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Analysis of Retrofitted Clutch Cum brake (CCB) Assembly

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ABSTRACT

Design optimization is an inevitable activity in the product life cycle of a component. It has been proved that finite element analysis helps to achieve design optimization with much ease. A mechanical element such as cone clutch and brake (CCB) used in specialized equipment has been analyzed in this work. Clutches are used to connect and disconnect the power transmission between power source and driven unit. It also avoids direct shock from the driven to the driver unit. The construction of clutch cum brake unit consists of clutch housing, brake housing and magnet enclosed with magnet housing. The Re-design of clutch unit for transmitting torque of 65 N-m has been attempted in this work. In the existing design, torque fluctuation has been observed in the CCB unit. Hence cone clutch cum brake has been redesigned by varying parameters such as cone angle, area of contact, electromagnetic force and the spring tension. These calculations are validated with Finite element analysis technique.

Keywords: Clutch cum brake, Cone angle, spring tension, Finite element analysis.

1. INTRODUCTION

Clutches are used to connect and disconnect the power transmission between power source and driven unit as may be necessary. For example, they are used for changing the load on power source and also for turning OFF and ON the driven part of the system temporarily and they are used to control the power from one system to another and also to avoid the direct shock from the driven to the drive unit. There are various types of clutches used depending upon various applications like, load, space, etc. The cone clutch design consists of two clutching members, one internal and one external. The internal member is a unique single tapered part with lubrication groves, attached to the spring, creating a cone clutch assembling. The external member is also tapered with a matching angle, when the two are forced together torque is transferred from one member to the other. This cone clutch design allows for more clutch capacity in the same space, and is less prone to chatter due to the reduced number of sliding surface. This means higher transfer capacity in every application without the noise (Anderson, 1985).

Brakes are used to stop the motion in various types of machines and to prevent unintentional movements. Their construction is similar to that of clutches, except that one member is stationary. Companies design the clutch unit for transmitting torque of 65 Nm. In their initial design with cone clutch and brake, the torque capacity fluctuation occurred due to some technical problem. For that, in our project tried to rectify that above problem by redesigning the cone clutch parameters such as cone angle, area of contact, by changing the electromagnetic force and the spring tension. Finally, the force relationship at the area of contact between the cones using FEM technique was analyzed.

1.1. Problem Definition

Clutches are used to connect and disconnect the power transmission between power source and driven unit. It also avoids direct shock from the driven to the driver unit. Here, the cone clutch with brake is used for transmitting higher torque and to prevent unintentional movements. The existing clutch cum brake unit used in defense equipment transmits a torque capacity of 50-55 Nm. In that design which has cone clutch cum brake, the required torque is not achieved. The problem is rectified by redesigning the cone clutch parameters such as cone angle, area of contact, changing the electromagnetic force and by changing the spring tension etc, In the present redesign work one of the parameters spring tension is taken into account. Finally, the force relationships at the area of contact between the cones are analyzed using FEM techniques, and validation is done by the comparison of theoretical stress and torque with Finite element analysis values.

2. CONE CLUTCH CUM BRAKE

2.1. Design requirements for clutches

The considerations that should be observed in the design of a clutch are selection of a type suitable for given operating conditions are, selection of materials forming the contact surfaces, sufficient torque capacity, transmission of the motion without shock, quick disengagement without drag, provision for holding the contact surfaces together by the clutch itself, low weight in order to keep down the inertia, especially in high speed service, balancing of all moving parts, especially in high speed service, provision for taking up wear of the contact surfaces, accessibility and provisions facilitating repairs, in an industrial clutch, absence of or protection of projecting parts, in a clutch frequently or continuously operated, provision for carrying away the heat generated at the contact surfaces (Joseph and Charless, 1993, Maleev, 1953).

