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DESIGN AND ANALYSIS OF FOOT BRAKE OF A MOBILE X-RAY MACHINE

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Abstract - *Need of mobile medical equipment's all across the world is increasing rapidly. This is also an important prerequisite for the progress of modern society. In order to achieve safety and control over the mobility of machine we need to have better and efficient braking system. The intent of this paper is to propose the methodology followed in reducing the cost without affecting the efficiency and quality. Paper studies an existing braking system in one of the X-Ray Mobile Units and methods of cost reduction i.e. redesigning, analyzing, changing manufacturing process and material substitution. The part is analyzed using ANSYS v15.0 for the stresses and it is found that the material with lower strength can be used also other factors are successfully implemented for the cost reduction.*

Key Words: mobile X-ray machine, Finite Element Analysis, Cost Reduction

1. Introduction

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. As the braking parts in any machine come under the safety mechanism, most of the companies never compromise on cost. Hence a braking system considered for cost reduction is complex and requires proper validation. When it comes to healthcare sector, the healthcare equipment manufacturing companies are serious about safety as it is in human contact. Most of the times these companies just focus on the product quality and parts like Braking system or other safety parts are given higher safety factors. However focusing on quality, sometimes companies invest unnecessarily.

A foot brake of one of the healthcare X-Ray mobile units is considered for the cost reduction. The foot brake locks the unit and is essential for the safety of the operator and the patient being diagnosed. This foot brake is analyzed and is compared with the need.

1.1 Background

Brake considered for the cost reduction has following parts:

- Right part
- Left part
- Shaft
- Pedal
- Cam and follower

1.2 Working

When the pedal is pressed as shown in figure 1.1, it moves downwards. This causes the movement of cam in such a way that the ball on the follower is slid from smaller radius on to the larger radius of cam causing downward movement of follower, which eventually leads to fictional contact between wheel and follower. Due to frictional resistance, the motion of wheel stops and so machine halts

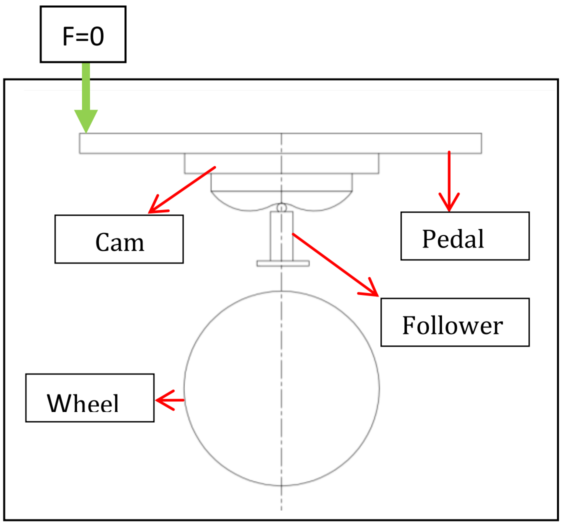

Fig 1- Braking Parts

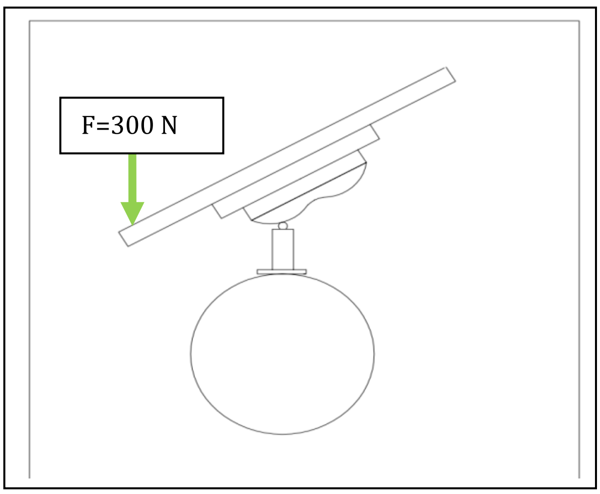

Fig -2 Brake: Force application

1.3 Material properties

Table 1 : Brake material properties[4][5].

Material	Syt	Sut
Brass	170 MPa	350 MPa
CRCA CR2 IS513	240 MPa	370 MPa
20C8 IS 1570	220 MPa	480 MPa

Where, Syt = yield tensile strength
Sut = ultimate tensile strength

2. Design and analysis of brake:

2.1 Existing brake analysis:

The three dimensional model of existing brake is designed using UGX/NX v10 and is analyzed to find out the strength requirements.

