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Study of Effect of Friction on the Pin of Pantograph Mechanism

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ABSTRACT

The research paper study the equivalent stress and shear stress generated on the pin due to friction between pin and links of a pantograph mechanism. The pin is subjected to biaxial loading of varying magnitude. The analysis comprises CAD model and simulated using a FEM solver. Materials of pin and links are selected considering real life applications and their coefficient of friction values are referred from variety of sources. Both static and dynamic coefficient of friction values are taken into consideration for analysis. Results thus obtained are tabulated and graphically demonstrated for better understanding of the outcomes.

KEYWORDS: *pantograph mechanism, pin, links, coefficient of friction, equivalent stress, shear stress*

I. INTRODUCTION

Pantograph is a four bar mechanical linkage used to trace a motion and can scale it up or down. Widely used in railways and milling machines, this mechanism has a simple but very effective design. Problem generally faced in applying this mechanism into practical application includes reduced accuracy in tracing the figures. Reason for this is the enlarged values of stresses due to friction, inertia and gravity effects for bigger mechanism. Here, we have analyzed the effect of friction in terms of equivalent stress and shear stress.

II. Literature Review

S. K. Saha, Rajendra Prasad and Ananta K. Mandal [1] have built a compact, lightweight, easily operated, economic carpet cleaning machine utilizing a pantograph mechanism made to work along with Hoe ken's mechanism. The machine is expected to ease the work of the carpet manufacturing labour and reduce the labour and production cost.

Coyote Steel and Co. [2] handbook on steel sizes and weights provide a large tabulation of data for various steel bars of different cross sections and lengths. The geometrical ratios are very helpful in determining the size of the links of pantograph mechanism in CAD modeling.

Engineers Handbook [3] is a website that provides value of coefficient of friction for different materials like aluminum, steel, copper, etc. This data is used throughout the simulation of the pin and links.

III. Design of mechanism

For the better understanding of the working of pantograph mechanism, a wooden model was constructed. A CAD modeled using SOLIDWORKS 2019 is generated. The dimensions of the links are given in Table. 1

Table.1: Dimensions of links

Link	Dimension* (mm)
GD	334.6
DT	836.5
CF	239
CE	239

*all the dimensions are measured between hole centers

The arrangement of the links are shown in Fig.1

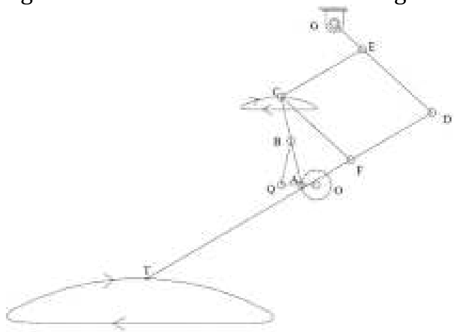

Fig.1: Link arrangement [1]

The thickness of the links is taken as 9.525mm (3/8 in) [2] for the width of 50.8mm (2 in) shown in Fig.2 and Fig.3.The width of the link is taken after referring the handbook data [2]. To ease the simulation, only two links are made in SOLIDWORKS. These links are GD and DT named link A and link B respectively.

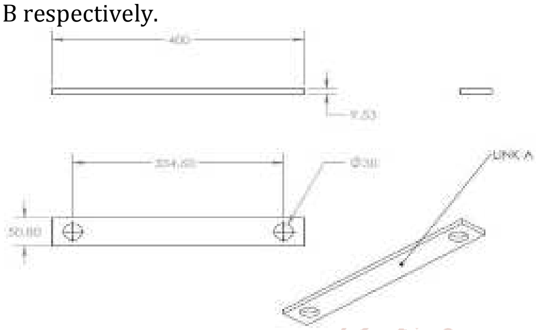

Fig.2: Link A

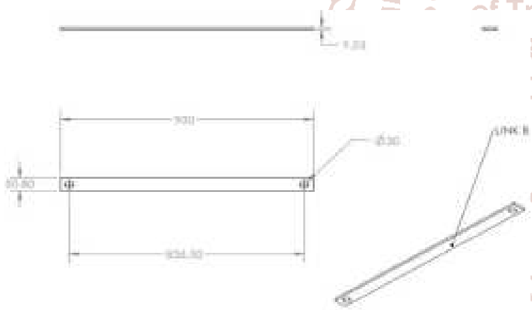

Fig.3: Link B

Pin (Fig.4) used to join link A and link B is of dimensions given in Table.2

Table.2: Dimensions of pin

Pin	Dimension (mm)
head diameter	44mm
head thickness	5mm
shank diameter	30mm
shank length	19.05mm