2.2. Friction materials for Clutches

A good friction material should have the following qualities:

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Table 1 Lining pressures and dry coefficients of friction		
Material	**Working Pressure (N/mm²)**	**Coefficient of friction**
Moulded materials and sintered metals	1 to 2	-
Cast iron on cast iron	1 to 1.7	0.15 - 0.2
Steel on cast iron	0.8 to 1.4	0.2 - 0.3
Bronze on cast iron	0.5 to 0.8	-
Wood on cast iron	0.4 to 0.6	0.2 - 0.25
Cork on metal	0.05 to 0.1	0.35
Asbestos blocks on metal	0.25 to 1.1	0.4 - 0.48

- A high and uniform coefficient of friction.
- The ability to withstand high temperatures, together with good heat conductivity.
- Good resiliency.
- High resistance to wear and tear, scoring and galling.
- Resistance against environmental conditions, such as moisture, salt water or fungi.
- Adequate mechanical and thermal strengths.

2.2.1. Coefficient of Friction

The coefficient of friction differs from material to material and therefore it depends upon the material compressing the friction surfaces (Barecki and Scieszka, 1989). The main materials used for friction clutch are as given under:

1. **Asbestos:**
It can be used at high temperature also linings of this material have coefficient of friction about 0.2.
2. **Reybestos and Ferodo:**
These materials are most suitable and generally used for clutch friction linings and have a coefficient of friction about 0.35.
3. **Leather:**
The coefficient of friction between Cork and steel or iron is 0.27.
4. **Cork:**
The coefficient of friction between cork and steel or iron is 0.32.
5. **Fabric:**
This material has co-efficient of friction about 0.4, but it cannot be used in a high temperature.

2.2.2. Lining Pressure

Typical lining pressures (in N/mm²) and dry coefficients of friction are given in table 1. For clutches running in oil the coefficient of friction will typically be in the range 0.05 to 0.15.

2.3. Clutches vs. Brake

The functional difference between a clutch and a brake is that a clutch connects two moving members of machine, whereas a brake connects moving member to a stationary member. That is if any one of the moving members of a clutch is fixed, then the device becomes a brake.

2.4. Functions of Clutch cum Brake

When the power supply is ON, ring shaped electromagnet gets magnetized and Clutch actuator attracted by the friction liner lock plate. So that Clutch will be disengaged. Due to this output shaft is free to rotate. The output shaft is connected to machine drive, which is motor driven. When the machine is driven by the electric motor the clutch will disengage. When power supply is OFF electromagnet releases and engages the clutch through lock plate. In case of power failure, the input shaft is rotated manually the brake is disengaged, but clutch remains engaged. Due to this output shaft keeps rotating because of the manual drive at that time torque will be transmitted (Table 1).

3. EXPERIMENTAL SETUP

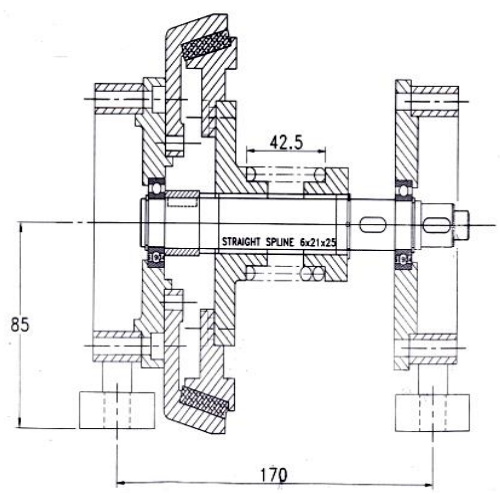

Figure 1
Cone type Clutch Unit (Without Housing)

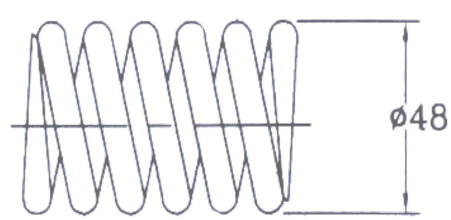

Figure 2
Compression Spring

4. MODELING AND ANALYSIS

The typical problem which is to be handled in this project is the design of the Clutch cum brake unit. For modeling the component we used the PRO/E software and for structural analysis we used ANSYS software and later the weight reduction was adopted to achieve the aims.

