Experimental Analysis of Automatic Single Plate Clutch Performance using Non Asbestos Material Clutch Linings

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Abstract— The clutch is part that is used to connect the driver element to the load or driven element at the will of the operator. The clutches are categorized as manual engagement or automated clutches. The automatic clutches form an integral part of the modern automatic transmission system. The conventional clutches use full ace lining for the clutch meaning that the entire face of clutch is lined with friction material and conventionally the friction lining material used is asbestos base. Here in the project non-asbestos liners will be used and the two conditions of liner application will be studies namely the full face lining and the staggered lining. Test will be done by replacing theses linings one by one to evaluate torque Vs speed, power Vs Speed, Efficiency Vs speed and comparative analysis will be done for the same to propose the best operating conditions for each case of liners.

Key words: Full face lining, friction, performance analysis

I. INTRODUCTION

Conventional transmission system uses single plate clutch with a manual transmission gear box. Disengage clutch, Change gear, gradually engage clutch thus three operations are to be performed while moving from one gear to another, hence in all 15 operations are performed to move to the top gear, it is important to note out of the 15 operations performed to reach the top gear. 10 operations are clutch operations, hence making clutch operations automatic will reduce human effort. Automatic clutch control has another advantage, i.e., out of three pedals i.e., one of accelerator pedal, Brake Pedal, Clutch pedal eliminating the clutch pedal will lead to easy driving as the controls become simple. he temporary dis-engagement of clutch required at the time of gear change is a solenoid actuated by switch in gear change knob. The hold time of the solenoid is only a few seconds thus prolongs solenoid life and reduces power consumption from battery.

Important part in clutch design is design of the clutch plate and selection of appropriate material for the clutch linings. The conventional liners used in single plate clutch are asbestos base with co-efficient of friction close to 0.4 resulting in lower friction force and lower power transmission ability. Hence it is decided to replace the friction material as FTL094 as molded lining with non-asbestos base to confirm to the present environmental norms. Secondly it is observed that the friction lining applied to the clutch are full faced, but it is a fact that the wear rate increases with the increase in temperature. If the clutch is not provided with proper ventilation and heat dissipation it will glaze and low transmission ability.

The conventional clutches use full face lining for the clutch means that the entire face of clutch is lined with friction material and conventionally the friction lining material used is asbestos base. Here in the project non-asbestos liners will be used and the two conditions of liner application will be studies namely the full face lining and the staggered lining. Test will be done to evaluate torque versus speed, power versus speed, efficiency versus speed and comparative analysis will be done for the same.

