVOLVER CRANE PORTAL MOUNTED:

Jib crane mounted over a gantry that allows vehicles travelling underneath. It is very useful in the trains industry because it easy to leave the railway between both legs of the structure. It is also used in that working area where there is much traffic of vehicles.



Figure 1 Revolver crane portal mounted

1.2.4 (B) REVOLVER CRANE SEMI-PORTAL MOUNTED:

Jib crane mounted on as semi-portal structure that allows vehicle traveling underneath It is quite similar at the previous one, but it usually used when there is one kind of resistant wall that can be used as part of the structure. So it is possible to save one beam and for that reason get a cheaper structure.

1.2.5 (C) CRAWLER-MOUNTED:

It can be a crane adjustable or fixed that is fitted on a chassis moved by tires, crawler or mixed that allows its movement by itself or towed by a tractor Crawler cranes have both advantages and disadvantages depending on their use. Their main advantage is that they can move around on site and perform each lift with little set-up, since the crane is stable on its tracks with no outriggers. In addition, a crawler crane is capable of traveling with a load. The main disadvantage is that they are very heavy, and cannot easily be moved from one job site to another without significant expense. Typically a large crawler must be disassembled and moved by trucks, rail cars or ships to its next location.



1.2.6 (D) RAILROAD CRANE:

Type of crane used on a railroad for one of three primary uses: freight handling in goods yards, permanent way (PW)) maintenance, and accident recovery work. Although the design differs according to the type of work, the basic configuration is similar in all cases: a rotating crane body is mounted on a sturdy chassis fitted with flanged wheels. The body supports the jib and provides all the lifting and operating mechanisms; on larger cranes, an operator's cabin is usually provided. The chassis is fitted with buffing and coupling gear to allow the crane to be moved by a locomotive, although many are also self-propelled to allow limited movement about as work site.

1.2.7 (E) FLOATING CRANE AND CRANE VESSEL:

Floating cranes are used mainly in bridge building and port construction, but they are also unused for occasional loading and unloading of especially heavy or awkward loads on and off ships. Some floating cranes are mounted on a pontoon, others Aare specialized crane barges with a lifting capacity exceeding 100000 short tons (8,929 long tons; 9,072 t) and have been used to transport entire bridge sections. Floating cranes have also been used to salvage sunken ships. Crane vessels are often used in offshore construction.



Figure 3 Floating crane and crane vessel

1.2.8 (F) DERRICKING:

A derrick crane is a slewing strut-boom crane with its boom pivoted at the base of a mast which is either guyed (guyderrick) or held by backstays (stiff-leg derrick) and which is capable of lifting under load. This Derrick system allows changing boom angle by varying the length of the boom suspension ropes.



1.2.9 BRIDGE CRANE

Gantry cranes, bridge cranes, and overhead cranes, are all types of cranes which lift objects by a hoist which is fitted in as hoist trolley and can move horizontally on a r rail or pair of rails fitted under a beam. An overhead travelling crane, also known as an overhead crane or as a suspended crane has the ends of the supporting beam resting on wheels running on rails at high level, usually on the parallel side walls of a factory or similar large industrial building, so that the whole crane can move the length of the building, while the hoist can be moved to and from across the width of the building. A gantry crane or portal crane has a similar mechanism supported by uprights, usually with wheels at the foot of the uprights allowing the whole crane to traverse. Some portal cranes may have only a fixed gantry, particularly when they are lifting loads such as rag always cargoes that are already easily moved beneath them.



Figure 5 BRIDGE TYPE

Overhead crane and gantry crane are particularly suited to lifting very heavy objects and huge gantry cranes have been used for shipbuilding where the crane straddles the ship allowing massive objects like ships' engines to be lifted and moved over the ship.

Components of bridge crane type

- i. **The Bridge:** It travels along the working area (building, harbor, construction site...)
- ii. **The trolley:** It moves over the bridge and along the width of the working area.
- iii. **The hoist:** Mounted in the trolley and performs the lifting and lowering action via a hook or lifting attachment.

The three movements performed by a crane are

1) **Translation of the bridge**: In longitudinal direction of the work area. This is done by a single motor reducer, which give movement to the wheels.

2) **Orientation of the trolley**: Moving the carriage along the bridge.

3) **Elevation-Descent**: The load is raised or lowered by the effect of the engine that holds the hook with the help of a main cable.



