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Telescoping Boom Cranes: Conceptualization and Analysis

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ABSTRACT

Telescopic boom design, automated boom extension rope system, and the self-compensating rope mechanism are all described here. CAD was used to generate the boom models, which were then verified for accuracy using finite element software. Filler plates were used to strengthen the parts that had been evaluated. Two rope options have been chosen for this investigation that minimise human participation in the extension process in order to reduce the danger of boom failure.

This research investigates the String Mechanism, Finite Element Analysis, and Telescopic Boom.

INTRODUCTION

Cranes are able to lift and lower items as well as move them from one point to another thanks to the use of wire ropes, chains, and sheaves. Telescoping boom assembly is the most important part of the pick and carry crane. This arrangement may employ anywhere from three to ten components. This project calls for the use of a crane with five boom sections and two rope control systems. Maximum loading conditions were considered throughout the design and analysis. It might be for any of the following:

- Access to a wider range of options
- Adjusting the rope may be done in two ways:
- Boom cross-sectional measures are shown in Figure 1.
- For the optimal weight/strength ratio, you may want to choose the right materials.
- Boom parts may be made in SolidWorks
- ANSYS software is used to simulate the boom components.
- Stiffener plates should be used in regions where research demonstrates they are essential.
- According to sectional failures, boom length is established.
- It's possible to categorise the assembly's components into the following:
- The album's opening song is titled Mother Boom.
- There are two boom parts in the centre (3 in number)
- Suggestions for the 3rd section
- Rope mechanisms are utilised to stretch the booms.

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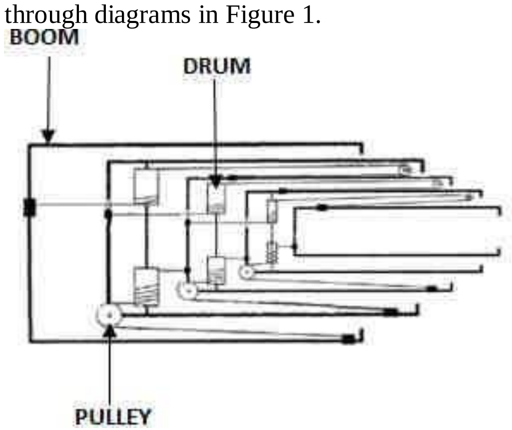
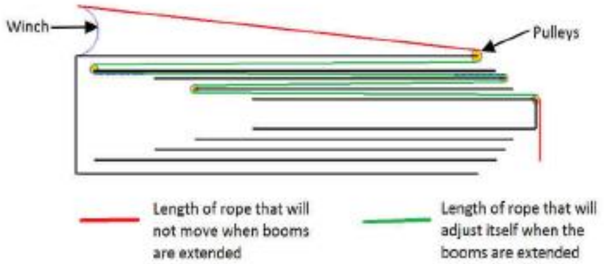
Typically, the extensions are operated by separate levers. As a consequence, the weight of the booms is unevenly distributed among them. A hydraulic cylinder that could extend two booms at the same time was designed by J.L. Grove in 1968, which was subsequently modified for five booms in this study. Using a system of pulleys, drums, and a single piston, each boom segment may be moved in relation to the previous portion. It aids in the uniform distribution of the boom's weight. Having a separate hydraulic system for each boom is also superfluous. The first intermediate element will be pushed by the mother boom's hydraulic piston, and the rope tension will result in the movement of the other booms. Each boom travels a different distance depending on how far the hydraulic piston extends. Mechanics are shown through diagrams in Figure 1.



Using a rope, the booms may be extended as shown in Figure 1.

For self-compensating rope, there is an installation mechanism. For a long time, extending the boom components required the operator to physically extend the rope. If the operator makes a mistake, the rope tension might increase. A pulley mechanism is used to alleviate this issue. While extending a boom component, the operator is required to physically stretch the rope. As a result, rope tension might rise if an operator commits an error. This issue is solved by using a pulley system.



An illustration of the self-compensating rope device may be seen in Fig. 2.

COST ANALYSIS FOR PROJECTS

The calculations were based on SAE J1078, which covers failure modes for boom components such as bending, shearing, and tensile. Multiple iterations were made by altering the material, thickness of the metal sheets, and cross section of the metal sheets after the completion of the design calculations[3].

The following are some of the most important design considerations:

The material's yield strength

The thickness of the metal sheets is the second factor to take into account. Dimensions of the cross-section (height and width) TABLE 1 summarises the results of these calculations in terms of boom section size. The cross section of anything varies as the material or thickness is altered.