Material used: Brass

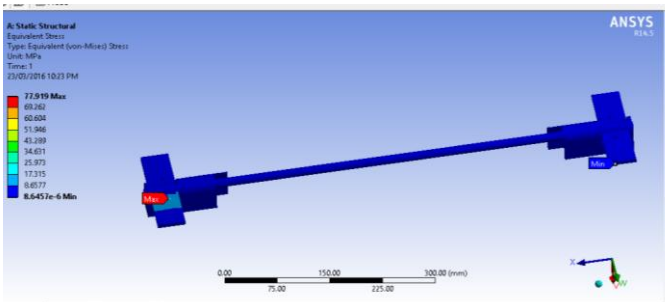

Fig -3: equivalent stress using

Maximum equivalent stress is found to be 77.98MPa.

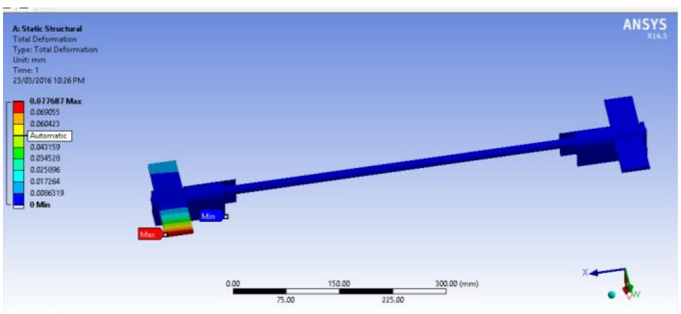

Fig -4: Total deformation using ANSYS

Total deformation in pedal is found to be 0.07mm.

2.2 Design of new braking system:

A new brake model with slight modifications for the manufacturing feasibility simulated.