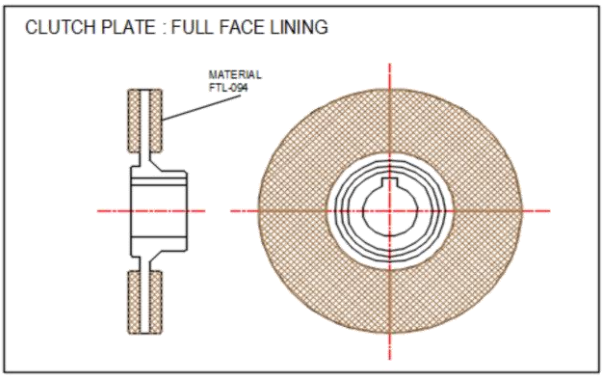


Fig. 1: Full Face Friction Lining

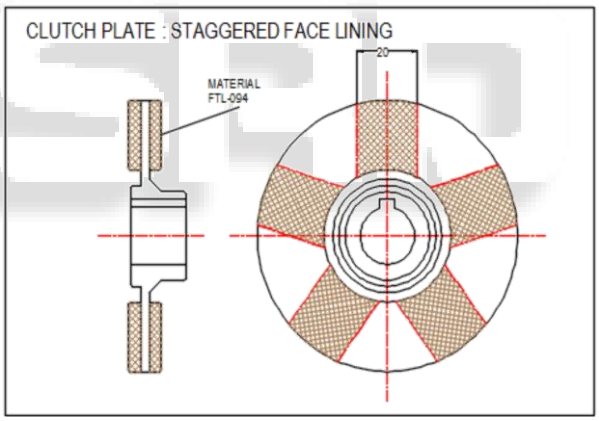


Fig. 2: Staggered Face Friction Lining

A. *Friction Lining Material:*

FTL094: Non-asbestos friction lining made of heat resisting organic fibre and fine brass wire impregnated with special resin binder. It does not contain glass fibre

B. *Objectives*

1) Design of mathematical model of single plate clutch system with automated mass- lever system for maximum power transmission capacity based on constant wear theory of clutch design.
2) Design & analysis of clutch plate and pressure plate using Ansys.
3) Test & Trial on developed clutch to determine maximum torque carrying capacity, transmission efficiency, maximum slip in drive. Plot Performance Characteristic Curves (Torque /Power /Efficiency) Vs speed

C. Methodology

1) System design & Mechanical design of the automated single plate clutch system as per configuration.
2) 3-D modelling using Unigraphix NX 8.0 and Analysis using Ansys.
3) Manufacturing of Model
4) Results and Discussion based on experimentation.

II. DESIGN & ANALYSIS

A. Design of Clutch Plate

Material – EN 24 Steel
Standard - A1S1 4340
From, PSG Design Data Handbook

Material Code	Ultimate Tensile Strength N/mm^2	Yield Strength N/ mm^2
EN24	800 N/mm^2	680 N/mm^2

Table 1: Standard Data from PSG Machine Design Data Book

$$\tau_{s_{max}} = \frac{s_{ut}}{fos} = \frac{800}{2} = 400 \ N/mm^2$$

This is the allowable value of shear stress that can be induced in the clutch material for safe operation.

So, to check Torsion shear failure of clutch plate

$$T_d = \frac{\frac{\pi}{16} \times f_{s_{act}} \times (D^4 - d^4)}{D}$$

$$f_{s_{act}} = 0.073 \ N/mm^2$$

As; $f_{s_{act}} < f_{s_{all}}$

So, Complete Face Clutch Plate is Safe Under Torsion Load.

B. Design of Pressure Plate

Material – EN 24 Steel
Standard - A1S1 4340
From, PSG Design Data Handbook

Material Code	Ultimate Tensile Strength N/mm^2	Yield Strength N/ mm^2
EN24	800 N/mm^2	680 N/mm^2

Table 2: Standard Data from PSG Machine Design Data Book

According to ASME code permissible values of shear stress may be calculated from various relations.

_ $f_{s_{max}} = 0.18 \times f_{s_{ut}}$
_ $f_{s_{max}} = 0.18 \times 800$
_ $f_{s_{max}} = 144 \ N/mm^2$ or
_ $f_{s_{max}} = 0.30 \times f_{s_{yt}}$
_ $f_{s_{max}} = 0.30 \times 680$
_ $f_{s_{max}} = 204 \ N/mm^2$

Considering minimum of the above values and this allowable value of shear stress that can be induced in the pressure plate material for safe operation.

So that,

$$f_{s_{max}} = 144 \ N/mm^2$$

$$\mathbf{T_{Design} = 0.252 \ Nm}$$

So, to Check for Torsional Shear Failure of Pressure Plate.

