Review on Torque limiter Gear Coupling using FDM

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Abstract-*Power is transmitted from motor to output shaft without any interference when no excessive load acting on the machine. But major problem is faced by industry on the machine that is when excessive load will act on the output shaft then problem of overloading 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 i.e.; motor from the output member is absolutely necessary to avoid damage itself. Such serious problem which face by the industry can be avoided by use of Torque for overload protection and this can be achieved by the overload slipping ball clutch which 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.*

Keywords-Torque limiter, Safety Clutch Overload protection, overload slipping Spring Ball clutch, FDM

I. INTRODUCTION

In an industry there is always need of more rapid, more rigid and precise equipment to increase capacity and productivity. Such requirement demands various mechanisms like gearing arrangements, high capacity motors and shaft drive mechanism. The output load on driving member exceeds in some of the applications like centrifugal pumps, grinders, ship propellers etc. When machine gets overloaded it results in failure of components such failure of shafts, burning of motor, gear teeth rupture [1]. In order to avoid overloading some preventive measures are incorporated between driving and driven mechanism, use of torque limiter is one of them. This paper describes spring ball type torque limiter made using FDM method.Till date many type of torque limiters are made available and used. These come with various specifications, e.g. shear pin torque limiter which uses so called mechanical component designed to with stand specified shear load. It has disadvantage that it requires replacement of shear pin after each breakage. Another type is permanent magnet torque limiter, this type creates backlash problems. Third type is pawl-spring torque limiter, in which spring-loaded, cam follower or pawl-detent device is used but due to need of operator for re-engagement it is disadvantageous.

Considering the disadvantages we designed this torque limiter to protect against overload at particular torque limit which inherits following features

i. Variable torque limits
ii. Automatically re-engaged
iii. No-manual replacement needed
iv. No part worn-out
v. No backlash

Conventional spring ball clutch is of a Flying ball type which transmits torque from input to output using balls held by a spring in assembly when overload occurs the balls will come out of assembly and thus disconnecting input and output thereby saving part failures. Hence in this paper the spring ball clutch is so designed that the balls will not come out of assembly when there is overload. There will only be slipping of the balls, this comes as an advantage as the clutch can be preset without removing it from assembly and this will save considerable amount of downtime of process as compared to the conventional clutch.

The following features must characterize the safety clutches [1]:

- Reliability and safe working.
- Limitation accuracy, to a certain required value of the transmitted torque;
- Adjustment possibility of the transmitted torque.
- The automatic re-establishment capacity of the kinematic flow, after the overload stops. The safety clutch use is recommended for the following situations:
- In the machines transmissions where the shocks occur or where the inertia masses are big, as a result of the impossibility to have precise determination of overloads;
- For the transmissions of the machines that process inhomogeneous mediums (dredger for clearing dry earth, farm implements, and so on);
- In the automatic machines transmissions, as a result of a lack of a permanent control of their working;
- In the kinematic chains with more strands (machine tools

and so on), due to the impossibility of the transmission protection by the electric motor;
- In all the transmissions where the over-measure cost – for overloads resistance – is higher than the cost of a reliable safety clutch.(1)

Disadvantages Of Current System Of Overload Protection

To protect the drive from failure, what is available in market is a Flying ball clutch. which transmits torque from input to output using balls held by a spring in assembly when overload occurs the balls will come out of assembly –thus disconnecting input and output thereby saving part failure But
- Rating of clutch is 1N-m, 5 N-m, 20 N-m etc. i.e. fixed value so if o/p torque change we have to replace clutch.
- Every time ball comes out of assembly we have to remove the clutch to replace ball this increases down time of machine
- Drive always remains coupled there is no flexible arrangement like automobile clutch i.e. possibility to disengage at will.
- If temporary overload occurs the clutch will slip and remain disengaged till it is preset even though the overload is now removed this leads to process down time.

Advantages Of Overload Torque Limiter

The overload slipping ball clutch has the following advantages.
- Overload slipping ball clutch prevents the burnoutor damage to the electric drive motor due to sudden over load**.**
- Over load slipping ball clutch can be easily preset after disengagement.
- Overload slipping ball clutch is capable of transmitting a wide range of torque which can be precisely preset on the drive itself. Low cost of manufacture.
- Compact size
- If temporary overload occurs the clutch will slip and remain disengaged only till the overload is removed thus if the overload is removed while in running condition the clutch shall automatically engage and start transmitting power.

II. LITERATURE REVIEW

Study of various configuration of Overload Torque limiters, using various Handbooks, United State Patent documents, Technical papers , etc.

