International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 04, April-2022

Modeling and Analysis of Compact Torque Limit Gear Coupling Drive

Ms. Mugdha G Shinde
PG Student,
Department of Mechanical Engineering
JSPMs Rajarshi Shahu College of Engineering, Tathawade
Pune, Maharashtra, India.

Mr. Pruthviraj D Patil
Assistant Professor,
Department of Mechanical Engineering
JSPMs Rajarshi Shahu College of Engineering, Tathawade
Pune, Maharashtra, India.

***Abstract*— In many transmission mechanism and drives the couplings play a crucial role of providing the vibration free, safe transmission of power from input to output shaft of equipment. Although the conventional rigid couplings when properly designed, selected and maintained, can provide good service life but they do-not provide the desired safety against the overloads. And how ever the useful life of rigid coupling is limited due to following factors namely, Human Errors, Corrosion, Wear, Fatigue, Hardware failures shaft failure. Gear couplings are standard, however in some cases customized couplings are needed which are not possible to produce because of very high molding costs. Although torque limiters are available in market but they are of fixed torque limits. In such cases 3-d printed couplings come as appropriate choice. Project aims at design, modeling, analysis and comparison testing of the gear coupling integrated with torque limiter that is 3-d printed .The modelling of the compact drive system will be done using Unigraphix Nx-8 where as the analysis is done using Ansys Workbench-16.0 .Test are conducted on the set up to find performance parameters of torque, power and efficiency at various speed conditions.**

Keywords—Transmission, gear coupling, torque limited, design, analysis

I. INTRODUCTION

Major modification couplings are a combination of standard parts, modified parts, special standardized parts and designed to order parts. Included with those designs are floating shafts, insulated couplings, long sliders or Jordan couplings, cut out couplings of two types, shear pin couplings, brake wheel couplings, and moderate speed units where careful machining and component balance will suffice.

The line between major modification couplings and total made-to-order couplings is blurred. The size range from 9 to 15 is in the gray area, but sizes above 15 are definitely made to order. Made to order couplings are costly and take a lot of time to manufacture hence an alternative process of manufacture is proposed for manufacture.

Processors face many challenges in creating gear geometries that maximize power while minimizing transmission error and noise. Such gear coupling call for great precision in molding concentricity, tooth geometry, and other properties. Some gear coupling, like helical types, can involve complex mold movements to release the finished product, while others need cored teeth in thicker sections to control shrinkage. Although the latest polymers, equipment, and tooling put the next generation of plastic gear coupling within reach of most molders, the true challenge any processor faces is in adapting its entire operation for such high-precision work. Tolerances needed for precision gear coupling generally go well beyond those defined as “fine” by The Society of the Plastics Industry. However, today’s molding machines with the latest process controls provide the accuracy to hold mold temperature, injection pressure, and other variables within a tight enough window to allow most processors to mold precision gear coupling. Some gear molders go a step further and place pressure and temperature sensors in mold cavities to improve consistency and repeatability.

Manufacturers of precision gear coupling also need specialized measuring equipment to verify gear quality, such as double-flank roll checkers for quality control and computer-controlled inspection to evaluate gear teeth and other features.

Though the process of plastic molding is a proven one for tight tolerances and accuracy but it is high on investment and process time, hence it is un economical for small batch quantities.[1-10]

II. EXPERIMENTAL SETUP :

Construction and Design Details Of The Compact Drive Gear Coupling With Torque Limiter:

The drive is transmitted to the gear coupling through the pinion gear via the AC motor. The output shaft carries the load during testing of the set up.

