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Design of Overload Slipping Ball Clutch

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ABSTRACT

Clutches are used to transmit power between two coincident shafts. The positive engagement between the clutch elements ensures 100% torque transmission on but occasionally the output shaft may the subjected to a sudden overload which may make the driving motor or engine to stall. which will lead to burnout of the electric motor .In extreme cases this overload will lead to the breakage of drive elements or the clutch itself .In order to avoid the damage of the transmission elements it is necessary that the input and output shafts be disconnected in case of sudden overloads. Here actually we are designing new product which is not designed in past. When clutch a jam-up or excessive loading occurs the Torque Limiter will reliably and quickly release to prevent system damage. These torque limiters are tamper-proof. Once installed, the torque value cannot be changed. This is an important feature that ensures the integrity of the machine design. Costly and potentially risky calibration procedures are not necessary. The torque value is controlled by the part number. That value determines what spring is used during the assembly at the factory. The torque value can be changed in the field, however; the torque limiter must be disassembled and the helical springs replaced to achieve the new torque value. [6].

Keywords -Safety clutch, Torque limiter, Helical spring, Overload protection, Torque value**.**

1. INTRODUCTION

Clutch mainly used for torque transmission. this we designing new clutch to transmit 125% to 150% of maximum motor torque. Also these clutch parts have minimum inertia and space. The clutch must take over axial, radial, angular deviation. Different types of torque limiting clutches are known, for example, positive clutches, friction clutches, shear and detent clutches etc. Here we are talking about positive clutches. Previously shear pin is sheared off when the torque exceeds a certain level. In such devices, a pin or bolt is sheared and must be replaced each time the torque limit is exceeded. In this newly modified device we are using plunger, spring and balls. When there occurs sudden increase in load as we are using by the driver for disengaging and the spring is used in this machine are steel sparing which are not much stiff as compared to single plate clutch. In cone clutch the angle of cone is made smaller than 20^0 the male cone tends to bind in the female cone and it became difficult to engage. This problem will not occur in the "overload ball slipping clutch".
Simply we can say that the "Overload ball slipping clutch is a safety device for electrical motor. [4]

2. LITERATURE REVIEW

Transilvania University Brasov, Romania" in the paper titled "Design Procedure of Elastic and Safety Clutches using Cam Mechanisms" states that, topological and structural generation of elastic and safety coupling, In the second part, on the basis of the functional characteristic of the cam gears, we propose a simple method for the structural and generation of elastic and safety couplings[2].

"Nicolae EFTIMIE" in the paper titled "Dynamic Simulation of The Safety Clutches with Balls" states that, explored the clutches are used largely in machine buildings, and by the correct selection of these depends to a great extent the safe and long working, both of these and of the kinematic chain equipped with them[2].

"M Jackel1, J Kloepfer, M Matthias and B Seipel" in the paper titled "The novel MRF-ball-clutch design a MRF-safety-clutch for high torque applications" states that the development of a safety-clutch by using magneto rheological fluids(MRF) to switch the transmission torque between a motor and a generator in a bus-like vehicle[3].

3. ADJUSTABLE TORQUE SPRING BALL CLUTCH

3.1. *Need for adjustable torque spring ball clutch*

Positive clutches are used to transmit power between two coincident shafts. The positive engagement between the clutch elements ensures 100% torque transmission on Butoccasionally the output shaft may the subjected to a sudden overload which may make the driving motor or engine to stall; which will lead to burnout of the electric motor.

In extreme cases this overload will lead to the breakage of drive elements or the clutch itself.In order to avoid the damage of the transmission elements it is necessary that the input and output shafts be disconnected in case of sudden overloads .The isolation of the input driver member ie; motor from the output member is absolutely necessary to avoid damage and it is possible by called ball clutch [5].

3.2. *Features of ball clutch*

- Clutch should be easily adjusted to transmit a range of different torques and also for setting to slip at various predetermined loads which vary within wide limits according to particular operation carried out on the machine.
- Clutch has to be entirely self-contained and compact unit so that it could be preset before installing the unit the machine.
- The clutch should operate at equal efficiency and facility, at different speeds.
- The clutch should accommodate itself for slight axial floating movements of driven shaft.

