Gantry Crane

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***Abstract*—Gantry cranes are used to lift heavy objects with ease and safety. This project has two main requirements: one is to have a maximum lifting capacity of 907kg (2000 lbs) and second is to have a foldable feature that allows the operator to store the crane in small space when it is not being used. The gantry crane built for this project will have similar and different features to other gantry cranes in the market. The crane built for this project will have an adjustable height feature to allow the operator to set the machine at a desired height. Using the same adjustable height feature, the operator can fully lower the height of the crane so that it does not consume more space and other work and experiments can be performed in the same room.**

I. Introduction

An Electromagnetic Shaker which produces mechanical vibrations is used to conduct Hand-Arm Vibrations (HAV) tests in vibrations laboratory. These tests are done by orienting the machine in horizontal position and in overhead position. Moving the machine from horizontal position to overhead position, and vice versa, with less effort requires some sort of crane; in this case it will be a gantry crane. The main function of the gantry crane built for this project is to lift and move this machine which weighs around 227kg (500 lbs). The crane will be able to lift the machine off the concrete base, move it to a desired location and orient it in a desired position. The lifting of the weight will be done using a hoist which will be attached to an I-beam trolly which will allow the operator to move the machine along the length of the I-beam.

The other requirement of the project is to make the crane fit in small space when it is not being used. The crane will have an adjustable height feature which will allow the operator to make the crane shorter to store it in a small space. Additionally, the crane will be able to move with a manual push or pull which allows the operator to move the machine from one position to another. Overall, this crane will save the operator's time and make it less difficult to move the machine from horizontal to overhead position and vice versa.

II. Methods and Materials

A. *Size and Material of the Gantry Crane*

The size of the gantry crane is determined by measuring the area where the Electromagnetic Shaker is kept. The material for the crane is selected by considering the maximum lifting capacity, safety of the operator, and the budget of this project. The materials used for the crane are as follows:

Table 1. Material selected for the gantry crane.

Parts	Material/Specification
Steel I-Beam	ASTM A992/A572-50
Steel Rectangular tube	ASTM A500
Steel flat bar	ASTM A569
Hoist	2000lb Capacity
Trolly	2000lb Capacity

B. *Adjustable Height Mechanism*

As mentioned before, the adjustable height feature will allow the operator to make the gantry crane shorter or taller to either change the height at which the weight needs to be kept or to store the crane in a small space when it is not being used. This feature will work by having the vertical beam through a middle support beam whose cross section will be slightly bigger than the vertical beam's cross section. Fig. 1 below shows the mechanism of this feature. The highlighted piece in the figure is the middle support beam and the beam that goes through it is the vertical beam. This mechanism will allow the vertical beam to slide up and down which will change the height of the crane and the holes on the vertical beam will allow the operator to lock the height of the crane by inserting a pin through the lined-up holes of vertical beam and middle support beam.

