Installation of Safety Brakes in EOT Cranes

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Abstract – *Electric overhead traveling crane or EOT crane is one of the most common types of overhead crane, or called bridge cranes, which consist of parallel runways with a traveling bridge spanning the gap. For this project work a steel plant is considered and analyzed. It was found that there was no or very less safety in the EOT cranes. So, there were many reasons for the safety issue. But, considering that the braking system was the major issue. Safety braking system is a mechanical device which was added to slow speed of Electrical Overhead Travelling Crane. The braking mechanism is working based on the wedge braking methods. Safety braking mechanisms consists of brake drum, shaft, brake block and wedge. The arrangements were added to another end of rope drum or drum flange. This report is intended to be used by company managements to promote safe lifting operations in the handling of Overhead Travelling Cranes, Gantry Cranes, Jib Cranes and Hoists. Most accidents in the crane happen during the lifting activity. The consequences of the accidents can be serious and fatal at times. By installation of safety braking systems in the cranes, can lower the chances of accidents as most of them occur during lifting.*

Key Words: EOT Crane, Safety braking system, High speed end, Low speed end, Safety braking mechanism, Safety brake analysis.

1. INTRODUCTION

EOT Crane is the short form of Electric Overhead Travelling Crane. The overhead crane is set up in a manner such that it has a parallel runway with travelling bridge spanning the gap. The hoist travels along the bridge. In the case where the bridge is rigidly supported on two or more legs running on a fixed rail at ground level, the crane is called a gantry crane. The electrically operated overhead cranes are called the EOT cranes and are the most common type of overhead cranes. These can be electrically operated via a control pendant, radio/IR remote control pendant or by an operator from an operator cabin attached with the crane itself. The EOT cranes are especially designed and manufactured to offer the best performance in various lifting applications. The chief components of the EOT crane are the motor, gear boxes, brakes, brakes and electrical panel. Most accidents related to gantry cranes, overhead travelling cranes, jib cranes and hoists occur during the lifting activity. The consequences of an accident can be serious, and fatal at times. Adopting the right method and using the right equipment will greatly minimize potential accidents during lifting operations. In cranes only one type of braking system is used known as thruster braking system. In case of the component failure this thruster braking system is not capable of holding the load. Hence, our work was to design a second braking system known as safety braking system to operate in such failure conditions and to prevent accidents to occur while working. Safety braking system is based on the working of wedge braking methods. EOT crane with two sides, viz. drive side and non-drive side. The drive side is called as high-speed end and the other is called as low speed end. The thruster brake is provided to retard the lifting speed and hold the load at the high-speed end, while there were no brakes in the other side. Due to these accidents used to take place when any component used to fail, the thruster brakes also used to fail. In order this happens there was safety braking system provided. Safety braking mechanism consists of brake block, brake drum, shaft and wedge.

2. NEED FOR SAFETY BRAKES

1. Thruster brake system can't hold the load drop in case of failures of couplings.

2. Thruster brake system can't provide adequate braking force due to improper brake shoe alignment.

3. Thruster brake system is not able to hold the load if the gear box gets failure as thruster brake is installed before the gear box.

4. if the connecting shaft is broken, the thruster brake system is not able to hold the load drop.