Tobias wolf

The concept of weight reduction through the use of high tech materials is not a new one. But for those involved in the design of motion control and automation systems, the elimination of excess mass and inertia is often the difference between success and failure. Energy savings, higher throughput rates, and reduced downtime, all without compromise to quality or accuracy, are the new requirements. To address them, R+W has introduced a new torque limiter, SL Series, with half the inertia and less than half the mass, allowing for a rapid and automatic recovery from torque overload even in the most advanced drive technology. The SL Series uses the proven spring loaded ball detent system, along with a previously patented preload for zero backlash operation.[1]

Andrew lechner

As a primary or redundant safety device, backlash free ball-detent torque limiters serve as a mechanical circuit breaker for machine drive protection, disconnecting drive and driven elements accurately(±5 percent torque) and virtually instantaneously(&3 msec)in the case of a machine jam or crash. A common misconception is that limiting current supplied to the drive will inherently protect the mechanical system from overload, though when placed on the output of servo worm or planetary gearboxes for example, precision torque limiters protect the mechanical system from reflected load inertia, where sufficient energy to do harm has already been supplied well in advance of the impact. Backlash, repeatability and response time are key to the successful application of mechanical torque limiters in high-speed servo applications.“Traditional torque limiters would not respond fast enough to an overload situation in higher speed applications.[1]

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 greatextent – the safe and long working, both of these and of the kinematic chain equipped with them[2].

M jackel1 et al.

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]

Mark S Landquist

He invented radial ball torque limiter which having a member with an annular wall defining a cavity with a plurality of rows of internal teeth extending circumferentially along the interior of the annular wall, an input shaft extending into the cavity , and one or more caged ball assemblies surrounding the input shaft with each having a circumferential row of balls loosely held by a generally annular cage to engage in ball receiving recesses between adjustment teeth and the cage has a hub connected to the input shaft.[4]

S.N.Shelke et al.

In there paper Design development, testing and analysis of torque limiter for overload protection conclude that safety clutch is easily adjusted to transit a range of different torques.[5]

Aitavade et al.

In there paper on Spring Loaded Torque Limiter conclude that The spring loaded ball clutch (torque limiter) ensures that
(1) The limitation and the adjustment of the transmitted moment.
(2) The torque limiters can take over technological and assembling deviations.[6]

Chandrakant Labade et al.

In there paper Torque Tender /Limiter For Overload Shaft found The enclosed design of the mechanical torque limiter enables it to operate in a wide variety of industrial environments. Special designs and materials can be made to withstand even more adverse conditions [7]

Guy James Burlington

presented that clutch mechanism includes clutch members having an engaged position, in which torque generated by a drive is transmitted to an output, and a disengaged position, in which torque is not transmitted to the output. The clutch members are capable of slipping with respect to each other in order to prevent damage caused by overload conditions. The clutch mechanism further comprises an actuator associated with a clutch member. [8]

William j silver

invented torque limiter comprises an outer cylindrical housing having a plurality of semicircular grooves disposed in an interior surface . aninner cylindrical housing is arranged at least partially within the outer cylindrical housing .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. That value determines what spring is used during the assembly. The torque value can be changed in the field, however; the torque limiter must be disassembled and the springs replaced to achieve the new torque value. As per torque value we have to change springs stiffness. (Springs)Standard Torque-Limiters are bidirectional. The torque value is the same regardless of rotation. If specified, these torque limiters can be configured at different torque ratings for different rotational directions.[9]

III. PROBLEM STATEMENT

Whenever an overload occurs in any shaft drive mechanism there are three possibilities:

a) Shaft / coupling/ belt drive fill fail or break
b) Application i.e. machine shaft will fail or break
c) Motor will be overloaded resulting into electric burn

In any case it is damage leading to machine part replacement Down time of machine and increased part replacement and maintenance cost.

IV. SCOPE OF WORK

- In many cases pump shaft drives either electrical or engine drives are normally furnished with the overload slipping ball clutch to avoid the breakage or damages arising due to pump clogging or blockage Compressor drives, especially in many mining applications are equipped with the over load slipping ball clutch.
- Compact size: The size of the Torque limiter gear coupling is very compact; which makes it low weight and occupies less space in any drive.
- Ease of operation: The changing of torques gradual one hence no calculations of speed ratio required for change torque .Merely by rotating adjuster lock nut torque can be changed.
- Machine tool slides are driven by electrical drives connected to lead screw. The over load slipping ball clutch isolates the electrical drive from the output in case of overload.
- Ease of replacement: Even if the torque limiter gets damaged ,the parts made by ABS polymer using 3d printing are very cheap and quick to manufacture

