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Comparison between Experimental and Analytical Analysis of Single Ball Continuous Variable Transmission System

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Abstract:

A mechanical torque transmission producing an output with variable controllable speed torque characteristics which compares a rotary input shaft adapted for attachment to the rotary power source connected to a main shaft. This invention relates to a mechanism transferring torque from one rotating shaft to another and in particular to a transmission mechanism that will enable an engine or motor to deliver power to a load at optimum torque and speed levels. Control can be utilized to activate or deactivate the clutch also change the phase relationship of the driven eccentric masses device in order to vary the transmission output under varying load condition. Continuous variable transmission system plays a crucial role in order to guarantee the overall vehicle performance in different working conditions.

Keywords — **Continuous variable transmission, Velocity theorem, Torque transmission, CVT**

1. INTRODUCTION

The primary function of a transmission is to transmit mechanical power from a power source to some form of useful output device. Since the invention of the internal combustion engine, it has been the goal of transmission designers to develop more efficient methods of coupling the output of an engine to a load while allowing the engine to operate in its most efficient or highest power range. Conventional transmissions allow for the selection of discrete gear ratios, thus limiting the engine to providing maximum power or efficiency for limited ranges of output speed. Because the engine is forced to modulate its speed to provide continuously variable output from the transmission to the load, it operates much of the time in low power and low efficiency regimes.

The development of modern CVTs has generally focused on friction driven devices, such as those commonly used in off-road recreational vehicles, and recently in some automobiles. While these devices allow for the selection of a continuous range of transmission ratios, they are inherently inefficient. The reliance on friction to transmit power from the power source to the load is a source of power loss because some slipping is possible. This slipping is also a major contributor to wear, which occurs in these devices.

Fig. 1 Single Ball Traction Drive

2. OBJECTIVE

1. Design and development of Continuous variable transmission.
2. Experimental testing And Trial to derive Following Performance Characteristics
   a) Torque Vs Speed
   b) Power Vs Speed
   c) Efficiency Vs Speed
3. Manufacturing of continuous transmission system.

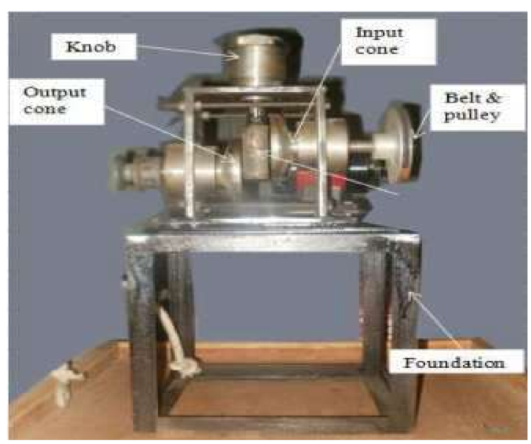


Fig.1 Experimental Setup

2. EXPERIMENTAL METHODOLOGY

1. Review of literature regarding the work done
2. Analytical design of CVT.
3. Manufacturing and assembly of the Actual testing set-up.
4. Perform experimental testing on CVT with different Performance Characteristics.
5. Result and Discussion.

3. ANALYTICAL ANALYSIS

3.1 Design of Input Cone and Output Cone

Material Designation	Tensile Strength (N/mm)	Yield Strength (N/mm)
EN24	800	680

$fs_{max} = 0.18\ fult$

$= 0.18 \times 800$

$= 144\ N/mm^2$

OR

$fs_{max} = 0.3\ fyt$

$= 0.3 \times 680 = 204 N/mm^2$

Considering minimum of the above values;

$\Rightarrow\ fs_{max} = 144\ N/mm^2$

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

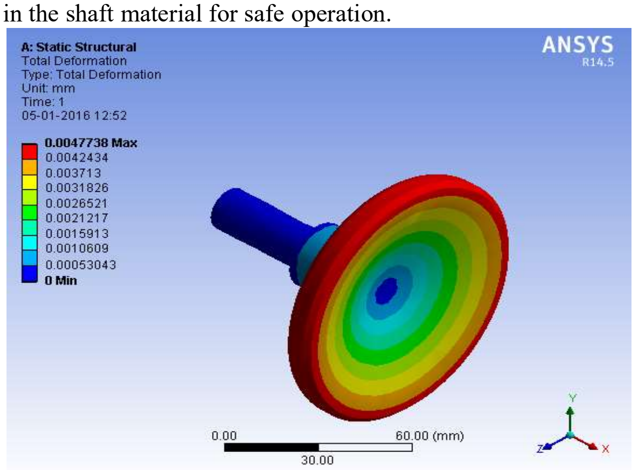


Fig.2 FEA analysis of input and output cone

3.2 Design of Ball Holder

Material Designation	Tensile Strength (N/mm)	Yield Strength (N/mm)
EN9	600	480

Force in compression is owing to radial force caused by the rotating ball

Given by F = T/r = 13791/35 =394 N

$$fc_{act} = \frac{W}{A}$$

$fc_{act} = 1.25\ N/mm^2$

As $fc_{act} < fc_{all}$; Ball holder is safe in compression.

