International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

Finite Element Analysis of Inner Boom for 3Tonn Telescopic Forklift

Vilas Randive[1], Prof. D.P.Kamble[2], Prof. Ashish Pawar[3]

[1]PG Scholer, Department of Mechanical Engineering, APCOER, Parvati Pune,
[2,3]Assistant Professor, Department of Mechanical Engineering, APCOER, Parvati Pune, Savitribai Phule Pune University, Pune

---***---

Abstract- The most significant element for load lifting and transport by telescopic hydraulic truck cranes is the boom. The telescopic boom consists of segments that retract or extend during operation. By changing its position in space, the boom of the truck crane transfers load onto the substructure of the machine and the vehicle and represents its most responsible part. Lessening of dead weight of the boom opens the opportunity for increasing the load, the lifting speed as well as the speed of retraction and extension of the segments. Cost of machine plays an significant role for utilization and affordability of machine. High cost of manufacturing results in low sales. Quite a lot of hundred workers die in construction in the United States every year because equipment operators are not capable to see their fellow workers during operation of their vehicle. Visibility outside from driver's seat is an important parameter in safety of fellow workers at the operating environment.

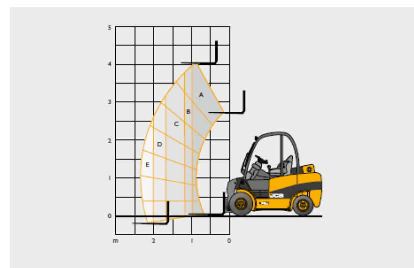
KEYWORDS: Telescopic Boom, Finite Element Analysis, Boom Nose, Safety, Ergonomics, Blind spots, Cost

1. INTRODUCTION

A telescopic handler, also called a telehandler, teleporter, or boom lift, is a machine widely used in agriculture and industry. It is somewhat like a forklift but has a boom (Telescopic cylinder), making it more a crane than a forklift, with the increased versatility of a single telescopic or articulating boom that can extend forwards and upwards from the vehicle. On the end of the boom the operator can fit one of several attachments, such as a bucket, pallet forks, muck grab, or winch.

Fig. 1 Telehandler with boom [Source: Product Brochure]

In industry the most ordinary attachment for a telehandler is pallet forks and the most common purpose is to move loads to and from places unreachable for a conventional forklift. For example, telehandlers have the ability to remove palletized cargo from within a trailer and to place loads on rooftops and other high places. The latter application would otherwise require a crane, which is not always practical or time-efficient.



Capacity bands	TLT30
A	3000 kg
B	2500 kg
C	2000 kg
D	1750 kg
E	1500 kg
@ 2 metres	1750 kg

Fig. 2 Load chart for 3T telehandler [Source: Product Brochure]

With no mast blocking the view ahead as on conventional forklifts, the telehandler unique side mounted boom design provides unrivalled forward visibility. The design also provides total visibility of fork tips and attachments when fully retracted and lowered, even inside containers and particularly when entering a pallet at ground level. The telehandler telescopic forwards reach allows you to unload lorries from one side. This means only one curtain needs opening and no forklift movements around the other side of the lorry are required, ensuring pedestrians stay safe and separate, increasing site safety.When a delivery truck has to park at the roadside, the Teletruk can carry out all unloading from one side so there is no need to travel into the public highway. The Teletruk's telescopic forwards reach allows you to unload lorries from one side. This means only one curtain needs opening and no forklift movements around the other side of the lorry are required, ensuring pedestrians stay safe and separate, increasing site safety.

Thanks to the telescopic boom, you can load and unload a lorry trailer from only one side. This results in up to 50% yard loading space saving; you can use the rest of the loading space for other duties and there is also no need to spend extra time repositioning vehicles around work yards.

The telehandler can often do the work of five machines on site – a conventional masted forklift, skid steer, telescopic handler, compact wheeled loader and rough terrain fork lift – reducing your machine fleet holding and getting more tasks done during every work shift.