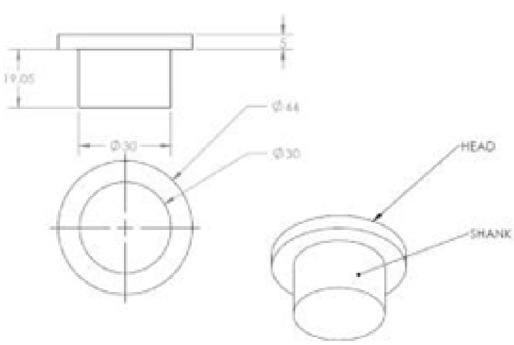

Fig.4: Pin

The links are made rigid to allow the entire load to transfer to the pin whereas pin is kept flexible to study the effects of friction on it.

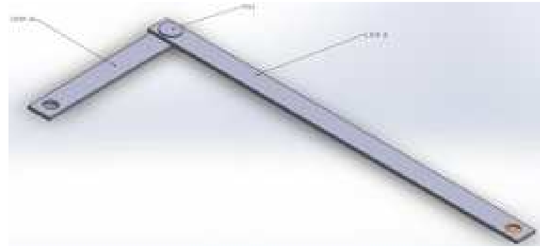

Fig.5: Link A, Link B and pin in assembly

IV. Material Selection and Loading

The materials selected for this application are Aluminum and Steel 4340. Aluminum and steel 4340 are most commonly available materials for construction of a machine. Their properties like toughness, high strength and fatigue strength, make them ideal for the analysis.

The loading conditions are biaxial. A tangential load and a radial load with respect to the pin is applied on links A and B as shown in Fig.6. Links are simulated in four conditions with different load magnitude given in Table.3.

Table.3: Loading Conditions

Serial No.	Tangential Load (N)	Radial Load (N)
1	25	2.5
2	50	5.0
3	75	7.5
4	100	10.0

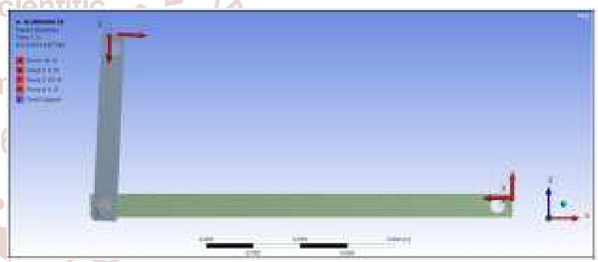

Fig.6: loading on the links (ANSYS)

These loading conditions are applied in two combination:-

1. Links-Aluminum, Pin:-Steel 4340
2. Links-Steel 4340, Pin:- Steel 4340

The shank of the pin is held fixed to mimic the fixed point of rotation of links.

V. Simulation and results

For solving the problem, ANSYS 19.2 is used. The assembly used is shown in Fig.7 is solved in Explicit Dynamics analysis system

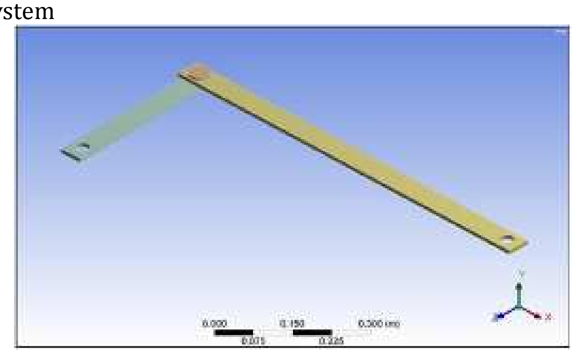

Fig.7: Assembly for final analysis

All the connections taken are frictional in behavior and such four frictional contacts are

- Between Link A and pin's shank
- Between Link B and pin's shank
- Between Link A and Link B
- Between Link B and bottom of pin's head