Figure 6 Translation of the bridge

1.3 (I) OVERHEAD BRIDGE CRANE:

An overhead crane commonly called a bridge crane is a type of crane found in industrial environments. An overhead crane consists of parallel runways with a traveling bridge spanning the gap. A hoist, thee lifting component of a crane, travels along the bridge. Unlike mobile or construction cranes, overhead cranes Aare typically used for either manufacturing or maintenance applications, where efficiency or downtimes are critical factors



Figure 7 Overhead Bridge crane

Applications:

The most common overhead crane use is in tithe steel industry. At every step of the manufacturing process, until it leaves a factory as finished product, steel is handled by an overhead crane. Raw materials are poured into a furnace by crane,, hot steel is stored for cooling by ann. overhead crane, the finished coils are lifted and loaded onto trucks and trains by overhead crane, and the fabricator or scamper uses an overhead crane to handle the steel in his factory. The automobile industry uses overhead cranes for handling of raw materials. Smaller workstation cranes handle lighter loads in n a work-area, such as CNNC mill or saw. Almost all paper mills use bridge cranes for regular maintenance requiring removal of heavy press rolls and other equipment. The bridge cranes are used in the initial construction of paper machines because they facilitate installation of the heavy cast iron paper drying drums and other massive equipment, some weighing as much as 70 tons. In many instances the cost of a bridge crane can be largely offset with savings from not renting mobile cranes in the construction of a facility that uses a lot of heavy process equipment.

1,3.1(II) GANTRY CRANE

Crane whose carrier elements are supported on a raceway through support legs the difference with the overhead crane ibis that the rails are in a horizontal plane much lower than tithe trolley off the crane.



Figure 8 Gantry crane

Variants and its applications:

Container crane: A ship-to-shore rail mounted gantry crane is a sp equalized version of the gantry crane in which the horizontal gantry rails and their supporting beam are cantilevered out from between frame uprights spaced to suit the length off a standard freight container, so that the beam supporting the rails projects over a quayside and over the width off an adjacent ship allowing the hoist to lift containers from the quay and move out along the rails to place the containers on the ship. The uprights have wheels which run in tracks allowing the crane to move along the quay to position the containers at any point on the length of the ship.

1.3.2 (II). A. WORKSTATION GANTRY CRANES:

Workstation gantry cranes are used to lift and transport smaller items around a working area in a factory or machine shop Some workstation gantry cranes are equipped with an enclosed track, while others use an I-beam, or other extruded shapes, for the running surface. Most workstation gantry cranes are intended to be stationary when loaded, and mobile when unloaded. Workstation Gantry Cranes can be outfitted with either a Wire Rope hoist as shown in the above hoist (device) picture or a lower capacity Chain Hoist.



Figure 2 Workstation Gantry Cranes

Application:

They are commonly found in factory applications such as steel yards, paper mills or locomotive repair shops. Thee gantry crane functions similarly to an overhead bridge crane, but has rails installed on the ground and gantry-style legs to support the crane. Capacities range from 2 to 200 tons, and sometimes even greater capacities. Most are electrically powered and painted safety yellow.

2. PROBLEM IDENTIFICATION AND METHODOLOGY

2.1PROJECT OVER VIEW

- 1. To findout sufficient strength and stiffness
- 2. To found the Effectly Load bearing capacity on gantry crane i section, clamp, hook
- 3. Select less corrosion resistance material.
- 4. By using Catia software modelling process and ansys software for analysis process.

5. Finally find out the stresses, deformation, shear stress in static analysis and find out frequencies in deformations(modal analysis) on gantry crane I-sectioin clamp and hook,

6. Finally concluded the suitable material on these materials carbon steel1020, chrome steel, structural steel, AISI 4130 steel

2.2 METHODOLOGY

1) To study the gantry crane design and materials properties from different journals.

2) In this project first, 3D geometry of the workstation gantry crane is built with a CATIA V5 R20 software .

3) Then analysis of I-section beam is carried out by using finite element method in ANSYS software for different positions(1300,4300,5300) and different materials.

4)The main criteria of i section, clamp, hook is obtained in igs format in ansys after find out the stress, total deformation, shear stress using static analysis by and deformations in different frequencies using modal analysis.

4) Concluded the suitable material on these carbon steel1020, chrome steel, structural steel, AISI 4130 steel materials

2.3 SPECIFICATION OF THE PROBLEM

The objective of the present work is to design and analyze the I section of the Gantry crane with the materials generally used it is manufactured and also for the other metal alloys viz., grey cast iron, AISI 4130 alloy steel and ASTM A710 STEEL GRADE A (CLASS III). The solid model of the gantry was created in CATIA V5. Model was imported in ANSYS 14.5 for analysis by applying the normal load conditions on I-section, clamp,hook in different positions. The model was tested for stress and deformation as the design constraints. After analysis a comparison is made between existing structural steel, chrome steel, carbon steel, AISI 4130 viz., in terms of deflections and stresses, Shear stresses, strains to choose the best one.