$$T_d = \frac{\pi}{16} \times f_{s_{act}} \times \frac{(D^4 - d^4)}{D}$$

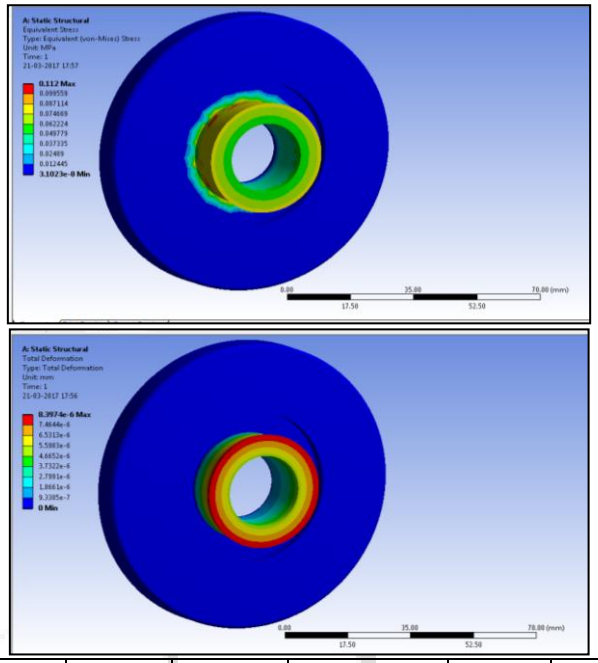
$$0252 \times 10^3 = \frac{\pi}{16} \times f_{s_{act}} \times \frac{(42^4 - 37^4)}{42}$$

$$f_{s_{act}} = 0.044 \ N/mm^2$$

As; $f_{s_{act}} < f_{s_{all}}$

C. Finite Element Analysis

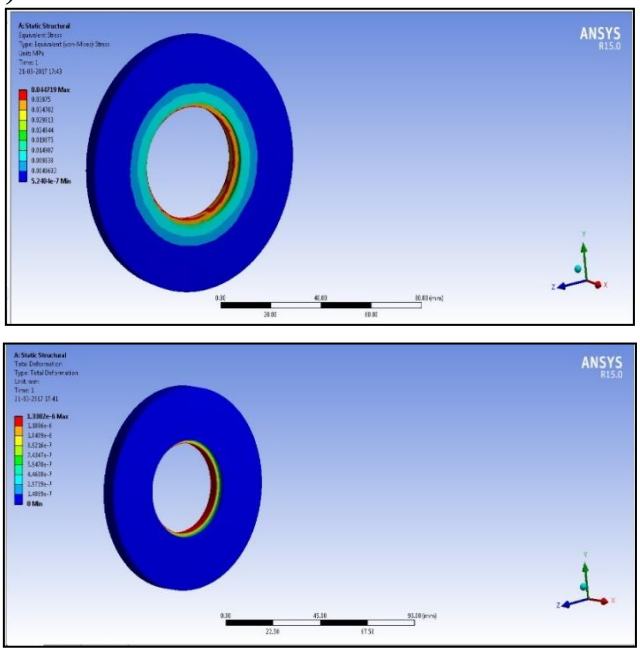
1) Clutch Plate:



Moment	Element	Node	Displacement	Von-Mises Stresses	Result
252 N-mm	2608	4963	8.397×10^{-6} mm	0.590 MPa	Safe

1) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the clutch plate shaft is safe.
2) clutch plate shaft shows negligible deformation under the action of system of forces

2) Pressure Plate:



Moment	Element	Node	Displacement	Von-Mises Stresses	Result
252 N-mm	2608	4963	1.338×10^{-6} mm	0.044 MPa	Safe

1) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the Pressure plate shaft is safe.
2) Pressure plate shaft shows negligible deformation under the action of system of forces

III. TESTING

A. *Experimental Set-up*

Fig. 3: Experimental set up

B. *Input Data:*

1) Drive Motor

Single phase AC motor
Commutator motor
TEFC construction
Power = 1/15hp=50 watt
Speed= 0-9500 rpm (variable)

2) Diameter (Effective) pulley = 75 mm.

C. *Procedure*

1) Start motor by turning electronic speed variator knob.
2) Let mechanism run & stabilize at certain speed
3) Place the pulley cord on pulley and add 200 gm. Weight into, the pan, note down the output speed for this load by means of tachometer.
4) Add another 200 gm. weight& take reading.
5) Tabulate the readings in the observation table
6) Plot Torque Vs speed characteristic and Power Vs speed characteristic.