3. SAFETY BRAKING MECHANISM

Safety braking system is an electro mechanical device consists of brake drum, brake block, wedge, rpm sensor and solenoid switch. The braking system was affixed with another end of rope drum by flange coupling. During normal operation the system doesn't work. When the rotational speed of rope drum reaches higher than normal, the system will be activated to stop and hold the rope drum with crane loads. The rope drum never reaches above the normal speed until any failure occurred in hoist mechanism.
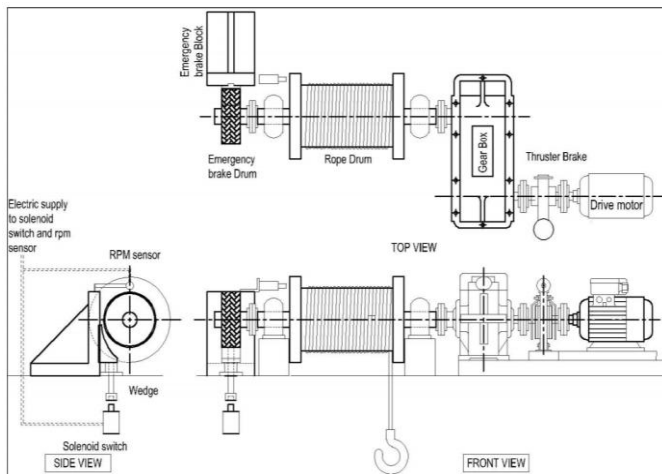
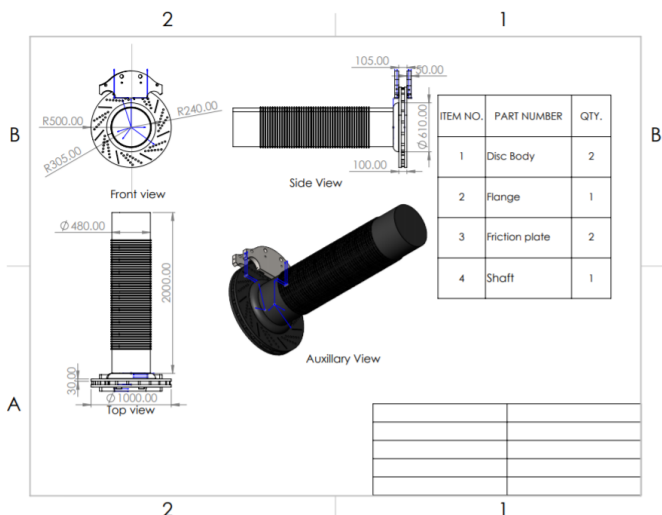**Fig -1:** Layout of Safety braking System

4. DESIGN

Fig -2: Assembly Design

5. CALCULATIONS

Brake calculation for existing crane in industry
Load mass – 31,000 kg (consider SWL, bottom block, wire rope weight)
Number of reevings line – 8 (as per specifications)
Drum diameter – 480 mm
Flange diameter – 1000 mm
Number of strands per rope drum – 2 per drum (as per the drawing given)
Safety factor – 2

Load x (drum diameter/2) x 9.81
= 31000 x (0.480/2) x 9.81
= 72986.4 x 2 (FOS) =145972.8 Nm

Braking torque/No. of reevings
= 145972.8/8
Braking torque = 18246.6 Nm

Number of strands per rope drum is 2

Therefore,
18246.6 x 2
= 36493.2 Nm
Braking torque =36493 Nm

Braking force needed
$F_b = M_B \times 2 / D_o - w$
$F_b = 36493.2 \times 2/ 1-0.13$
$F_b = 83892$ N

F_b = Braking force, N
M_b = Braking torque, Nm
D_o = Disc outer diameter, m (1m)
w = pad radial width, m (0.13 m)

Clamping force (F_s) needed using the coefficient of friction μ = 0.4 –

$F_c = F_b/2 \times \mu$
$F_c = 83892 / 2 \times 0.4$
$F_c = 1,04865$ N

Suitable brake model K-DAF/70-DS

Quantity – 1 no.
And each brake giving the clamping force of 1,19,000 N considering the air gap of 2 mm per side. Hence, selected brake model is ok.
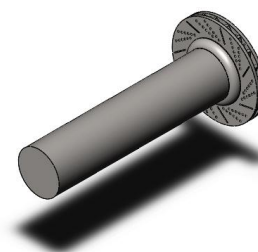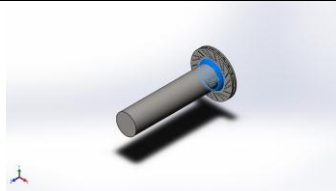
6. ANALYSIS

Fig -3: Model

Body/Model	Volumetric Properties
 Flange	Mass:124.145 kg Volume:0.0159161 m^3 Density:7800 kg/m^3 Weight:1216.63 N
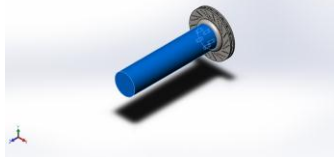
	Mass:236.457 kg Volume:0.0303151 m^3 Density:7800 kg/m^3 Weight:2317.28 N
Flange	
	Mass:2813.72 kg Volume:0.360733 m^3 Density:7800 kg/m^3 Weight:27574.5 N
Shaft	