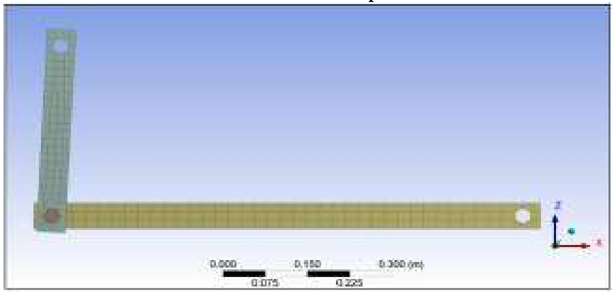

Fig.8: Assembly after meshing

I. For combination 1:-

Links	Aluminum (Rigid)
Pin	Steel 4340 (Flexible)
Fixed entity	Pin's shank
Static coefficient of friction	1.05 for Aluminum-Aluminum contact 0.61 for Aluminum-Steel 4340 contact[3]
Dynamic coefficient of friction	1.4 for Aluminum-Aluminum contact 0.42 for Aluminum-Steel 4340 contact[3]
Meshing	Coarse
End time	1 sec
Number of cycles	1e+05

Data thus obtained is in Table.4

Table.4:

Load (N)		Equivalent stress (Pa)		Shear stress (Pa)	
Tangential	Radial	Max	Min	Max	Min
25	2.5	1.80e7	46108	2.18e6	-9.45e6
50	5.0	9.05e6	11799	1.27e6	-3.37e6
75	7.5	2.48e7	19043	2.42e6	-1.33e7
100	10	8.68e7	1.47e5	8.55e6	-4.88e7

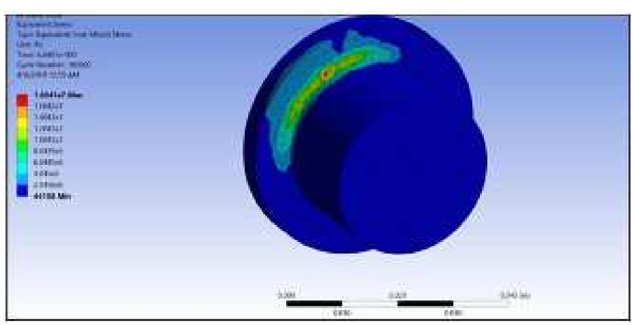

Fig.9: Equivalent stress on pin for 25N tangential load and 2.5N radial load

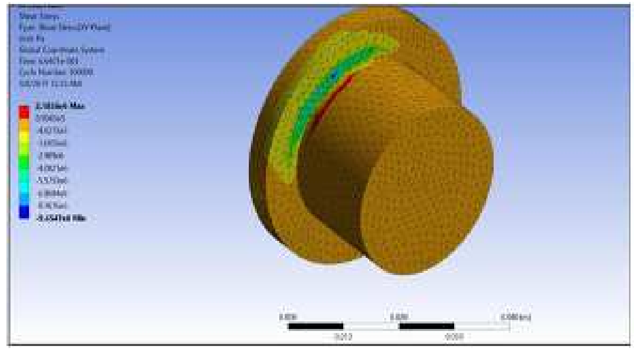

Fig.10: Shear stress on pin for 25N tangential load and 2.5N radial load

Following the data obtained from Table.4, the variation of equivalent stress and shear stress with respect to load in shown in Fig11-13.