Sr. No.	Load (KG)	Speed (RPM)
1	0.2	1100
2	0.4	1070
3	0.6	1000
4	0.8	900
5	1	740
6	1.2	650
7	1.4	610

Table 3: Observation Table (Full Face Lining)

Sr. No.	Load (KG)	Speed (RPM)
1	0.2	1180
2	0.4	1120
3	0.6	1040
4	0.8	930
5	1	800
6	1.2	740
7	1.4	650

Table 4: Observation Table (Staggered Face Lining)

Load (KG)	Speed (RPM)	Torque (NM)	Power (Watts)	Efficiency %
0.2	1100	0.073575	8.470935	16.95806
0.4	1070	0.14715	16.47982	32.99113
0.6	1000	0.220725	23.10255	46.24925
0.8	900	0.2943	27.72306	55.49909
1	740	0.367875	28.49315	57.04074
1.2	650	0.44145	30.03332	60.12402
1.4	610	0.515025	32.88263	65.82809

Table 5: Result Table (Full Face Lining)

Load (KG)	Speed (RPM)	Torque (NM)	Power (Watts)	Efficiency %
0.2	1180	0.073575	9.095685	18.17401
0.4	1120	0.14715	17.26638	34.49981
0.6	1040	0.220725	24.04961	48.0533
0.8	930	0.2943	28.67453	57.29432
1	800	0.367875	30.83283	61.6068
1.2	740	0.44145	34.22444	68.38355
1.4	650	0.515025	35.07234	70.07774

Table 6: Result Table (Staggered Face Lining)