2. LITERATURE SURVEY

In Previous study a number of researchers have examined the influence of different parameters on the telehandler boom. Jia Yao et all (May 2015) studied Buckling failure analysis of all-terrain crane telescopic boom section. Jia Yao et all (May 2016) studied the torsional buckling of a telescopic boom section under multi-directional loads is investigated. Mile Savković et all (April 2014) studied resents the analysis of local stress increases at the contact zone between the inner and outer segments of telescopic booms of truck cranes. Navneet Kumar et all (July 2012) gives the introduction about the construction of telescopic boom and different forces and moment acts on the different parts and area while picking up the load. Gurjot Kaur et all (August 2016) states challenges in making high strength and light weight booms. Damian Derlukiewicz et all (2008) has done a range of calculations for designbing telescopic jib mounted platform, including jib profile selection, definition of the stable area of operation etc. Soumitry J. Ray et all (Oct 2011) has done work on Coarse head pose estimation of construction equipment operators to formulate dynamic blind spots. Jimmie W. Hinze et all (Feb 2011) has stated about Visibility-related fatalities related to construction equipment. Jochen Teizer et all (Dec 2009) studied Automating the blind spot measurement of construction equipment has discussed.

3. PROBLEM SPECIFICATION

In the age of globalization and tough competition, the use of machines is increasing for the earth moving works. Substantial attention has been focused on designing of the earth moving equipments. Thus, it is very much necessary for the designers to provide not only an equipment of maximum reliability but also of minimum weight and cost, keeping design safe under all loading conditions. Telescopic boom is a variable reach boom used on telehandlers to mount various attachments. To optimize inner boom nose structure to improve visibility from driver's seat & minimize overall cost of assembly.

4. OBJECTIVES OF PROJECT

The Objective of this work is to Improve visibility from driver's seat & to minimize overall cost of assembly of boom such that stresses acting on structure due to all loading conditions are within the permissible limit

5. METHODOLOGY

a) Problem statement

b) Literature survey

c) CAD Model preparation & FEA of existing boom.

d) Final design & concept modeling

e) FEA of concept model

f) Final design & concept finalization.

g) Experimental Testing

h) Building prototype & testing

i) Production release

6. Finite Element Analysis of Inner Boom of telescopic Forklift

Inner boom of telescopic forklift is consist of Top plate, side plate, Bottom plate, side plate LH, Nose plate LH, Nose plate RH, strengthening block, Torsion box, Extension ram boss, Torsion box front cut out, Spreader plate, Crown ram spacer boss and Inner boom back plate. A detail model of existing & new concept inner boom was prepared in NX 8.5. Existing model for inner boom telescopic forklift is as shown in figure no 3

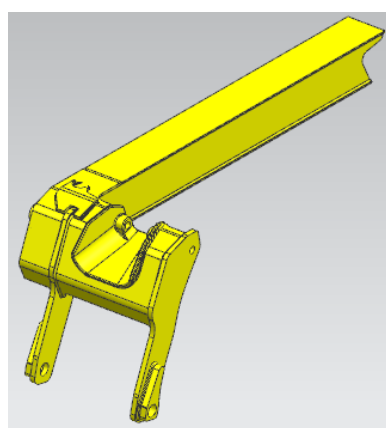


Fig. 3 Existing Inner Boom [Source: CAD Model]

Preapare model is imported in Ansys Workbench 16.0 for finite element analysis. as per generalised FEA procedure model is descrised by giving mesh size as 15mm with Tetrahedron. Mesh model is as shown in figure no 4. Proper contact are defined between mating parts as per working of product.

Table 1:Different load cases considered in FEA for inner boom are as follows

Case No.	Boom Existing / New	Load Case	Position of Boom
1	Existing Boom	3 Tonne; Acceleration 3g,2g,2g in X,Y & Z direction respectively.	0 deg.; Retracted
2		1.5 Tonne	0 deg.; Extended
3		3 Tonne	60deg.; Retracted
4		3 Tonne	60 deg.; Extended
5	New Boom	3 Tonne; Acceleration 3g,2g,2g in X,Y & Z direction respectively.	0 deg.; Retracted
6		1.5 Tonne	0 deg.; Extended
7		3 Tonne	60deg.; Retracted
8		3 Tonne	60 deg.; Extended