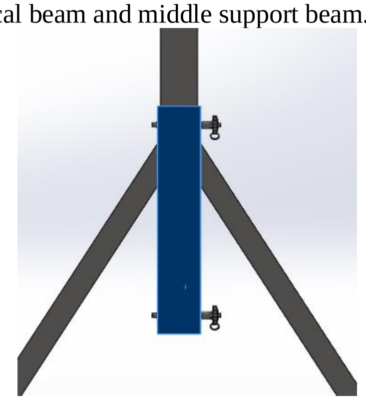

Figure 1. Adjustable height feature mechanism

C. *Construction of the Gantry Crane*

To construct this gantry crane, several methods such as welding, cutting, drilling, and grinding will be used. First the 3in x 2in rectangular tube are cut into two 1.625m (5.33ft) pieces and four 1.219m (4ft) pieces. The 4in x 3in rectangular tube is cut into two 0.914m (3ft) pieces. The steel flat bar is cut into four 0.1143m x 0.127m (4.5in x 5in) pieces and two 0.1016m x 0.127m (4in x 5in) pieces. Holes are drilled through each of the steel flat bar pieces, the two 1.625m (5.33ft) rectangular tubes, and the two 3ft rectangular tubes. The 60 degrees angled cut is made on one end of 1.219m (4ft) rectangular tubes, and 30 degrees cut on the other end. Then the end with 30 degrees cut is welded to the center of the 0.1143m x 0.127m (4.5in x 5in) steel flat bar pieces, and the end with 60 degrees cut is welded to the 0.914m (3ft) long rectangular tubes. One end of the 1.625m (5.33ft) tubes is welded to 0.1016m x 0.127m (4in x 5in) steel flat bar pieces. Then, the bolts and nuts are used to attach wheels to the 0.1143m x 0.127m (4.5in x 5in) steel flat bar pieces and I-beam to the 0.1016m x 0.127m (4in x 5in) steel flat bar pieces. Finally, the 3in x 2in rectangular tubes are passed through the 4in x 3in rectangular tubes and the metal pins are passed through the lined-up holes in 3in x 2in and 4in x 3in tubes to set the crane at a desired height. Once the gantry crane is constructed, it will look like the crane shown in the figure below.

Figure 2. Structure of the gantry crane

III. Results and Discussion

The analysis of the gantry crane 3D model is done using ANSYS. For this analysis, the model was vertically cut in half and then imported to ANSYS because it was unable to calculate the results as the number of nodes and elements created were higher than the limit. This analysis includes the normal stress, shear stress, principal stress, and total deformation results of the crane when the 2224N (500 lbf) is applied to the crane.

Results	Minimum	Maximum	Units
Equivalent Stress	0.	1.2767e+008	Pa
Maximum Principal Stress	-1.1401e+007	1.3684e+008	Pa
Shear Stress	-5.5741e+006	5.2496e+006	Pa
Total Deformation	0.	3.7638e-004	m
Normal Stress	-2.8398e+007	3.7157e+007	Pa

Figure 3. Result summary from ANSYS

Fig. 3 shows the result of the analysis performed on the gantry crane model. The factor of safety is calculated using the Maximum principal stress value and the yield strength of the overall crane. The factor of safety calculated using the results is 3.023 which is good enough for this gantry crane and confirms that the gantry crane will be able to safely lift the electromagnetic shaker, which weighs around 227kg (500 lbs), and will be safe for the person using it.

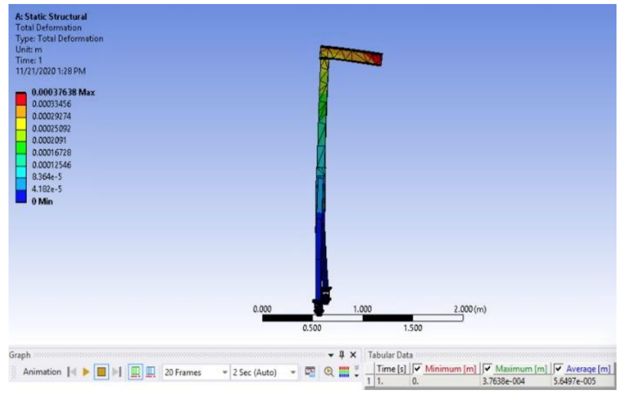

Figure 4. Total deformation

Fig. 4 shows how the crane will deform when the 2224N (500 lbf) is applied. The maximum deformation value is 0.00037638m. This shows that the maximum deformation value is significantly small with respect to the size of the crane and confirms that it will be able to lift the machine without failing the structure.

IV. Conclusion

Gantry cranes are mainly built to lift and move heavy objects with ease and safety. Some are built just to focus on lifting and moving the objects. Whereas some of them are built to offer more functionality to the operator other than lifting and moving. The height changing factor is what makes the gantry crane, built for this project, unique. It allows the operator to not only use it for lifting and moving heavy objects, but also allows the operator to change the height of the crane and to store it in a small space when it is not being used.

Like mentioned before, the gantry crane will be able to lift anything up to 907kg (2000 lbs). It will be very easy and straightforward for the operator to use this crane as long as they follow the steps of using this crane properly and know all the safety issues related to this crane. Overall, this crane will make the task of moving the machine a lot easier and safer.

V. Acknowledgement

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