D. *Performance of System Using Full Face Lining*

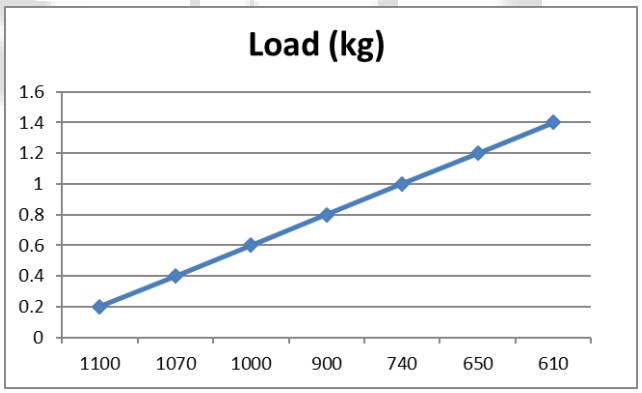


Fig. 4: Graph of Load Vs Speed

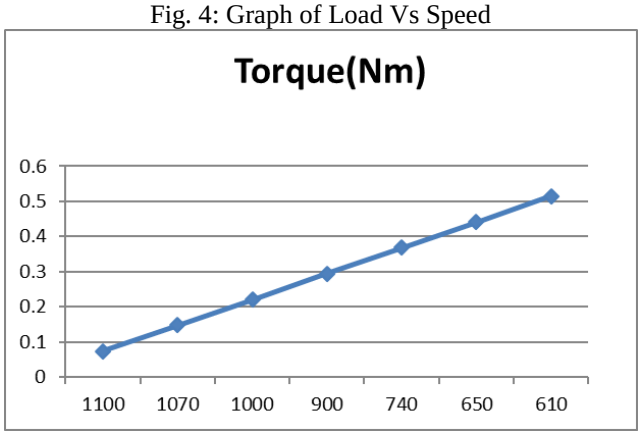


Fig. 5, Graph of Output Torque Vs Speed

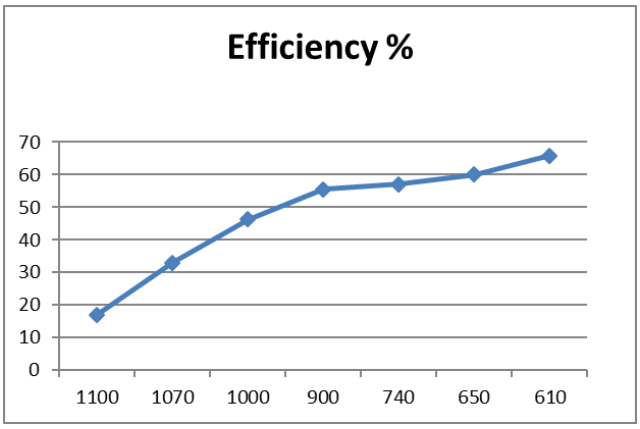


Fig. 6: Graph of Efficiency Vs Speed Performance of System Using Staggered Face Lining