Table 2 Mechanical Properties of the material for existing boom

Part	Min.yeild (N/mm^2)	Min.UTS (N/mm^2)	Max. C (%)	Max. Mn (%)	Max. Si (%)	Max. P (%)	Max. S (%)
Plates	355-345	630-490	0.24	0.24	0.16	0.035	0.045
Ram Bosses	345	415	0.14-0.20	1.00-1.30	-	0.040	0.040
Pin	650 (d=40 to 100mm)	900-1100	0.35-0.45	0.60-0.95	0.10-0.35	0.040	0.040
Pin	550 D ≤ 45.99	770-930	0.35-0.45	0.60-0.95	0.10-0.35	0.04	0.04
Torsion Box cutout	330	650-450	0.12	1.20-1.80	0.60	0.025	0.020

Table 3 Mechanical Properties of the material for new boom

Part	Min.yeild (N/mm^2)	Min.UTS (N/mm^2)	Max. C (%)	Max. Mn (%)	Max. Si (%)	Max. P (%)	Max. S (%)
Plates	355-345	630-490	0.24	0.24	0.16	0.035	0.045
Nose Plates	690	750	0.1	1.80	0.24	0.020	-
Seamless Pipe	230	330	0.25	0.27-0.93	0.1	0.035	0.035
Ram Bosses	345	415	0.14-0.20	1.00-1.30	-	0.040	0.040
Pin	650 (d=40 to 100)	900-1100	0.35-0.45	0.60-0.95	0.10-0.35	0.040	0.040
Pin	550 D ≤ 45.99	770-930	0.35-0.45	0.60-0.95	0.10-0.35	0.04	0.04

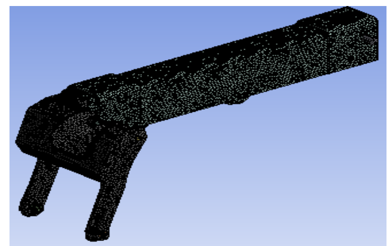


Fig. 4 Existing Inner Boom [Source: FEA Report]

Material used for boom is steel with Modulus of elasticity (E) 210 GPa, Density 7850 Kg/m3 & Poisons ratio 0.3

Type of element used solid 168, Mesh size used is 10

Rear mounting pin is fixed.

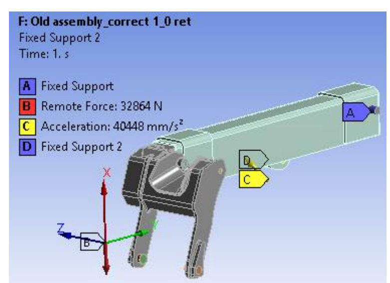


Fig. 5 Boundary condition for Inner boom [Source: FEA Report]

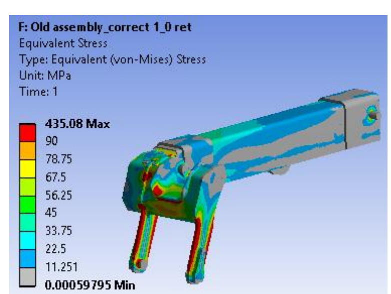


Fig. 6 Stress plot for case 1 [Source: FEA Report]

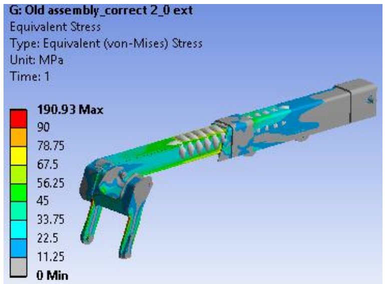


Fig. 7 Stress plot for case 2 [Source: FEA Report]

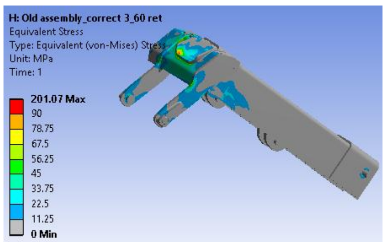


Fig. 8 Stress plot for case 3 [Source: FEA Report]

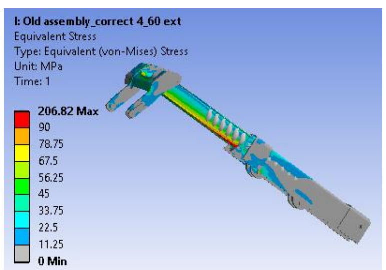


Fig. 9 Stress plot for Case 4 [Source: FEA Report]

New model was prepared by considering fork front tip visibility by reducing nose width of boom in NX 8.5 as shown in figure 10.