V. OBJECTIVES

- Design of ball detent 3 ball set overload torque limiter with adjustable torque limit.
- To design a Test rig, plunger, base flange output shaft which easily avoid the excess load acting on the system.
- To prevent the Motor from stalling or burning which cause due to overloading on output shaft by doing static structural analysis.
- Design and geometrical derivations of the groove profile in input base flange.
- Design and geometrical derivations of spring plunger profile.
- Selection and geometrical profile of clutch body ball holder.
- Selection and design of torque control using plunger and casing arrangement.
- Mechanical design : This includes the design and development of springs selection of suitable drive motor, strength analysis of various components under the given system of forces.
- The critical components of assembly input pulley, Safety ball clutch input shaft, input base flange, plunger, cylindrical body, output shaft etc., components will be designed using conventional theories of failure using various formulae, 3-D models of the above parts will be developed using Catia V5R21 software and meshing,analysis will be done, the result of stress produced will be validate dusing ANSYS-Workbench 16 release.

Testing ofdrive to derive performance characteristics for

a) Torque Vs Speedb) Power Vs Speedc)Efficiency Vs Speed

VII. METHODOLOGY

Phase 1 : Data collection

Data collection phase involves the collection of reference material for project concept, the idea is taken from book HMT handbook.

Phase 2: System design

The system design comprises of development of the mechanism so that the given concept can perform the desired operation. The mechanism is basically an inversion of four bar kinematic linkage , hence the mechanism is suitably designed using Grashoff's law and the final outcome is shown in the figure shown before.

Phase 3 : Mechanical design

The parts mentioned above in the part list will be designed for stress and strain under the given system of forces, and appropriate dimensions will be derived. The standard parts will be selected from the PSG design data handbook.

Phase 4 : Production drawing preparation

Production drawings of the parts are prepared using Auto Cad ,with appropriate dimensional and geometric tolerances. Raw material sizes for parts are also determined.

Phase 5 : Material procurement & process planning

Material is procured as per raw material specification and part quantity. Part process planning is done to decide the process of manufacture and appropriate machine for the same.

Phase 6 : Manufacturing

Parts are produced as per the part drawings.

Phase 7 : Assembly –test & trial

Assembly of device is done as per assembly drawing ,and test and trial is conducted on device for evaluating performance.

Phase 8 : Report preparation

Report preparation of the activities carried out during the above phases is done .

VI. CONSTRUCTION

The adjustable torque spring ball Torque Limiter is an safety device used in the transmission line to connect the driving and driven elements such that in case of occasional overload the Torque Limiter will slip there by disconnecting the input and output members . This protects the transmission elements from any breakage or damage. For a particular loading conditions the Torque Limiter is preset to set there moved body for slipping at a different overload, it is simply mounted on input member by means of a key sleeve 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 Torque Limiter is there connected to the output member.

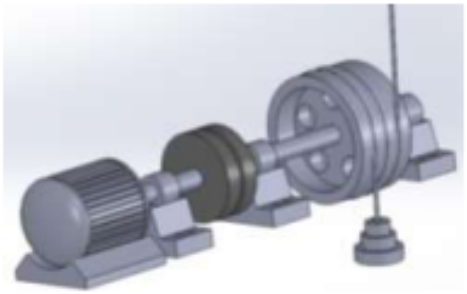

Fig 1. Testing setup for the torque limiter

Table: Parts of Torque limiter gear coupling

Part No.	Part Name	Material	Nos
1	Input shaft	EN24	1
2	Base flange	ABS	1
3	Cylindrical Body	ABS	1
4	Left hand gear	ABS	1
5	Right hand gear	ABS	1
6	Sleeve	ABS	1
7	Casing	ABS	1
8	Output shaft	EN24	1
9	Steel balls	STD	3
10	Springs	STD	3
11	Plunger	EN24	3
12	Key	STD	1
13	Lock nut	NYLON	1
14	Bearing	STD	4