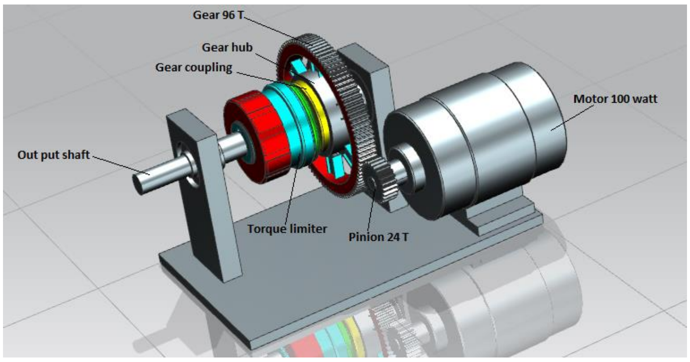

Fig 1.Compact torque limiter gear coupling drive

Gear coupling transmits the power to the torque limiter via the base flange. The balls transmit the power to the torque limiter body and then to the output shaft. The plunger when pushed forward by the casing the torque can be increased to the desired value. When over load ball slips in the flange slots and thus the torque limiter is disengaged.

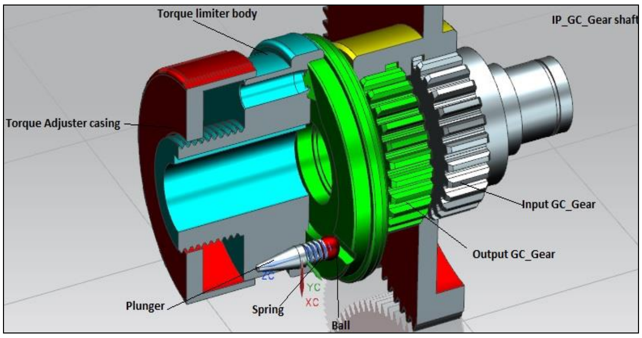

Fig. 2 Assembly of Compact Drive Gear Coupling

III. DESIGN OF PART ASSEMBLIES:

1 Design of motor Pinion(24 T) :

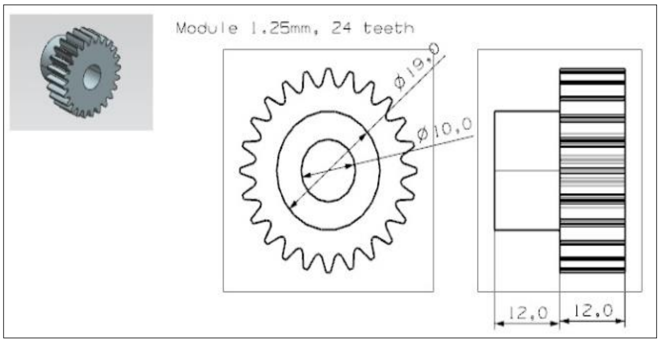

Fig. 3 Motor Pinion 24T

Table No. 1 Material Selection for Motor Pinion 24T

Designation	Textile Strength (N/mm^2)	Yield Strength (N/mm^2)
Nylon 66	80	56

Check for torsional shear failure of shaft:
$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4)/D$

$\Rightarrow fs_{act} = 0.128\ N/mm^2$

As $fs_{act} < fs_{all}$

⇒ Motor pinion is safe under torsional load.

1.1 Analysis of motor pinion :

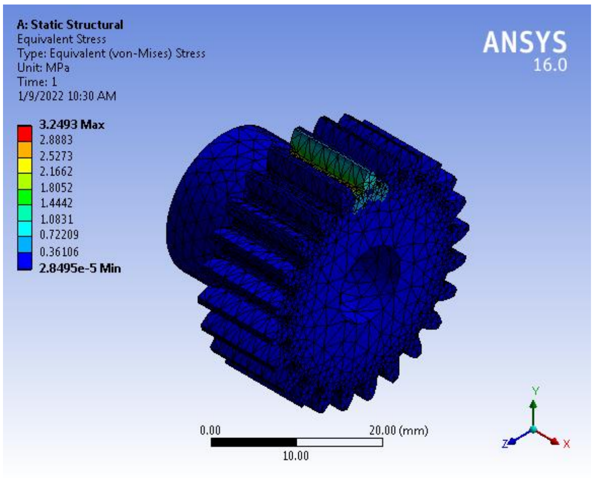

Fig. 4 Von mises stresses of Pinion 24T

Statistics		
Nodes	**Elements**	**Mesh Metric**
31734	18046	None

The maximum theoretical stress in the pinion under torsional load is 0.128 MPa where as the analytical stress is 3.25 MPa thereby suggesting that the design of pinion is safe under given system of forces