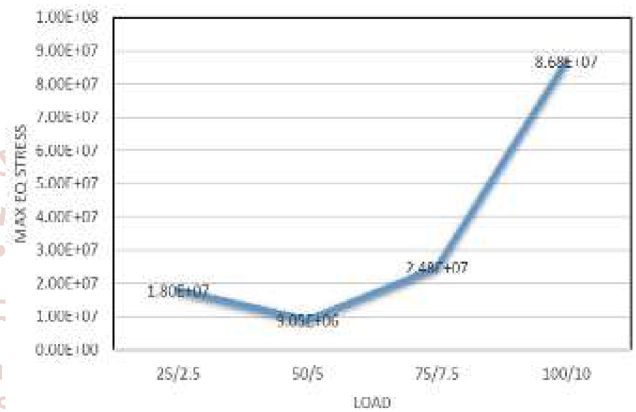

Fig.11: Maximum Equivalent stress vs load

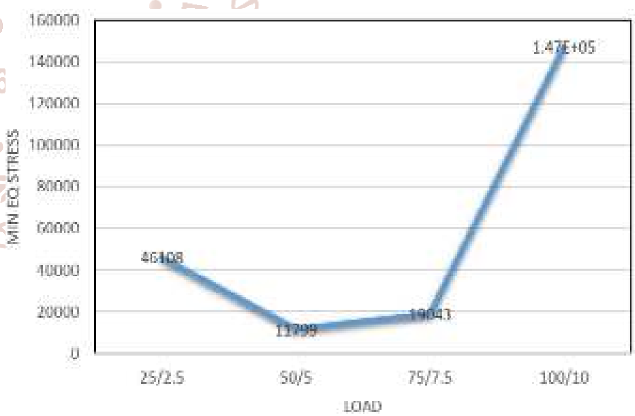

Fig.12: Minimum Equivalent stress vs load

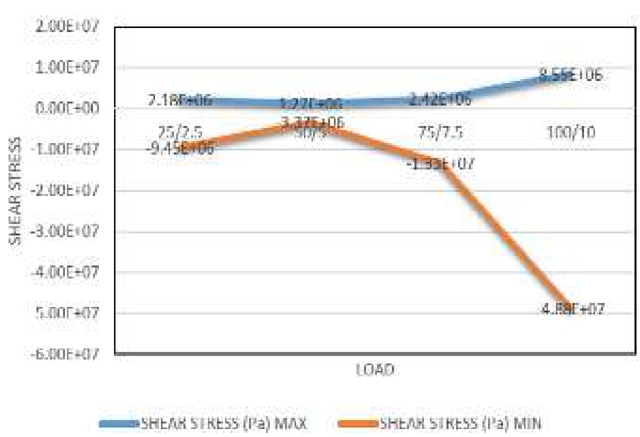

Fig.13: Shear stress vs load

II. For combination 2:-

Links	Steel 4340 (Rigid)
Pin	Steel 4340 (Flexible)
Fixed entity	Pin's shank
Static coefficient of friction	0.78 for Steel 4340-Steel 4340 contact [3]
Dynamic coefficient of friction	0.42 for Steel 4340-Steel 4340 contact [3]
Meshing	Coarse
End time	1 sec
Number of cycles	1e+05

Data thus obtained is in Table.5

Table.5:

Load (N)		Equivalent stress (Pa)		Shear stress (Pa)	
Tangential	Radial	Max	Min	Max	Min
25	2.5	2.68e6	3471.9	2.47e5	-1.39e6
50	5.0	3.44e6	6799.5	1.08e5	-1.87e6
75	7.5	4.25e6	5241	5.3e5	-2.2e6
100	10	9.27e6	3.4e4	1.06e6	-4.73e6

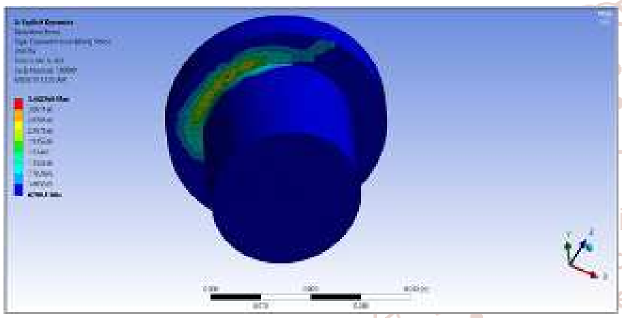

Fig.14: Equivalent stress on pin for 50N tangential load and 5N radial load

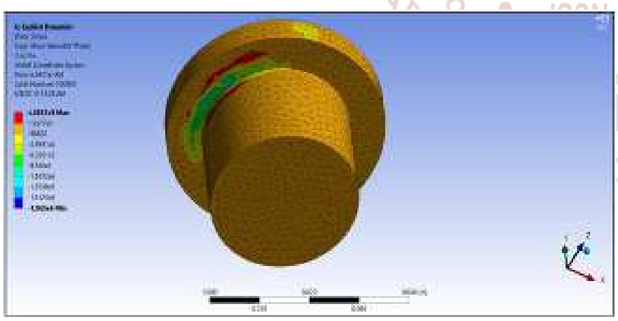

Fig.15: Shear stress on pin for 50N tangential load and 5N radial load

Following the data obtained from Table.5, the variation of equivalent stress and shear stress with respect to load in shown in Fig16-18.