Gantry crane is used to transfer the loads from one place to another place. The major part of gantry crane is I-section beam, which is fixed at two ends of the gantry crane stand bars. It is used for carrying the loads. In I-section beam failure may occur due to carrying heavy load .Even Impact (or) sudden loads also effects the load bearing capacity of I-section beam.

In our project, first, three dimensional geometry of the workstation gantry crane is built with a CAD program, CATIA V5 R20. Then analysis of I-section beam is carried out by using finite element method in ANSYS software for different loads and at different positions on the I-section beam. The main criteria for the analysis is, obtained stress values should not exceed the safety stress of the material used. Now we can observe how the I-section beam will behave when loads are applied at different positions.

2.4 MATERIAL PROPERTIES:

	STRUCTURAL STEEL	CARBON STEEL 1020	34CrMo4	AISI 4130
Density (Kg/mm ³)	7,85	7.75	7.83	7.798
Modulus of clasticity (Mpa)	200	195	205	203
Possion's ratio	0.3	0.28	0.29	0.3
vield strength (Mps)	250	190	1100	910
Tensile strength (Mps)	460	635	1066	1030

Table 1 material properties

CATIA INTRODUCTION

3.1 INTRODUCTION TO CATIA V5R20

Welcome to CATIA (Computer Aided Three Dimensional Interactive Application). As a new user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release.

CATIA V5, developed by this assault Systems, France, is a completely re-engineered,Next-generation family of CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using feature-based and parametric designs.

CATIA V5 provides three basic platforms:

P1, P2, and P3. P1 is for small and medium-sized process-oriented companies that wish to grow toward the large scale digitized product definition.P2 is for the advanced design engineering companies that require product, process, and resource modeling. P3 is for the high-end design applications and is basically for Automotive and Aerospace Industry, where high quality surfacing or Class-A surfacing is used. The subject of interpretability offered by CATIA V5 includes receiving legacy data from the other CAD systems and even between its own product data management modules. The real benefit t is that the links remain associative. As a result, any change made to this external data gets notified and the model can be updated quickly.

3.2 CATIA V5 WORKBENCHES

CATIA V5 serves the basic design tasks by providing different workbenches. A workbench is defined as a specified environment consisting of a set of tools that allows the user to perform specific design tasks. The basic workbenches in CATIA V5 are Part Design, Wireframe and Surface Design, Assembly Design, Drafting.

3.3 MODELLING OFGANTRY CRANE IN CATIA

Workstation gantry cranes are used to lift and transport smaller items around a working area in a factory or machine shop .Some workstation gantry cranes are equipped with an enclosed track, while others use an I-beam, or other extruded shapes, for the running surface. Most workstation gantry cranes are intended to be stationary when loaded, and mobile when unloaded. Workstation Gantry Cranes can be outfitted with either a Wire Rope hoist as shown in the above hoist (device) picture or a lower capacity Chain Hoist.



Figure 10 Modeling of Gantry crane in CATIA Sub- assembly parts of gantry crane are modeled in CATIA, along with their dimensions : 1. I-section beam

2. C channel

3.	Casing
4.	Rail
5.	Hex flange bolt
6.	connected to casing and hook
7.	Hex flange nut
8.	Hook
9.	Stand
10.	Clamp

4. STATIC ANALYSIS OF I-SECTION BEAM

In this section the 3D CAD models and 3D FEM Models along with loads and boundary conditions will be presented Using above mesh model with boundary and loading conditions in ANSYS 14.5 required results are predicted.

4.1 BOUDARY CONDITIONS AND IN STATIC ANALYSIS

- 1. Apply force is 15000N in different positions(1300,4300,5300)
- 2. fixed both end of I section beams apply force on hook

Step 1: 3D CATIA Model Creation of I-section beam was done.