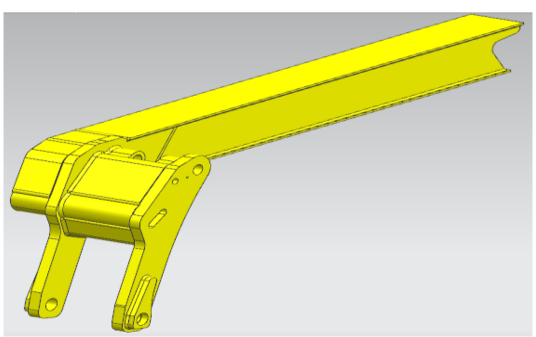


Fig. 10 New concept inner boom[Source: CAD Model]

Similar to existing model; new model is analyzed by considering all loads acting on it and giving proper contact. The obtained results for stress are as shown in figure no

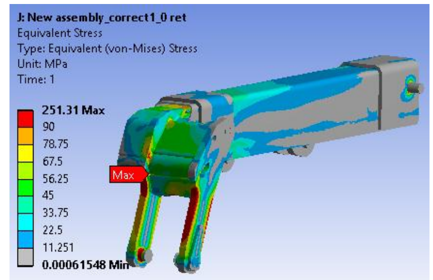


Fig. 11 Stress plot for New Inner boom(Case 5) [Source: FEA Report]

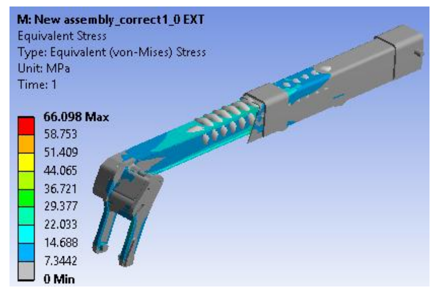


Fig. 12 Stress plot for case 6 [Source: FEA Report]

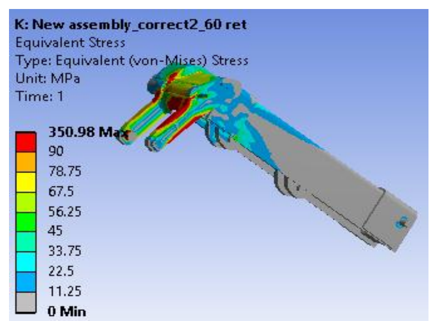


Fig. 13 Stress plot for case 7 [Source: FEA Report]

Fig. 14 Stress plot for case 8 [Source: FEA Report]

7. EXPERIMENTAL DETAILS

Picking and placing with different boom geometries, quarry floor and wave surface travelling, smooth surface travel(top oval), kerb drop offs, crowding against the pry post (with bucket) and shuttle runs (laden and unladen). For details of specific tests. Two different test drivers were used to complete the testing program. For smooth surface travelling the top oval track was used (20 minute test duration = 7 laps). For rough surface travelling the bottom oval was used, more specifically a combination of quarry floor and wave surface (20 minute test duration = 20 laps). Test weights used for this validation exercise were; 1.75 ton, 2 ton and 3.0 ton.