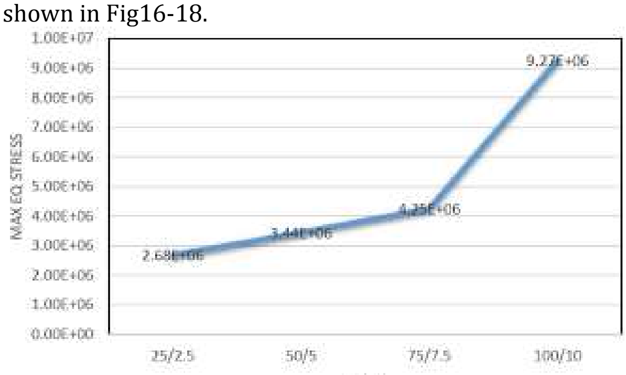

Fig.16: Maximum Equivalent stress vs load

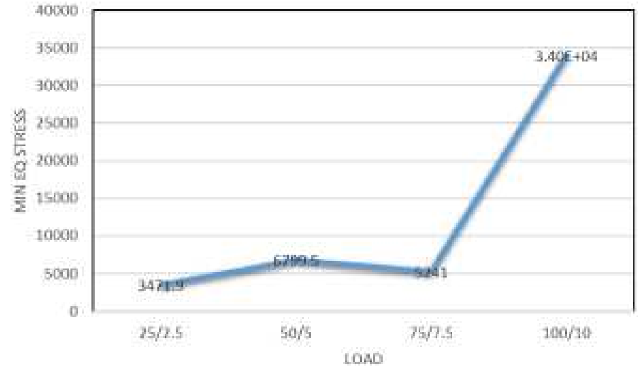

Fig.17: Minimum Equivalent stress vs load

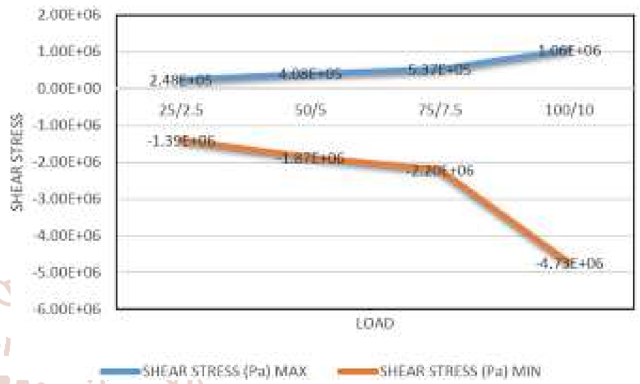

Fig.18: Shear stress vs load

VI. Observations

From the obtained data, we can see that for combination 1, the values of equivalent stress and maximum shear stress at 50N tangential load, 5N radial load is minimum, and highest value of minimum shear stress is obtained here.

For combination 2, at 75N tangential load and 7.5N radial load, only minimum equivalent stress shows a deviation from general trend of increment.

VII. Conclusion

- From obtained data we can tell that under same loading conditions, Steel 4340 shows less equivalent stress and shear stress at pin hence much better for construction
- Equivalent stress and maximum shear stress curves for Aluminum-Aluminum combination has an inverted bell shape and upright bell shape for minimum shear stress
- Steel 4340-Steel 4340 shows continuously increasing trend in maximum equivalent stress and maximum shear stress.
- The value of minimum equivalent stress for Steel 4340-Steel 4340 experiences a reduction

References

[1] Saha, S. K., Prasad, R., & Mandal, A. K. (2003). Use of Hoeken's and Pantograph mechanisms for carpet scraping operations. In *Proceedings of the 11th National Conference on Machines and Mechanisms* (pp. 18-19).

[2] Coyote Steel & Co. 2030 Cross Street Eugene, Oregon 97402 USA No.1 Handbook of STEEL SIZES & WEIGHTS for Industry, copyright 2001

[3] Reference table of coefficient of friction. (n.d.). Retrieved from http://www.engineershandbook.com/Tables/frictioncoefficients.htm