Here, in this case the resistance to torsional buckling needs not to be checked, by clause (8.2.2)[3]

These all the calculations were done for the actual initial cross section of the boom in a excel sheet.

3. Optimization

For the optimization of the objective function above designed problem was solved using Evolutionary algorithm bundled with Microsoft Excel Spread sheet programmer 2010.The designed problem was written on the Excel sheet and the constraints were fed to the invoked dialog box along with the target cell.

The weight applied to solve this problem was kept fixed to 18604N, which actually changes along with change in cross section of the boom.

For the solver, the integer optimality was 0.5%, and convergence 0.0001, mutation rate 0.075 was used. Then solver was asked to solve the problem. It was found that the solver was exploiting the stress level constraint and giving 110MPa for compressive stress, which was highest limit for compressive stress, and was showing savings in cross sectional area at great extent, which is impractical. Further several trials were made at different stress levels, i.e. the constraint of the compressive stress was reduced from 110MPa to 95, 90, 85 etc. and several optimized Areas for respective stress level were found by running the algorithm.

The obtained various scenarios and obtained solution were compared. Figure 3shows the area for respective stress level.

4. Result and Discussion

The obtained various scenarios and obtained solution were compared. Figure 3 shows the optimized area for respective stress level. Whereas the figure 4 shows the bending moment and deflection at optimized area at various stress level. For the crane under consideration, during the regular use and for the specified life (Fatigue life), the operating stress has to be between 1/3 to 2/3 of the maximum stress P [2] here the maximum stress selected was 110MPa compressive to which the bottom cover plate was reaching even before the Tension i.e. upper cover plate could reach to its maximum stress i.e. 165MPa. Considering this the optimized area for stress of 2/3P i.e. 73.34 MPa (Compressive) was selected as optimized area.

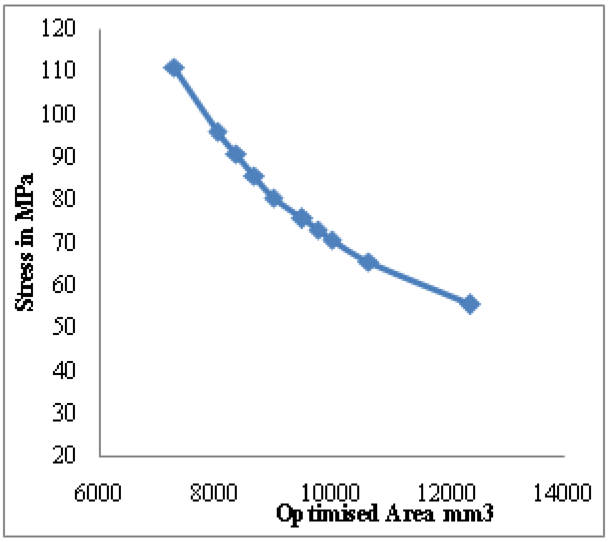
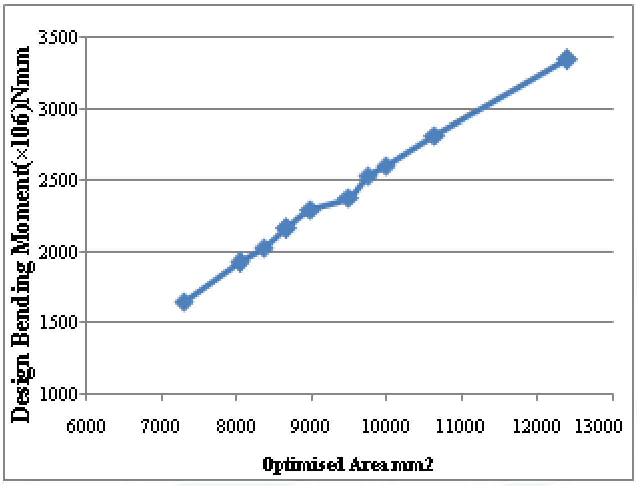


Figure 3: Optimized Area vs. various stress levels

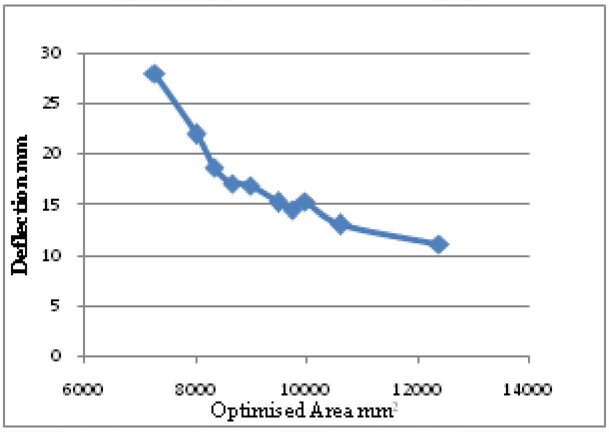
Table 1 shows the comparison between parameters of actual crane. The values of the optimized parameter were rounded off to nearby value. The percentage savings in area without rounding off the values was 21.34% whereas after rounding them off to nearby value it was found to be 18.30%. The savings in the weight of boom was found to be 13%. The results of the optimization model which was fed into the solver did calculation for the cross section which was not the actual one and was considered to be a cross section area with same bottom and top cover plate having same dimensions. If the top and bottom cover plate thickness allowed to change independently, it was found that the savings were higher. Here the results of only one model that was fed to the excel solver i.e. the thickness of the top and bottom flange not changing independently has been shown in Table 1.

Table 1: Comparison of Boom parameters before and after optimization

Parameter	*Boom Before Optimization*	*Boom After Optimization*
Breadth of top and bottom cover plate	300mm	283.89mm
Thickness of top and bottom Cover plate	10mm	7.79 mm
Height of Web	400mm	398.30 mm
Thickness of web	8mm	6.68 mm
Cross section area of boom	12400mm^2	9752.60 mm^2
Plastic section modulus	1471193.65mm^2	1116379.59 mm^2
Elastic section modulus	1607301.59mm^2	1221961.59 mm^2
Design Bending Moment	334362193Nmm	253722635Nmm
Bending Moment due to applied load	85735828.81Nmm	89299200Nmm
Deflection	9.83mm	14.60mm
Bending stress (Tensile) Top cover plate	53.34MPa	73.07MPa
Bending Stress (Compressive) Bottom cover plate	53.34MPa	73.07Mpa
Weight of boom	447.76kg	390.44kg



(a)



(b)

Figure 4: a. Optimized area at various stress level v/s Design Bending Moment, b. Optimized area at various stress level v/s Deflection

5. Conclusion

Optimization of the jib crane is a nonlinear problem, if this problem was considered to be solved by classical method along Kuhn-Tucker condition it becomes too complex and too difficult to solve, hence automated programming has to be used. In this paper it was found that evolutionary algorithm yields satisfactory results and can be used for obtaining the optimized parameters for the crane and the values of parameter found to be feasible and within limits. There are some of the limitation in the presented optimization model such as the weight applied was kept fixed which actually changes along with change in cross sectional area of the boom, which when removed may give encouraging result. It was also found that by changing the mathematical model relation the results varied a little. The crane dimension obtained has to be tested experimentally to found its validity.

References

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