Table -1: Solid Bodies

Study Name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal effect	On & include thermal loads
Zero strain temperature	298 Kelvin
Solver type	FFE Plus
Incompatible bonding options	Automatic
Compute free body forces	On
Large Displacement	Off
Friction	Off
Inplane effect	Off
Large displacement	Off

Table -2: Study Properties

Units are as follows –

Unit system – SI (MKS)
Length/Displacement – mm
Temperature – Kelvin
Angular velocity – rad/sec
Pressure/Stress – N/m²

Mechanical properties of the model are as follows –

Name – Plain carbon steel
Model type – Linear elastic isotropic
Default failure criterion – Max von mises stress
Yield strength – 2.20594e+08 N/m2
Tensile strength – 3.99826e+08 N/m2
Elastic modulus – 2.1e+11 N/m2
Poisson's ratio – 0.28
Mass density – 7800 kg/m3
Shear modulus – 7.9e+10 N/m2
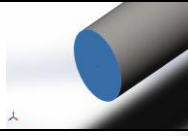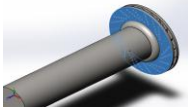Thermal expansion coefficient – 1.3e-05 /Kelvin

Fixture Name	Fixture Image	Fixture Details
Fixed – 2		Entities – 1 Face Type – Fixed Geometry
Fixed – 5		Entities – 1 Face Type – Fixed Geometry

Table -3: Fixtures
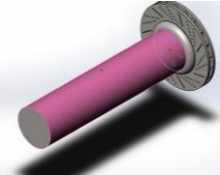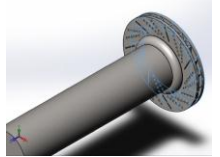
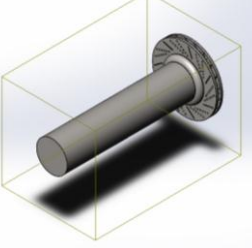| Loads Name	Load Image	Load Details
Torque – 1		Entities – 1 Face Type – Apply torque Value – 78308 N.m
Force – 1		Entities – 1 Face Type – Apply normal face Value – 238000 N

Table -4: Loads

Contact	Contact Image	Properties
Global contact		Components – 1 Type – Bonded Options – Compatible mesh

Table -5: Contact Information

Mesh information is as follows

Mesh type – Solid mesh
Mesher used – Curvature – based mesh
Jacobian points – 4
Maximum element size – 85.2242 mm
Minimum element size – 17.0448 mm
Mesh quality plot – High
Total nodes – 103880
Total elements – 61508
Maximum aspect ratio – 34.881
% of elements with Aspect Ratio < 3 – 88.2
% of elements with Aspect Ratio > 10 – 0.439
% of distorted elements (Jacobian) – 0
Time to complete mesh – 14 seconds

Resultant forces for entire model in N

Sum X – 1158.42
Sum Y – 1156.72
Sum Z – -238000
Resultant – 238006

7. RESULTS

Name	Type	Minimum	Maximum
Stress 1	Von Mises Stress	0.004 N/mm² (MPa) Node: 81727	11.419 N/mm² (MPa) Node: 83893
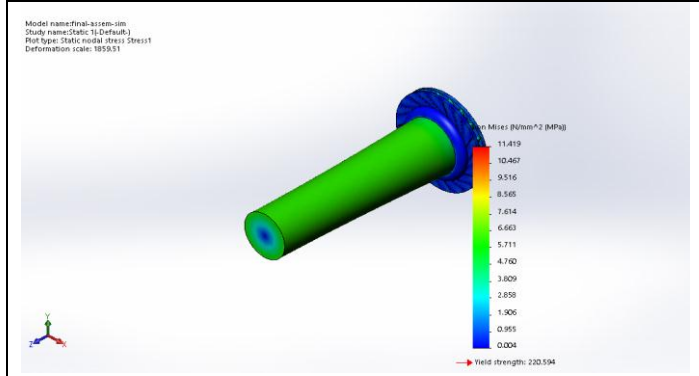
Table -6: Static 1-Stress-Stress1