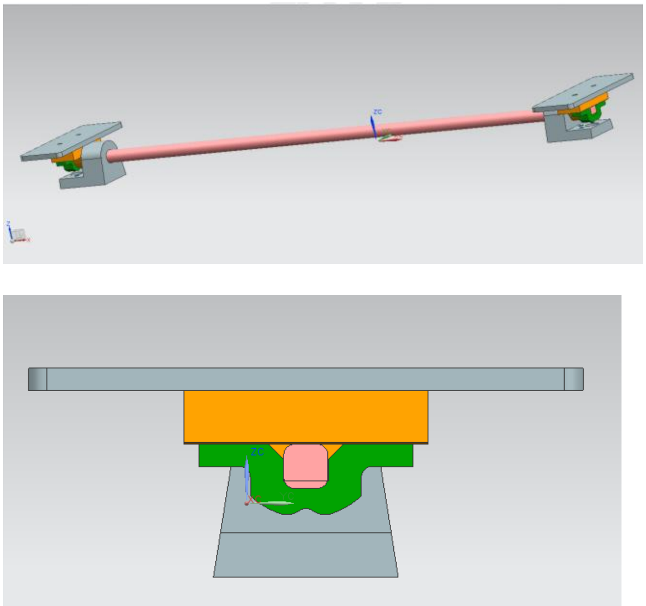

Fig 5-New Brake Model

2.3 Analysis of new braking system

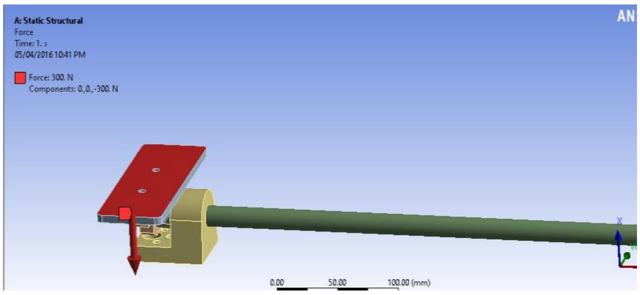

Fig -6 Application of force

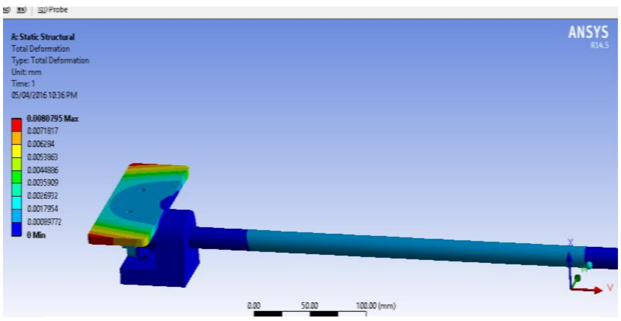

Fig -7 Total deformation using ANSYS

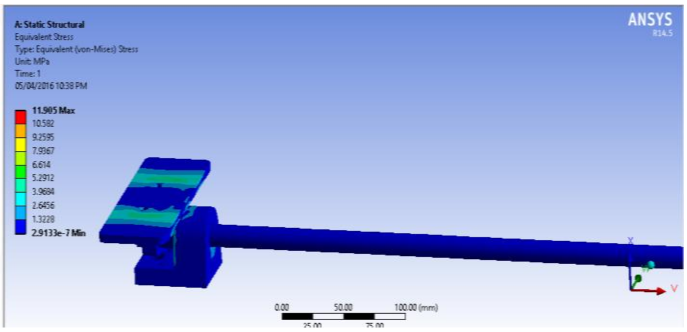

Fig-8 equivalent stress using ANSYS

Maximum equivalent stress is found to be 11.5 MPa

3. Design Validation

The designs i.e. existing and proposed are compared based on factor of safety obtained.

The model is simulated in ANSYS and the directional deformations are obtained.

3.1 Existing brake:

Material: Brass

Ultimate Tensile Strength: 350 MPa

Manufacturing: Casting

Obtained Stress (ANSYS): 77.9 MPa

Factor of Safety (FOS):

$$FOS = \frac{Syt}{stress}$$

Brass FOS: 4.49

3.2 Proposed Model:

Material: CRCA CR2 IS513

Ultimate Tensile Strength: 370 MPa

Manufacturing: Machining

Obtained Stress (ANSYS): 11.9 MPa

Factor of Safety (FOS):

$$FOS = \frac{Syt}{stress}$$

CRCA FOS: 31.09

3.3 Cost Comparison

Table 2-Cost Comparison table

	Part Name	Quantity	Cost (INR)	Tax (%)	Total Cost Per Unit (INR)	Annual
Existing Brake	Right part	1	3326.5	1.1	3399.683	130
	Left part	1	3326.5	1.1	3399.683	
	Rod	1	192	1.1	196.224	
	Pedal	2	1863	1.1	3766.986	
Total					10762.576	1399134.8
New Brake	Right part	1	1099		1099	130
	Left part	1	1099		1099	
	Rod	1	552		552	
	Pedal assembly	2	1128		2256	
	Rubber Buffer	2	25		50	
Total					5056	657280
Saving					5706.576	629610.696

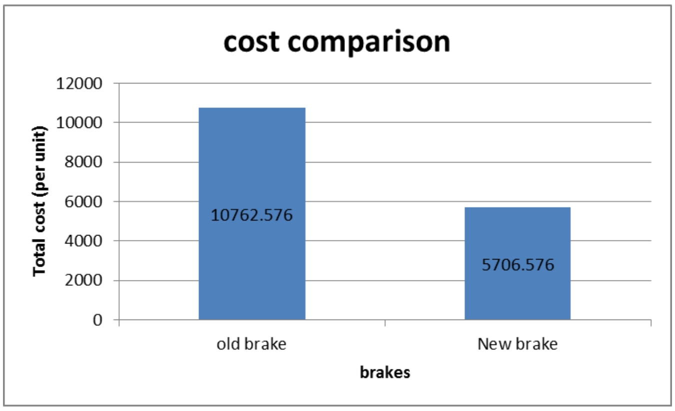

Chart-1: Total cost comparison (per unit)

4. Result

Old brake had four casted parts while new brake has two press (machining) parts. The casted parts were difficult to manufacture by machining because of their complicity. We can manufacture them with combination of press part and some mild steel parts welded to these press parts. However, press tools can easily manufacture them. As the steel grades have more strength than brass material, material change did not affect the performance. Moreover, local suppliers can manufacture these parts so that we need not to import them. The analysis shows that the equivalent stress and deflection is within the permissible value. Due to material as well manufacturing process substitution there is significant reduction in cost. This is presented above. From table 2 the cost of new foot brake is 5056 Rupees and that of the old foot brake is 10762 Rupees. The cost of new foot brake is reduced by around 53%. Moreover, annual saving is 629610 Rupees.

8. Conclusion:

1. **Material Change:** It is observed that material substitution with proper analysis increased the performance, thus proper analysis of the parts can be effective in cost savings.
2. **Safety Factor:** ANSYS analysis showed that the existing material can be substituted with new material i.e. CRCA CR2 IS 513 without affecting performance. Moreover, as the factor of safety for CRCA CR2 IS 513 is 16.66 and that for the brass material is 2.2 which shows new material is more reliable.
3. **Manufacturing Feasibility:** The new material (CRCA CR2 IS 513) can be ordered from local suppliers which reduced transportation costs and taxes to a significant level which is shown in cost-benefit analysis. Also, it is clear from cost benefit analysis that there is reduction in annual costs in percentage, these accounts to be around 53% reduction in annual cost.

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