Table 1: Boom section dimensions derived from calculations

Part	Material yield Strength (MPa)	Thick-ness (mm)	Height (mm)	Width (mm)
Tip Boom	410	8	150	110
Boom 4	410	8	242	208
Boom 3	410	8	334	300
Boom 2	410	8	426	393
Mother Boom	410	8	520	486
Tip Boom	250	8	185	150
Boom 4	250	8	277	242
Boom 3	250	8	370	333

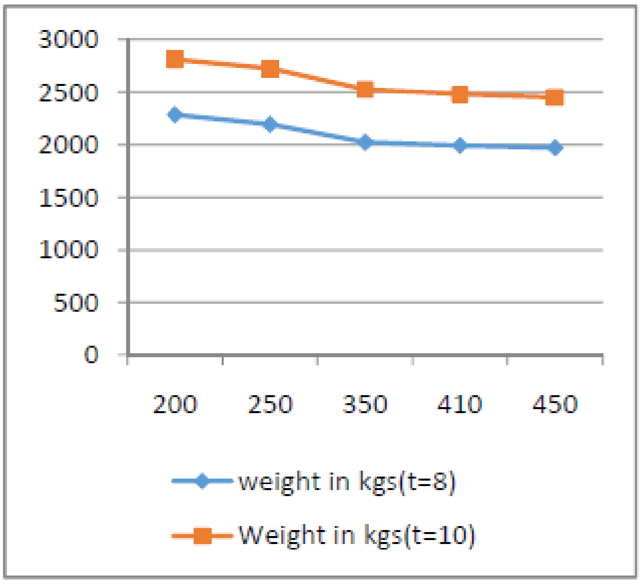
Sheet metal's composition

Material selection is dependent on a number of factors, including the availability, machinability, weldability, yield strength, and cost of the material under discussion. To put it another way,

selected is mild steel IS2062 E-250 and its properties[4] are as given below:

Ultimate tensile strength (min.)	410 MPa
Yield Strength (min.)	230-250 MPa
Percentage Elongation	23
Bend Test	25 mm
Mass Density	7.85 kg/m3
Poisson's Ratio	0.29

Fig. 3 shows the variation in weight of material used with change in material used. The graph is plotted for two different thicknesses of 8mm and 10mm respectively. The graph has yield strength (N/mm^2) on X-axis and weight(kgs) on Y-axis.



Each material change is shown graphically in Fig. 3 as a bar graph representing the overall weight of the boom.

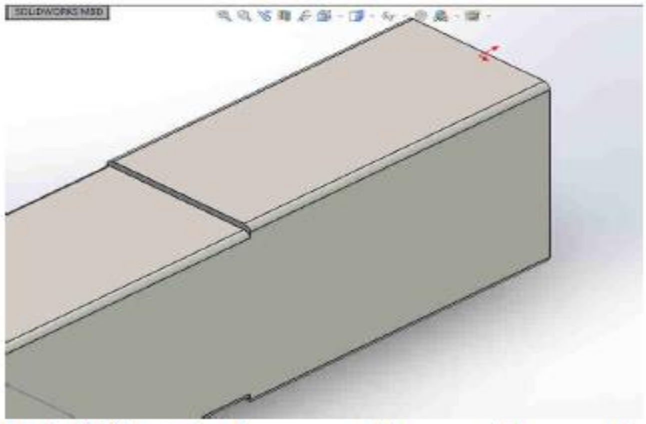
Metal sheet thickness

For weldability concerns, a thickness of at least 4mm is required because of the concentrated load at the connection and the lack of fatigue strength in the boom. It's best to keep the thickness of the check no thicker than 12 mm if the weight of the material is considered. Table 1 shows that when material thickness increases, so does the cross-sectional area, as can be seen. The thickness of the plates selected is 10 millimetres. Booms in cross-sections.

In order to determine the cross-sectional dimensions of each boom, engineers rely on the SAE J1078 standard. While designing the tip section's characteristics, consideration was given to cross-sectional area, yield strength, and material thickness (height and width). Clearances were taken into consideration while calculating the cross-sectional dimensions of the other booms. Mechanisms and bearing pads are accommodated by allowing 1.5" to 2" between boom sections. SAE J1078 was used to verify this set of measurements.

STIFFENERS

In order to prevent the web from buckling or deteriorating, a bar, angle, channel, or other attachment is often used. The Analysis part of the paper compares stiffer and non-stiffened regions. Stiffeners shield critical boom components. Appendix 4 depicts the boom stiffeners, as seen in Figure 4. After ANSYS software analysed the model, stiffener locations were discovered. Figures 11 and 12 show the intermediate boom before and after the stiffener plates were placed (Von Mises stresses). Figures 13 and 14 illustrate how stiffener plates were added to the intermediate boom to make it more rigid. When stiffener plates are fitted, they reduce deformation and stress dramatically.



The boom section's intermediate boom has a stiffener connected to both the top and bottom of the boom section. It's a Good Material for Keeping Things Safe.