4.1. Modeling in pro/engineer

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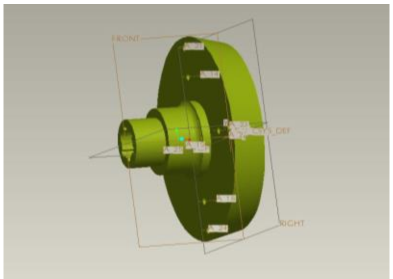

Figure 3
Model of bearing housing

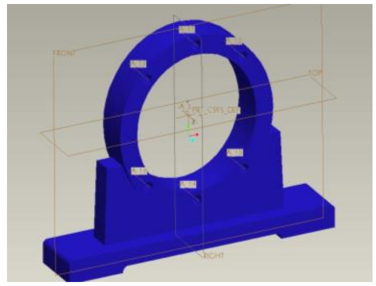

Figure 4
Model of Internal Cone Clutch

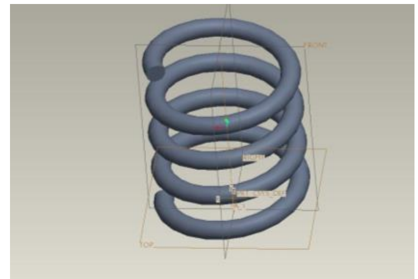

Figure 5
Model of External Cone Clutch

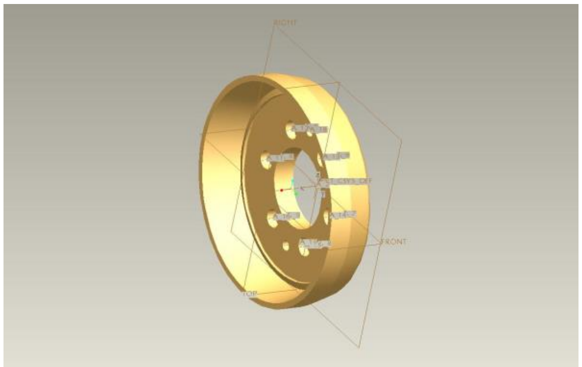

Figure 6
Model of Compression Spring

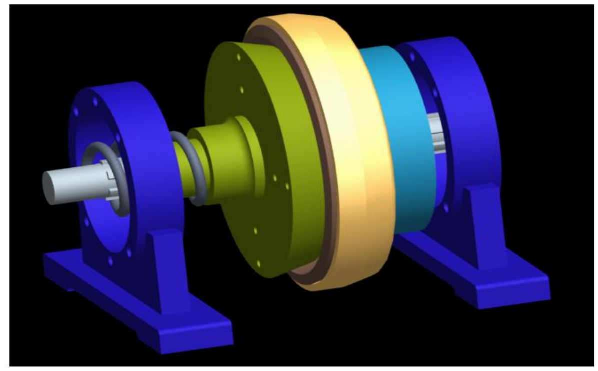

Figure 7
Assembly of CCB Unit (Without Housing)

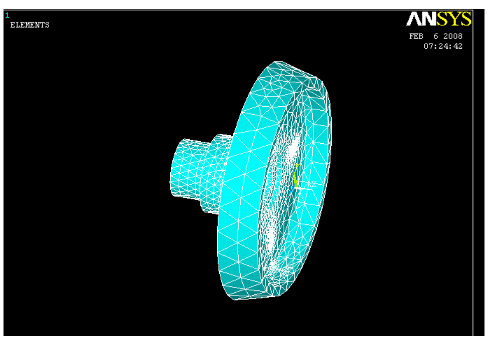

Figure 8
FEM of Liner and Internal Cone with B.C

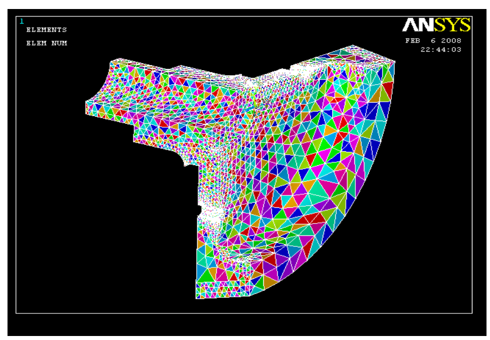

Figure 9
Fem of Internal cone clutch

4.2. Analysis in Ansys 10.0

Finite Element Method is a numerical procedure for obtaining approximate solutions to many of the problems encountered in the engineering analysis. FEM is one of the most effective tools available in the industries to solve almost all kinds of engineering problems. The major areas in which the FEM application is more pronounced are automotive industry, aerospace industry and architectural applications for various analysis like static, modal, heat transfer, soil and rock mechanics, hydraulics etc.,

4.2.1. Structure analysis

The functional elements like male cone, liner, female cone, compression spring are subjected to steady state dynamic loads and would lead to induction of stresses in the functional elements. Hence it is required to study deformation and stresses induced in the model because of the static loads.