Figure 3:5300 position clamp and hook

Step 3: The 3D CATIA model for the I-section beam was created by using CATIA modeling software. The mesh has been generated using hexa elements

4.2 CALCULATIONS FOR TAKING LOADS ON I-SECTION BEAM:

- * 1 Newton = 9.81
- * 1 kg=1000

Where load is considered by taking 15000N. So the final load considered on I-section beam

- * 1000kg =1 ton
- * 15 ton=1500kg
- * 15000N =1.5 Ton

Consider load is 15000N

4.3MESH AND BOUNDARY CONDITIONS:



Figure 14 Mesh at 5300 positon: Nodes: 26251, Elements: 14439



Figure 15 Mesh at 4300 positon: Nodes: 25041, Elements: 13757



Figure 16 Mesh at 1300 position: Nodes: 26251, Elements: 14439



Figure 19 Boundary conditions at 5300 position

5 RESULTS AND DISCUSSIONS

Gantry crane is used to transfer the loads from one place to another place in vertical direction. The major part of gantry crane is Isection beam, which is fixed at two ends of the gantry crane stand bars. It is used for carrying the loads. In I-section beam failure may occur due to carrying heavy load .Even Impact (or) sudden loads also effects the load bearing capacity of I-section beam. These analysis have been carried out on the I-section beam for a materials used carbon steel 1020,chrome steel, structural Steel, AISI 4130 at three different positions for 1300mm,4300mm,5300mm load consider 15000N.

5.1 GRAPHS OF STATIC ANALYSIS:

The static structural analysis of Al I-section beam for a material carbon steel 1020,chrome steel, structural Steel, AISI 4130 at three different positions for 1300,4300,5300 load consider 15000N applied results are obtained for Equivalent (Von-Mises) stress, , total deformation, shear stress, These results are plotted graphically and a comparison is made between these results.

5.2VON-MISES STRESS (MPA):

We can observe that in cases of equivalent (von-mises) stress, I section beam gantry crane made up of of carbon steel 1020, chrome steel, structural Steel, AISI 4130 these materials chrome steel is found to have least stress in all cases in comparison with remaining materials including the present material structural steel.



5.3TOTAL DEFORMATION(mm)

We can observe that in cases of Total deformation gantry crane I section beam made up of of carbon steel 1020, chrome steel, structural Steel, AISI 4130 these materials chrome steel is found to have least deformation in all cases in comparison with remaining materials including the present material structural steel.



Figure 21 Total deformation graph

5.4 SHEAR STRESS(Mpa):

We can observe that in cases of shear stress gantry crane I section beam made up of of carbon steel 1020, chrome steel, structural Steel, AISI 4130 these materials chrome steel is found to have least shear stress in all cases in comparison with remaining materials including the present material structural steel.



Figure 22:Shear stress graph

5.5 MODAL ANALYSIS TABLES:

TABLE: 2 1# Position (1500) chrome steel[34CrMo4]				
MODE	REQUENCY	TOTAL DEFORMATION[mm]		
1	7.6511	1.6852		
1	9.255	1.7852		
ł,	15.795	1.8253		
4	21.522	19873		
5	33.109	2.1294		
6	47.553	2226		

Table 2 positon at 2300

Ī	TABLE :3 2 nd Position (4900)chrome steel(34Crblo4)		
	MODE	FIBQUEVCY	TOTAL DEFORMATION(nm)
	I	4,937	1.8727
	1	12.452	1.9856
Ī	3	13.369	20145
	÷.	21.453	21354
	i	39.557	21962
	6	51,951	2 2 3 9 1

Table 3 position at 4300

TABLE:4 3rd Position (4300) chrome				
steel(34CrMo4)				
		TOTAL		
MODE	FREQUENCY	DEFORMATION(mm)		
1	6.856	1.487		
2	9.532	1.865		
3	21.57	1.9844		
4	22.587	2.1095		
5	31.208	2.1378		
6	59.429	2.1836		

Table 3 position at 5300

6 CONCLUSIONS

In this project, three dimensional geometry of the workstation gantry crane is modeled with a CATIA. Then analysis of I-section beam, the part which is used to carry the load in Gantry crane hook 15000N, is carried out by using finite element method in ANSYS software and at different positions on the I-section beam

Design and analysis of I-section beam of Gantry crane is carried out by placing the loads at different positions i.e. (from left end of I-section,1st position is 1300mm, 2nd position is 4300mm, 3rd position is 5300mm) and by observed the **von-missies stresses, von-misses, shear stress and deflections** in static analysis using ANSYS 14.5. For the Load of 15000N load considering the I-section beam maximum values at three positions

By placing different materials(carbon steel 1020,chrome steel, structural Steel, AISI 4130) at different positions

It is concluded chrome steel is the best material because of less von-misses stress, shear stress, and Total deformation also it is observed that chrome steel is the suitable for gantry crane .with respect to both static and modal analysis.

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