Each boom is supported by a bearing pad or wear pad as a safety measure. In certain cases, there may be an adaptable cushioning element that may be tailored to each pad element's specific loading or stress requirements. 150x30x150 mm t. mm thick bearing pads are offered. When calculating thickness, the distance between booms is critical. [7] On the surface of the boom, there is a 2 mm groove that enables the boom assembly to move freely. Nylon 6,6 is used to make these pads. With the bearing in the middle, booms are shown in Figure 5.

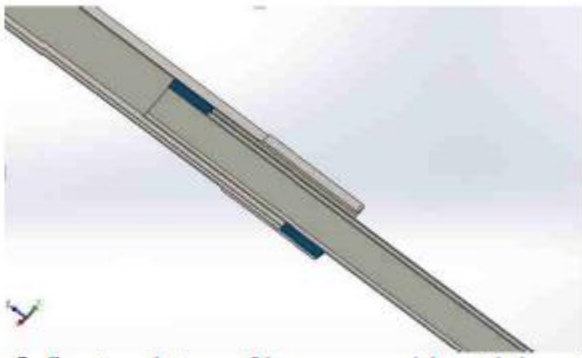


Figure 5 shows a cross-section of the boom assembly with bearings.

ANALYSIS

Instead of assessing the whole telescopic boom assembly as a whole, each boom was evaluated individually[8]. This was done to ensure that there would be no more problems and to make it as easy as possible to locate the source of the problem. The booms were believed to be completely extended in order to locate critical regions. Introducing a New Class of Models The boom models were created in SolidWorks'13. The selected material was ISC2048 E-250. Design calculations yielded the booms' matching measurements. Figure 6 shows a boom model with a tip portion.

Figure 6 shows a model of the tip piece. loading and unloading, as well as a variety of other situations

The research was conducted with the aid of ANSYS16.2 software. In this case, the previous boom's overhang is considered to be permanent. Next boom's overhang is employed to distribute loads. With the boom's reflexes, it may be possible to provide the boom in front of it a greater amount of force. The self-weight of the boom is determined by its centre of gravity. According to the manufacturer's specs, the crane can lift 14 metric tonnes and carry a payload of 1.5 metric tonnes when fully extended.

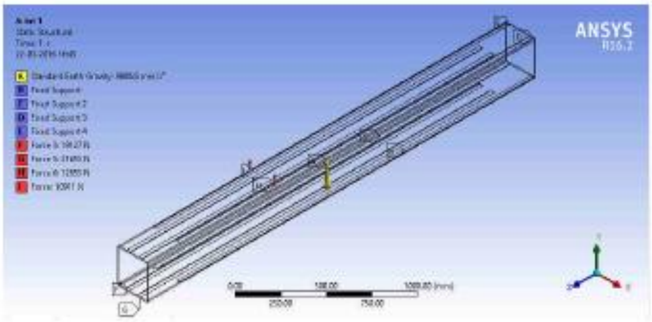


Fig.7: Boundary and loading conditions for intermediate boom without using stiffener

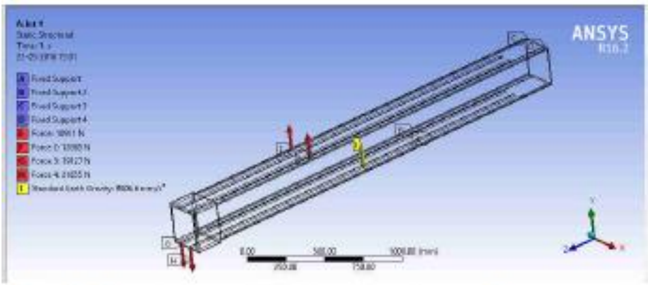


Figure 8: Intermediate boom stiffener boundary and loading conditions

Figures 7 and 8 depict the boom under boundary and loading circumstances before and after stiffener addition, respectively.

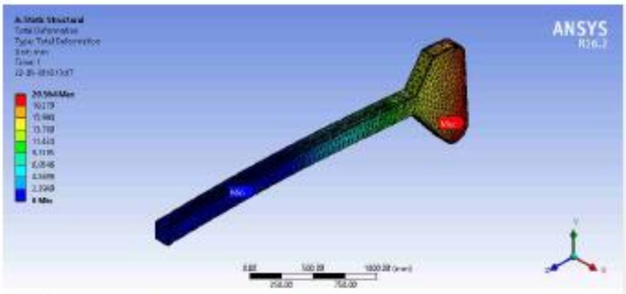


Fig.9: Total deformation of tip section

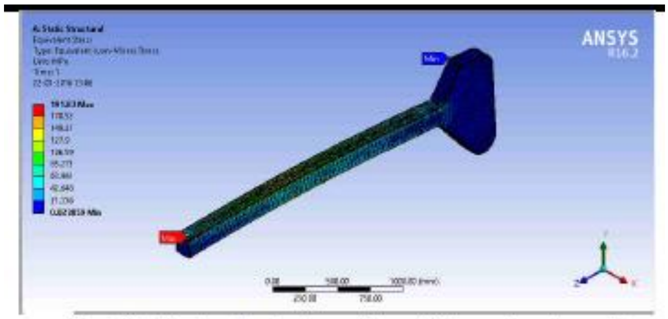


Fig.10: Equivalent stress (Von-Mises stress) on tip section

Figures 11 and 13 depict the co-stresses, whereas Figures 12 and 14 show the co-stresses with and without stiffeners, respectively.