2. Design of Gear (96 T) :

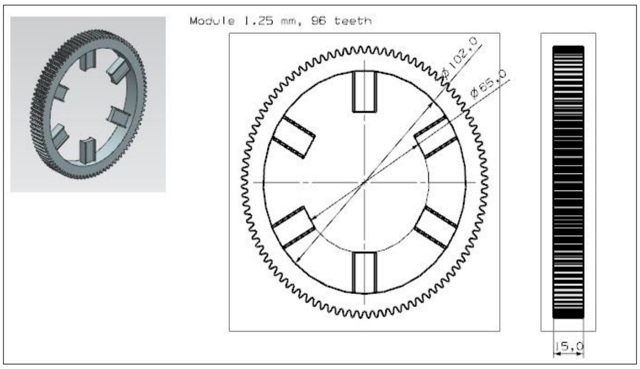

Fig. 5 Analysis of gear

Table No. 2 Material Selection for Gear 96T

Designation	Textile Strength (N/mm^2)	Yield Strength (N/mm^2)
Nylon 66	80	56

Check for torsional shear failure of shaft: .
$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4)/D$
$\Rightarrow fs_{act} = 0.128\ N/mm^2$
As $fs_{act} < fs_{all}$
⇒ Motor pinion is safe under torsional load.

2.1 Analysis of gear :

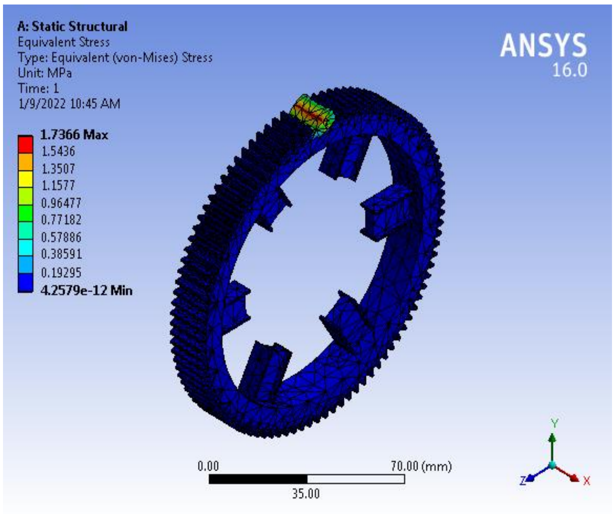

Fig. 6 Von mises stresses of Gear

Statistics		
Nodes	**Elements**	**Mesh Metric**
29172	15031	None

The maximum theoretical stress in the pinion under torsional load is 0.128 MPa where as the analytical stress is 3.25 MPa thereby suggesting that the design of pinion is safe under given system of forces.

3. Design of Input Shaft :

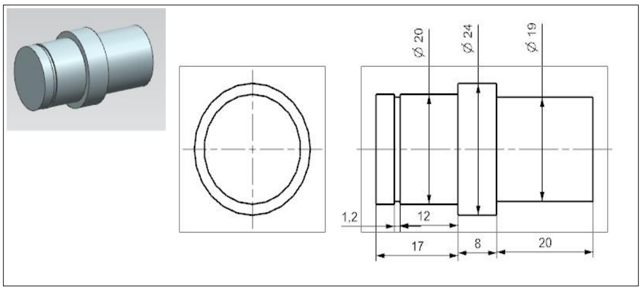

Fig. 7 Input Shaft

Table No. 3 Material Selection for Input Shaft

Designation	Ultimate Tensile Strength (N/mm^2)	Yield Strength (N/mm^2)
EN 24	800	680

Check for torsional shear failure of shaft:

$Td = \Pi/16 \times fs_{act} \times d^3$

$\Rightarrow fs_{act} = 0.475\ N/mm^2$

As $fs_{act} < fs_{all}$

$\Rightarrow$Input shaft is safe under torsional load.