3.3. *Problem Definition*

As the torque value increasing suddenly system does not stops but it is getting damaged. Many times there is loss in time and increase in the work of operation as there are damages occurs in the system. This causes the economic loss as the torque limit is not much more for the given working system. Over this we have to increase the torque limit.

4. CONSTRUCTION

The construction of test rig in general shall be as follows.

4.1. *Input Motor*

Input motor forms the basic prime mover arrangement that is used to drive the input shaft .The motor is an Single Phase AC motor (commutation type) .The motor is coupled to the input shaft directly by means of an reduction pulley

4.2. *Ball Clutch*

Ball clutch is the transmission element that connects the input shaft and output shaft. It is a self-contained and compact unit . Its members are keyed to the input and output shafts respectively.

4.3. *Rope Brake Dynamometer*

Rope brake dynamometer is provided in the form of andyno-brake pulley which is key to the output shaft.

4.4. *Frame*

Frame is the base member in the form of the stand which supports the entire test rig arrangement on the base plate on its top face.

5. CONSTRUCTION OF BALL-CLUTCH

5.1. *Input Shaft*

In put shaft is the main shaft which is mounted in the ball bearing in the bearing housing .It is driven by an input motor by means of reduction pulley.

5.2. *Base Flange*

Base flange is an slightly hollowed out flange on its end face to leave an narrow annular band at the periphery . A series of radial V shaped serrations of identical size and shape and at equal pitch spacing a part, milled across the annular band as shown.The sides of these serrations are inclined at $37\ ½^0$ (or 45^0) relative to the axis of shaft. The included angle between the faces of the Vee serrations is 90^0.This is important dimension , can of course , be varied within certain limits in accordance with the load to be

transmitted and the magnitude of overload at which the clutch is required to slip.

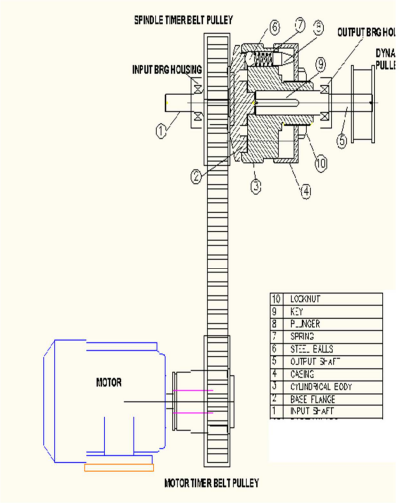

Fig. Test Rig of Overload Clutch. [6]

5.3.*Cylindrical Body*

The cylindrical steel body of the ball clutch is keyed to the driven shaft but it is made slightly longer than the shouldered end of that member so that the short smaller diameter concentric portion of its bore is a slip fit over the adjoining end of the shaft. Projecting beyond the base flange as shown . The purpose of this arrangement is to maintain a body of the clutch perfectly concentric with the base flange for ensuring the smooth and accurate engagement of the balls in the base flange serrations**.** The left hand end of the body is recessed a small depth to admit the Serrated portion of flange , the outside diameter of which has a tight clearance fit in recess.

Six holes are accurately drilled and reamed passing axially through the body, The holes are spaced exactly 60^0 a part around the same pitch circle, the diameter of which is equal to pitch diameter of the serrations in the annular band of base flange.The right hand end of the body is reduced in diameter and threads to receive the hardened steel casing.

5.4.*Casing*

Hardened steel casing is of the same outside diameter as the front end of the body. The sleeve deeply bored at one side to be close fit over the reduced portion on the outside of the body. By fitting the casing over the body at that point its correct and accurate location relative to the body is not determined by the fit in the threads.

6. WORKING

The overload slipping ball clutch is an safety device used in the transmission line to connect the driving and driven elements such that in case of occasional overload the clutch will slip there by disconnecting the input and output members This protects the transmission elements form any breakage or damage. For a particular loading conditions the clutch is preset to set the removed body for slipping at a different overload , it is simply mounted on input member by means of a key .sleeve 'M' is adjusted in the appropriate direction , during which the balls will remain pressed against the serrations ; thus setting operation is simple , rapid and reliable .The clutch is there connected to the output memberWhen the input shaft is rotation through the coupling and motor the base flange is rotated along with it the balls pressed against vee - serration also rotate.