Fig. 15 Strain gauge testing of inner boom [Source: Testing report]

8. RESULT & CONCLUSION

This study investigates the bending stress acting on the inner boom of the telescopic fork lift.The implicit method was used to analyse the stress acting on the structure due to all load cases as mentioned in previous part. It was observed that stress acting on the structure for the exciting machine due to all load cases ie. fully retracted down, fully extended down, fully retracted up and fully extended up was less than the acceptance criteria. Stress acting in the weld zone was also below 90 Mpa for fully retracted down, fully extended down, fully retracted up and 147 Mpa for fully extended up condition. For new concept the stress acting on the structure was also below acceptance criteria ie. less than yield of the material. Front nose width was changed from 732mm to 509 mm giving rise to better front fork visibility for driver resulting better safety at operating condition without hampering load carrying capacity and stability of the machine. Experimental results are in tune with Finite Element Analysis.

Finite Element Analysis is better tool to check the structural strength of the inner boom for any change in geometry of structural part consuming less time. Static testing is used to check the strength of the boom & dynamic testing is used to check the life of the boom. Result for the static analysis has been obtained & compared with the ansys results. Good correlation has been achieved for ansys & experimental results for all four load cases see table 4.

Table 4: Stress Comparison of Booms

Load Case	FEA Stress (N/mm2)	Testing Results (N/mm2)	% Deviation
1	260	230	9.62
2	190.93	195.3	2.29
3	201.07	191.2	4.91
4	206.82	205.3	0.73
5	251.31	230.9	8.12
6	66.09	70.6	6.82
7	261.5	248.3	5.05
8	258.8	225.6	12.83

Below table shows the results achieved through design of new boom per machine. Annual machine volume is around 1500 machines.

Table 5: Benefits achieved through by designing new concept boom

Sr. No.	Existing Boom	New Concept	Benefits
1	Nose Width=731 mm	Nose Width= 506 mm	225 mm
2	2 x Tilt Rams=34400	1 x Tilt Ram=28500	5900
3	Weight = 260 Kg.	Weight = 254 Kg.	6 Kg.

REFERENCES

1. Jia Yao, Xiaoming Qiu, Zhenping Zhou, Yuqin Fu, Fei Xing, Erfei, Buckling failure analysis of all-terrain crane telescopic boom section,May 2015

2. Jia Yao, Fei Xinga, Yuqin Fu, Xiaoming Qiu, Zhenping Zhouc, Jianhong Hou, Failure analysis of torsional buckling of all-terrain crane telescopic boom section,May 2016

3. Mile Savković, MilomirGašić, GoranPavlović , RadovanBulatović , Nebojša Zdravković, Stress analysis in contact zone between the segments of telescopic booms of hydraulic truck cranes, April 2014

4. Navneet Kumar and Mohd. Parvez, FORCE DISTRIBUTION ON TELESCOPIC BOOM OF CRANE, Vol. 1, No. 2, July 2012

5. Gurjot Kaur, Stress Analysis of a Boom of Pick-n-Carry Mobile Crane, Volume 5 Issue 8, August 2016

6. Damian Derlukiewicz, Grzegorz Przybyłek, Chosen aspects of FEM strength analysis of telescopic jib mounted on mobile platform, 2008

7. IS 807:2006, DESIGN, ERECTION AND TESTING (STRUCTURAL PORTION) OF CRANES AND HOISTS — CODE OF PRACTICE (Second Revision)

8. Marcin Milanowicz, Paweł Budziszewski, Krzysztof Ke˛dzior, Numerical analysis of passive safety systems in forklift trucks,July 2017

9. Alexandra Guesset, Valérie de Labonnefon, Marine Blancheton , Ergonomics and visibility in tramway driving cab,April 2016

10. Soumitry J. Ray, Jochen Teizer , Coarse head pose estimation of construction equipment operators to formulate dynamic blind spots,Oct 2011

11. Jimmie W. Hinze, Jochen Teizer, Visibility-related fatalities related to construction equipment,Feb 2011

12. Jochen Teizer, Ben S. Allread, Uday Mantripragada, Automating the blind spot measurement of construction equipment, Dec 2009

13. Roger Bostelman, Jochen Teizer, Soumitry J. Ray, Mike Agronin, Dominic Albanese, Methods for improving visibility measurement standards of powered industrial vehicles, Sept 2013

14. ERNST DREYER, COST-EFFECTIVE PREVENTION OF EQUIPMENT FAILURE IN

THE MINING INDUSTRY