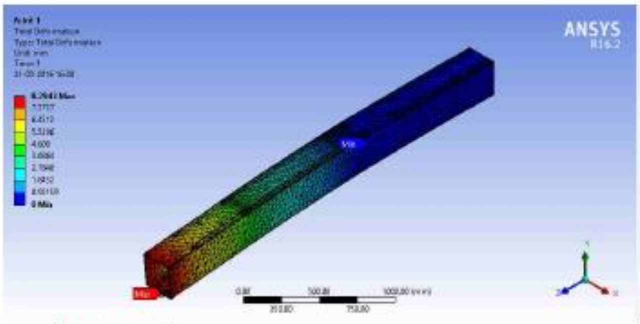


Fig.11: Total deformation of intermediate section without using stiffener

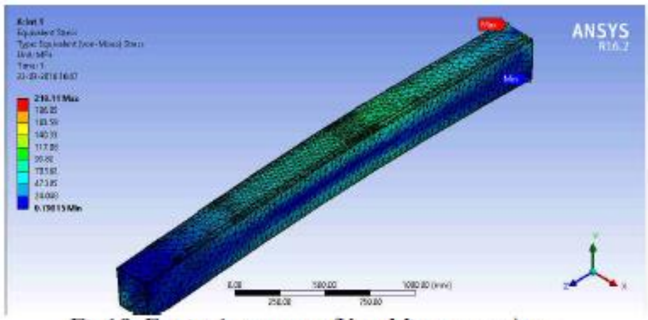


Fig12. Equivalent stress (Von-Mises stress) on intermediate section without using stiffener

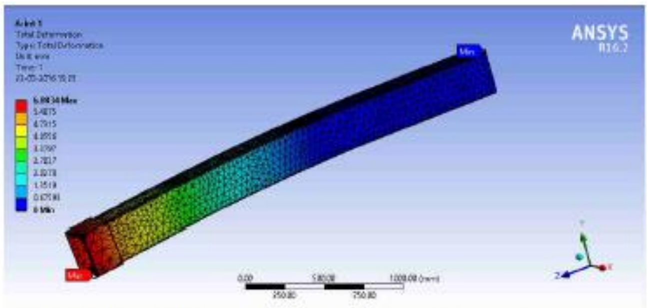
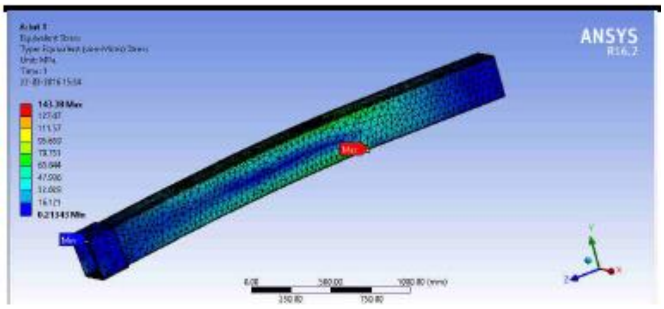


Fig.13: Total deformation of intermediate section using stiffener



A stiffener in the intermediate segment reduces the equivalent stress (also known as the Von-Mises stress)

If the stiffeners hadn't been employed, the boom's centre would have distorted by 8 millimetres. When the stiffener was applied, the distortion was decreased to 6.08mm. Without stiffeners, the maximum equivalent stress in the middle boom section was estimated at 210 MPa. After applying the stiffener, the stress decreased to 143.38 MPa.

CONCLUSION

It has been suggested in a recent research that crane booms built using CAD and FEA may be thoroughly tested using a number of approaches to guarantee that they work as intended. Utilizing this approach in future study and design efforts may be beneficial. There are no small attachments like a pulley or spring in analytical models for the purpose of convenience. They have little impact on the loading factor since the overall load is so great. A finite element analysis of the SolidWorks'13 boom pieces was performed using ANSYS16.2 software. The structure's support plates.

After the test, it was less stressful and anxiety-inducing. Use of deflections in non-essential areas is a waste of time and money. Stress levels exceeded expectations.

According to the design specifications, these materials' tensile and yield strengths. Lifting a total of 14 tonnes is possible with this design. In the future, mobile crane boom cross-section shapes may be investigated to determine the optimal design.

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