This motion is transmitted through springs; plunger to the cylindrical body which then rotates the output shaft. When the load on the output shaft exceeds the preset design overload the resistance of the balls to more in direction of motion of base flange , there by balls start slipping in the vee serrations . At one point the balls completely come out of the serrations into open space in base flange thereby disconnecting the base flange and the cylindrical body. Thus the input shaft keeps rotating whereas the output shaft comes to stand still [6].

7. SYSTEM DESIGN

7.1. *Input data*

7.1.1. *Motor details*

Single Phase AC Motor
230 Volt, 50Hz
0.5 Amps,
Power = 0.125Hp
= 93.25 watt
Speed = 1500 rpm

7.2. *Torque calculations*

Wire Diameter mm	Outer Diameter mm	Stiffness Of spring Per turn K1 N/mm	Permissible load	
			Static Load N	Dynamic Load N
1.0	12.0	7.98	32.4	14.5

Power (P) =2πNT/60

T=60*P/2πN

T= 60 x 93.2/2 x π x 1500

T = 0.59365 x 10^3 N-mm

Considering 25% over load

Tdesign = 1.25 x T

= 1.25 x 0.59365 x 10^3

8. DESIGN OF UNDIRECTIONAL CLUTCH.

Ball Clutch Nomenclature

D= Diameter of ball , mm

D = Pitch circle diameter of groove , mm

Ft = Total tangential force on balls, N

F_s = Total spring force, N

F = spring force on each ball, N

∝ = Angle of inclination of groove

Ks = Springstiffness, N/mm
Lf = Free length of spring, mm
M_t = Torque transmitted, N mm
N = Number of turns in the spring
P = Pitch of spring coil, mm
Zb = Number of balls in the clutch
μ = Coefficient of friction
K1 = Stiffness per turn N /mm
δ2 = Movement of ball while Clutch is slipping, mm
δ1 = Compression of spring to exert force F, mm

8.1. ***Calculation of tangential force on balls (ft)***

Ft =2*Mt/D

== 2 x 0.742 x 10^3 /D

Assuming pitch circle diameter of the grooves

(D) = 90 mm

F_t = 2*0.742*103/90

Ft = 16.489 N

8.2. ***Calculation of force on each spring (f)***

F = Fs /Zb
Zb = Number of balls in clutch

= 3 No's
F = 12.727/3
F = 4.242 N

8.3. ***Stiffness of spring (ks)***

Ks = KI / n

where K1 = Stiffness of spring per turn K1 (N/mm)
n = Number of turns of spring = 6
Ref . PSG DESIGN DATA HANDBOOK

Stiffness and permissible static and dynamic loads for helical compression springs

$$Ks = \frac{K1}{n}$$

Ks = 7.98/6

Ks = 1.33 N/mm

8.4. ***Compression of spring to exert a force f' (δ1)***

$$\delta 1 = \frac{F}{Ks}$$

$$= \frac{4.24}{1.33}$$

δ1 = 3.18947 mm

8.5. ***Movement of ball while the clutch is slipping (δ2)***

$$\delta 1 = \frac{d(1-\cos\alpha)}{2}$$

Where,

d = Diameter of ball

=14 mm

$$\delta 2 = \frac{14(1-\cos 45)}{2}$$

δ2 = 2.050 mm

8.6. ***Maximum deflection of spring (δmax)***

δmax =δ1 +δ2

= 3.18947 + 2.050

δmax = 5.23947 mm

8.7. ***Free length of spring (lf)***

Lf = Solid length + Maximum deflection

+ Clearance between adjacent coils

= n' d + δmax + (n'–1)

Where,

n' = n + 2

= 6 + 2

n' = 8

Lf = 8 x 1 + 5.23947 + (8 –1)

Lf =20.23947mm

9. CONCLUSION

From the above discussion, it can be concluded that overload slipping ball clutch can be used as a safety device. It has versatile application in protecting pump, compressor etc. from mechanical damage, when subject to overload. It also saves motor from burning under overload condition. This mechanism can be easily implemented in practical application where motor is used. No doubt, in future, overload slipping ball clutch will play key role as a safety device.

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