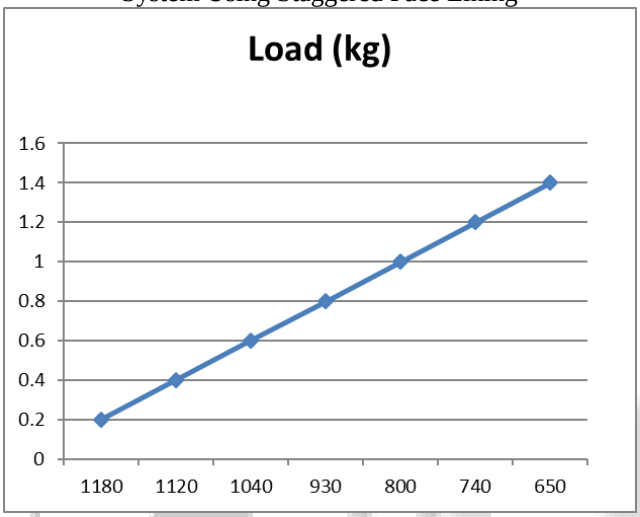


Fig. 7: Graph of Load Vs Speed

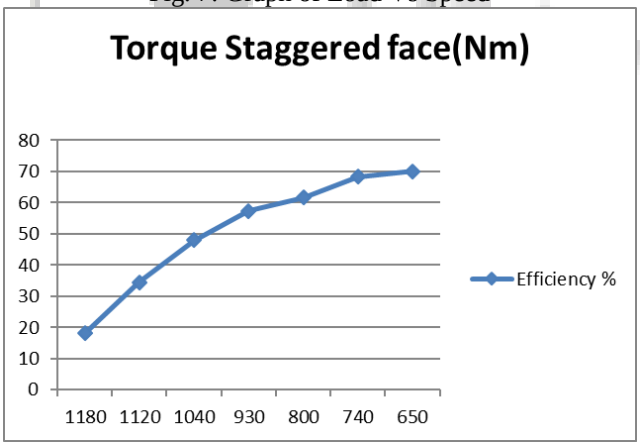


Fig. 8: Graph of Output Torque Vs Speed

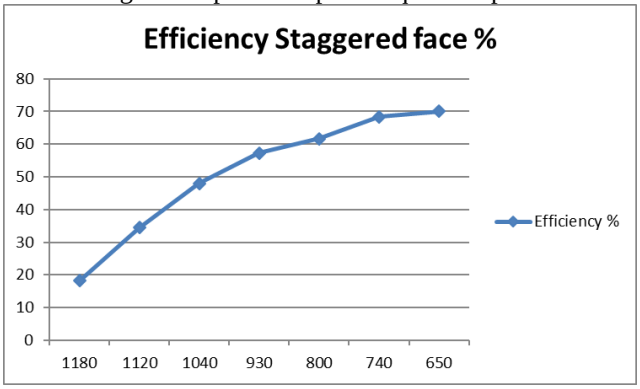


Fig. 9: Graph of Efficiency Vs Speed

E. Comparison between Full Face and Five Element Staggered Clutch

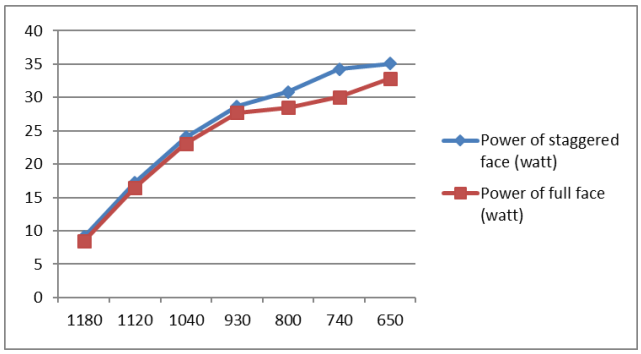


Fig. 10: Output power in case of staggered liner is more as compared to that in the full face liner

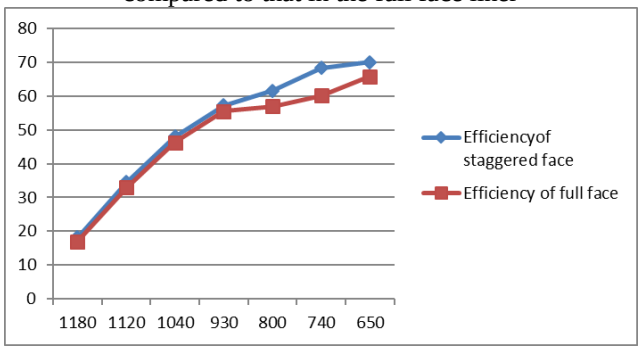


Fig. 11: Efficiency in case of staggered liner is more as compared to that in the full face liner

F. Discussion

1) Speed drops with increase in load in both cases
2) Torque increases with decrease in speed in both cases
3) Output power increases with decrease in output speed and maximum power is attained in range of 750 to 850 rpm
4) Output power in case of staggered lining is better than the full face lining
5) Efficiency in case of staggered lining is better than the full face lining

IV. CONCLUSIONS

1) Clutch was design and developed with automatic engagement facility
2) Testing was done with complete face lining and clutch showed maximum efficiency of 65.8 percent in case of complete face liner
3) Testing was done with staggered face lining and clutch showed maximum efficiency of 70.07 percent in case of complete face liner
4) Thus staggered face lining is better than the full face lining.

REFERENCES

[1] Nilkanth Badhe, S.V.Patil, "Performance Testing of Single Plate Automatic Clutch", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 12, December 2015
[2] Ganesh Raut, "Analysis of Multidisc Clutch Using FEA", International Journal of Engineering Trends and Technology, December-2013.pp 23-47

[3] Ravikiran M.Tale, S. H. Sarje "Design and Analysis of Clutch Plate for Automatic Single Plate Clutch", International Journal for Scientific Research &Development Vol. 3, Issue 09, 2015
[4] B. Nivas, M. Nithiyanandam, S. Tharaknath, A. Avinash Kumar "Design and Analysis of Clutch Plate Using Steel Material [En –Gjs-400 -15steel]" IOSR Journal of Dental and Medical Sciences .Volume 13, Issue 5 Ver. VI. (May. 2014), PP 76-78
[5] N.V.Narasimharao.L, Ch.Chandrarao "Static and Dynamic Analysis of Clutch Plate With Crack" IJRMET Vol. 4, Issue Spl - 1, Nov 2013 - Apri l 2014
[6] Tse-Chang Li ,Yu-Wen Haung, Jen-Fin Lin "Studies on centrifugal clutch judder behaviour and the design of frictional lining materials" Mechanical Systems and signal Processing 66-67 (2015)811-828
[7] Engg. Mechanism, Erdman and Sandor
[8] Machine Design, R S Khurmi
[9] P S G Design data Book