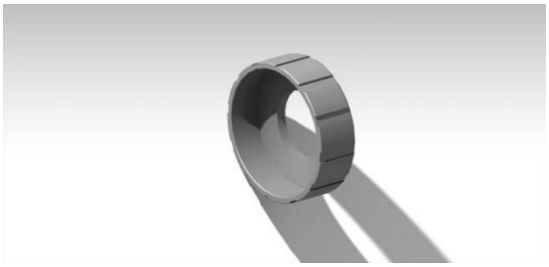

Fig 2 .Body

Fig 3 . Left hand gear

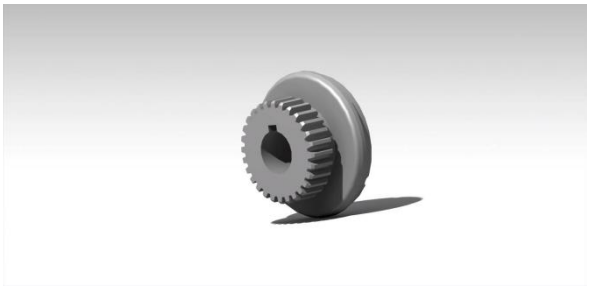

Fig 4. Left Hand Gear

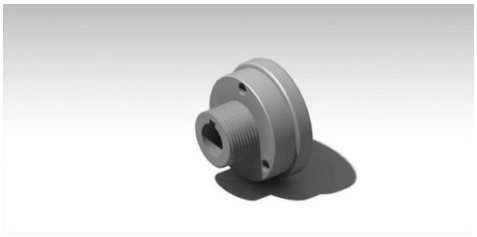

Fig 5 . Flange

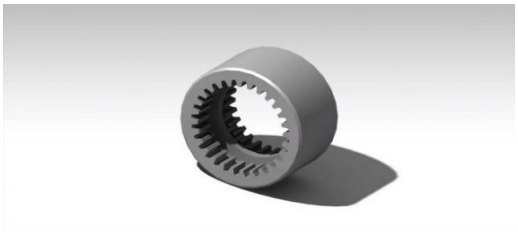

Fig 6 . Sleeve

Fig 7. Locknut

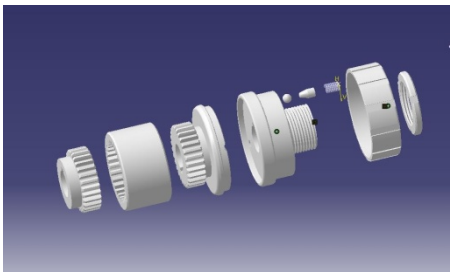

Fig 8. Exploded view

VII. WORKING

When the input shaft is rotation through the coupling and motor the base flange is rotated along with it the balls pressed against V- 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 "V" serrations. At one point the balls completely come out of the serrations into open space in base flange there by disconnecting the base flange and the cylindrical body. Thus the input shaft keeps rotating where as the output shaft comes to stand still. To increase the overload value; move sleeve towards the base flange where as to reduce the overload; move the sleeve a way from the base flange The sleeve can be locked in position by means of the lock nut. The overload slipping ball clutch is safety device used in the transmission line to connect driving and driven elements such that in case of occasional overload the clutch will slip by disconnecting input shaft and output members. This protects the transmission elements from damage.

For particular loading conditions the clutch is preset to set the cylindrical body for slipping different overload, it is simply mounted on output member by means of key. Casing is adjusted in appropriate direction during which balls will remain pressed against the serrations thus setting operation is simple, rapid and reliable The clutch is there to the output member or load. When input shaft is in rotation through reduction pulley and motor, the base flange is rotated, along with it and balls pressed against V-serration also rotate. This motion is transmitted through springs, plunger to the cylindrical body which when rotates the output shaft. When load on output shaft exceeds the preset design of balls to more in direction of motion of base flange, thereby balls start slipping. At one point balls completely come out of serretations into open space in base flange thereby disconnecting base flange and cylindrical body. Thus, input shaft keep rotating where as the output shaft comes to stand still. The overload value at which clutch slips can be designed and preset by moving casing in either direction of cylindrical body. To increase overload value, move casing towards base flange whereas to reduce overload, move casing away from the base flange.

VIII. APPLICATIONS

Pump shaft drives

Pump shaft drives either electrical or engine drivesare normally furnished with the overload slipping ballclutch to avoid the breakage or damages arising due topump clogging or blockage.

Compressor drives

Compressor drives, especially in many mining applications are equipped with the over load slipping ball clutch.

Machine tool slide drives

Machine tool slides are driven by electrical drives connected to lead screw .The over load slipping ball clutch isolates the electrical drive from the output incase of overload.

Hydraulic pump drives

It is used in pump drives for hydraulic power packs.

IX. CONCLUSIONS

- Excess load acting on output shaft can
- be reduced by Design and Analysis of Torque Limiter Timer Belt Spindle Drive for Overload Protection.
- The torque carrying capacity can be obtained by varying three number of Ball & spring sets.
- In this way stalling of motor can be avoided by design and development of torque limiter.
- The torque limiters allow the damp of the torsionshocks transmitted in different transient regimes of the mechanical transmission.

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