5. RESULT AND DISCUSSION

5.1. Stresses and Deformations

Various results of the analysis are plotted along with its deformed shapes. The table below shows various results from the software.

6. CONCLUSION

The re-design of clutch cum brake unit for transmitting torque of 65NM has been attempted in this work. In the existing design, torque fluctuation has been observed in the CCB unit. Hence cone clutch brake has been redesigned by varying parameters such as cone angle, area of contact, electromagnetic force and the spring tension. These calculations are validated with finite element analysis techniques. The final result shows that the modified design clutch cum brake is able to transmit the desired torque without fluctuation.

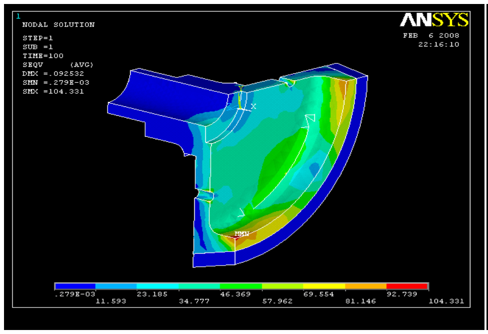

Figure 10

Contact Pressure in Male Cone Clutch

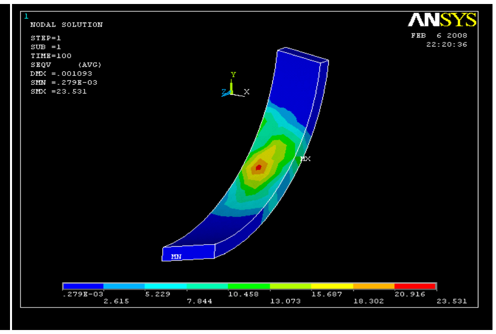

Figure 11

Contact Stress at Between Male Cone and Liner

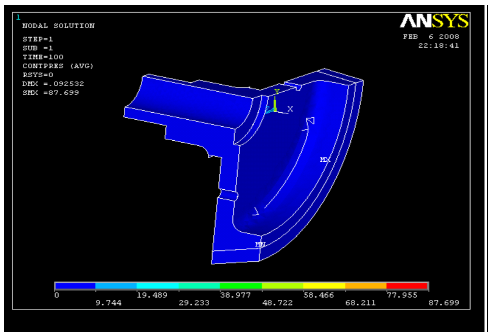

Figure 12

Contact stress at Male Cone Clutch

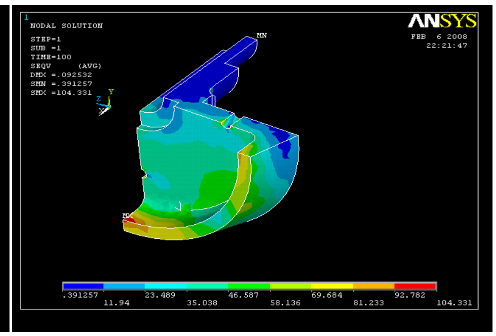

Figure 13

Contact stress at Outer ring

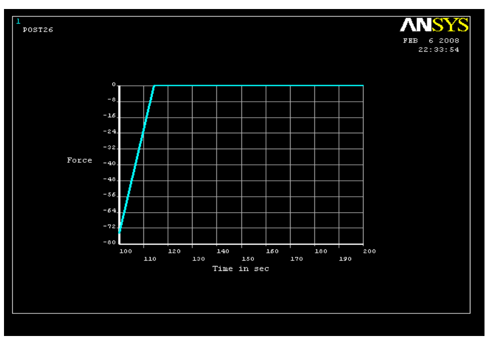

Figure 14

Force Vs Time

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