3.1. Analysis of Input shaft :

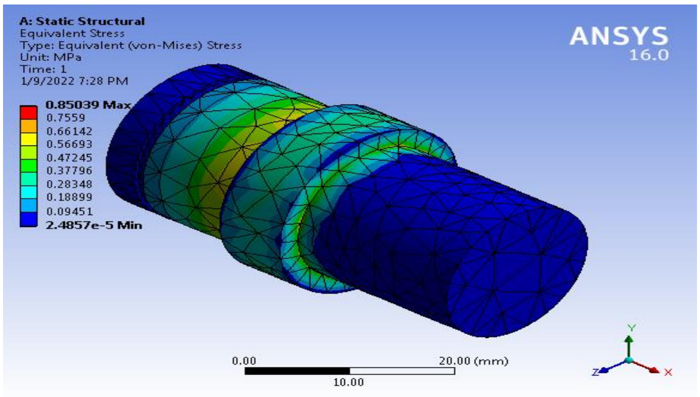

Fig. 8 Von mises stresses of Input Shaft

Statistics		
Nodes	**Elements**	**Mesh Metric**
4623	2611	None

Maximum stress 0.85 MPa by theoretical method and Von-mises stress are well below the allowable limit, hence the input shaft is safe.

4. Design of Output Shaft :

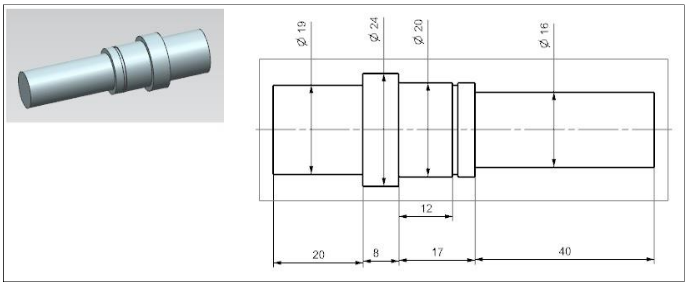

Fig. 9 Output Shaft

Table No. 4 Material Selection for Output Shaft

Designation	Ultimate Tensile Strength (N/mm^2)	Yield Strength (N/mm^2)
EN 24	800	680

Check for torsional shear failure of shaft:

$\Rightarrow fs_{act} = 0.7965\ N/mm^2$

As $fs_{act} < fs_{all}$

$\Rightarrow$Output shaft is safe under torsional load.

4.1. Analysis of Output shaft :

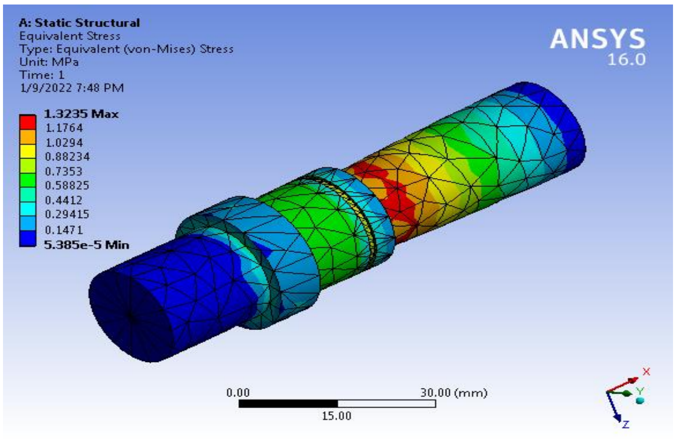

Fig. 10 Von mises stresses of Output Shaft

Statistics		
Nodes	**Elements**	**Mesh Metric**
4623	2611	None

Maximum stress 1.32 MPa by theoretical method and Von-mises stress are well below the allowable limit, hence the output shaft is safe.