Name	Type	Minimum	Maximum
Displacement 1	URES: Resultant Displacement	0.000 mm Node: 9549	0.119 mm Node: 1494
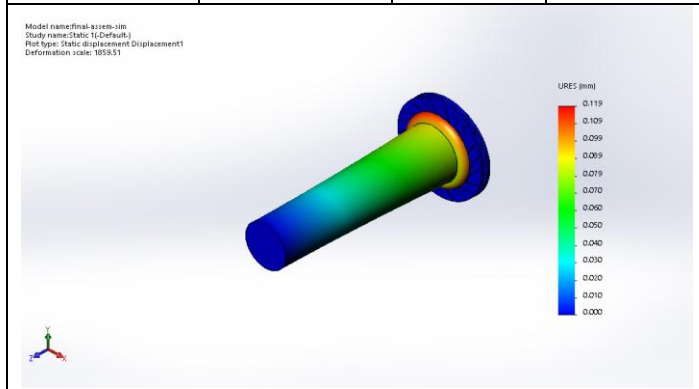
Table -7: Static 1-Displacement-Displacement1

Name	Type	Minimum	Maximum
Strain 1	ESTRN: Equivalent Strain	0.000 Element: 30089	0.000 Element: 47073
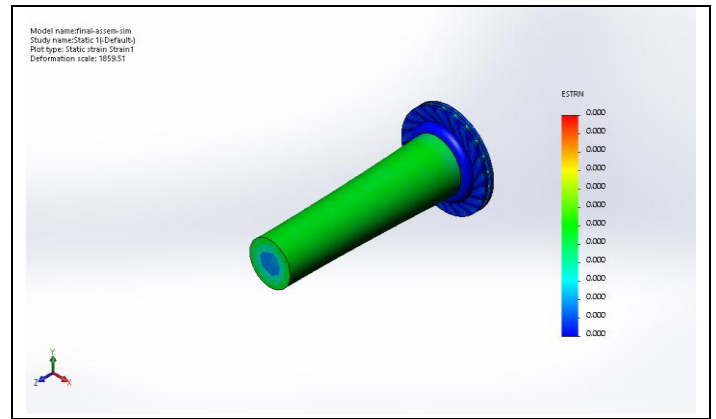
Table -8: Static 1-Strain-Strain1

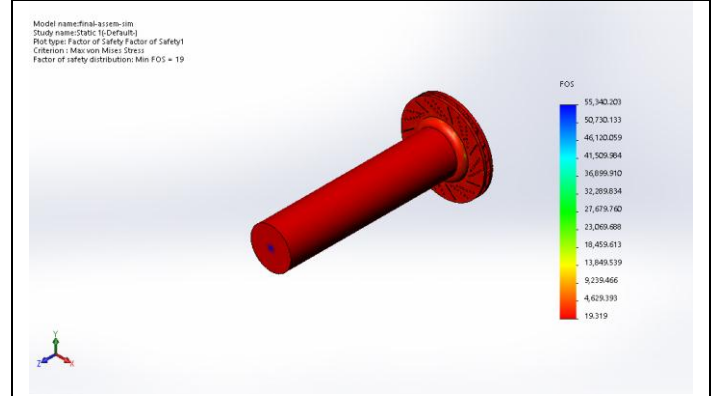| Name	Type	Minimum	Maximum
Factor of Safety 1	Max von Mises Stress	19.319 Node: 83893	55,340.207 Node: 81727

Table -9: Static 1-Factor of Safety-Factor of Safety1

Fig – 4: Safety Braking System

Fig -5: Safety Braking System

The above figure 4 and figure 5 shows the successful implementation of the braking system.

8. CONCLUSION

After proper calculation and analysis, the safety braking system was successfully installed in a steel plant at the slow speed end. Hence, after installing the safety brake mechanism the occurrence of the accidents will be less as compared to before. Now the crane can be controlled easily even if the thruster brake fails to handle the load when some of the component is damaged. The safety braking mechanism does not work under normal working conditions and will be automatically activated when the rope drum will reach a speed greater than the rated speed, monitored by rpm sensor. Therefore, by installing the safety braking mechanism the safety of the EOT crane is increased.

ACKNOWLEDGEMENT

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