5. Design of Torque Adjuster Casing :

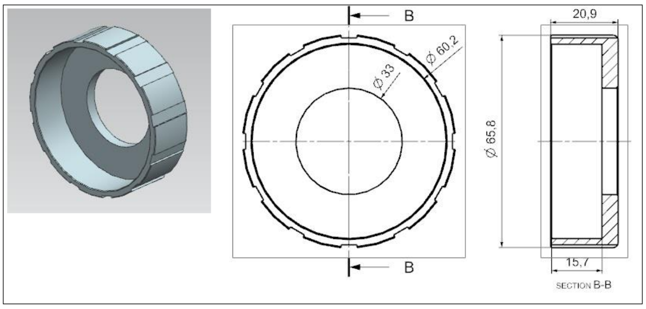

Fig. 11 Torque Adjuster Casing

Table No. 5 Material Selection for Torque Adjuster Casing

Designation	Ultimate Tensile Strength (N/mm^2)	Yield Strength (N/mm2)
Abs Polymer	60	42

Check for torsional shear failure of shaft:

$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4)/D$

$\Rightarrow fs_{act} = 0.016 N/mm^2$

As $fs_{act} < fs_{all}$

$\Rightarrow$ Casing is safe under torsional load.

5.1 Analysis of Casing (Torsion) :

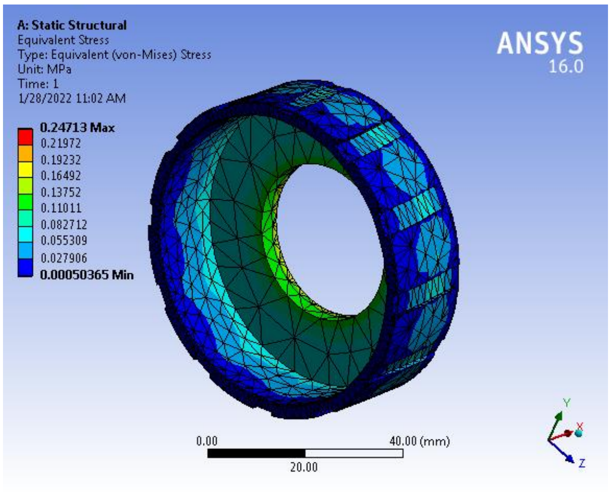

Fig. 12 Von mises stresses of Torque Adjuster Casing

The maximum stress induced in the body is 0.24713 Mpa which is far below the permissible stress in the material of casing hence the part is safe.

IV. RESULT DISCUSSION:

1. Although the conventional rigid couplings when properly designed, selected and maintained, can provide good service life but they do-not provide the desired safety against the overloads. Conventional method of manufacturing is the plastic molding , but this is only for a substantial batch quantity. In present day situation many a times it is required to produce small quantity of products for which plastic molding is not a economical solution. In such cases the method of FDM (Fused deposition modeling) can be used.
2. The maximum theoretical stress in the pinion under torsional load is 0.128 MPa where as the analytical stress is 3.25 MPa thereby suggesting that the design of pinion is safe under given system of forces
3. The maximum theoretical stress in the pinion under torsional load is 0.128 MPa where as the analytical stress is 3.25 MPa thereby suggesting that the design of pinion is safe under given system of forces.
4. Maximum stress 0.85 MPa by theoretical method and Von-mises stress are well below the allowable limit, hence the input shaft is safe.
5. Maximum stress 1.32 MPa by theoretical method and Von-mises stress are well below the allowable limit, hence the output shaft is safe.

V. CONCLUSION:

1. Rarely occurring overloads must be considered during the design process of a power train.

2. These overloads can be evoked by malfunctions in the electronics of inverter and installation control, by obstructions in the work flow, by mis-operation etc.
3. These overloads may create pre-damages which lead to full failure of the assembly or its components. Such affecting loads are avoidable by means of overload clutches. Thus reliable overload clutches are of strongly increasing interest for years.
4. Although torque limiters are available in market but they are of fixed torque limits. In such cases 3-d printed couplings come as appropriate choice. Project aims at design, modelling, analysis and comparison testing of the gear coupling that is 3-d printed.
5. The modelling of the compact drive system has been done using Unigraphix Nx-8 where as the analysis is done using Ansys Workbench-16.0 the parts are found to be safe by both methods. The developed overload clutch will be integrated with gear coupling to develop a compact drive system.

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