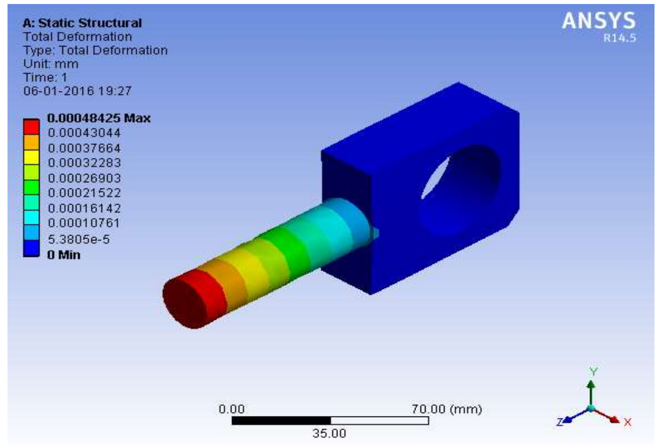


Fig.3 FEA analysis of ball holder

3.3 DESIGN OF SPEED CHANGING KNOB

T= 100 x 35 = 3500 N-mm

$\Rightarrow fs_{max} = 130\ N/mm^2$

Check for torsional shear failure:-

$$T = \frac{\Pi \times fs_{act}}{16} \times \left(\frac{Do^4 - Di^4}{Do}\right)$$

$$3500 = \frac{\Pi \times fs_{act}}{16} \times \left(\frac{48^4 - 36^4}{48}\right)$$

$\Rightarrow fs_{act} = 0.235\ N/mm^2$

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

Knob is safe under torsional load

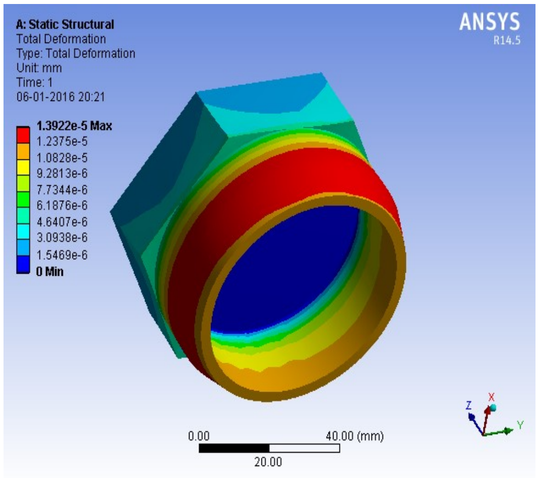


Fig.3 FEA analysis of speed changing knob

4. ANALYTICAL RESULTS:

The maximum torque is given by the formula:

$$T = m^* \omega * R_{CG} *D$$

Where,

T : Maximum torque (N-m)

M : Masse (kg)

ω : Angular acceleration (m/s)

R_{CG} : Radius of offset mass

D : Radius of lobe

TABLE 1: ANALYTICAL RESULTS

Sr. No	Speed (rpm)	Angular Speed		Torque (N-m)
		W	W^2	
1	2000	209.43	43864	0.28
2	1875	196.34	38553.14	0.24
3	1545	161.79	26176	0.17
4	1390	145.56	21187.85	0.14
5	1250	130.89	17134.7	0.13
6	1030	107.86	11633	0.72
7	830	86.91	7554.63	0.46
8	750	78.53	6168.5	0.38
9	660	69.11	4776.88	0.297
10	595	62.30	3882.31	0.234

5. EXPERIMENTAL RESUITS

The Following test results will be derived from Test and Trial method On CVT

TABLE2: EXPERIMENTAL RESULT

Sr No.	Load (gms)	Speed Rpm	Torque (n-m)	Power	efficiency
1	120	2000	0.047088	9.8633664	56.36209
2	170	1875	0.066708	13.099784	74.85591
3	220	1545	0.086328	13.968993	79.82282
4	270	1390	0.105948	15.423839	88.13622
5	320	1250	0.125568	16.438944	93.93682
6	370	1030	0.145188	15.662204	89.49831
7	420	830	0.164808	14.32654	85.78766
8	470	750	0.184428	14.486819	82.78183
9	520	660	0.204048	14.104614	80.59779
10	570	595	0.223668	13.93817	79.64668

6. SUMMARY OF RESULT

The result correlation summarized as show in table

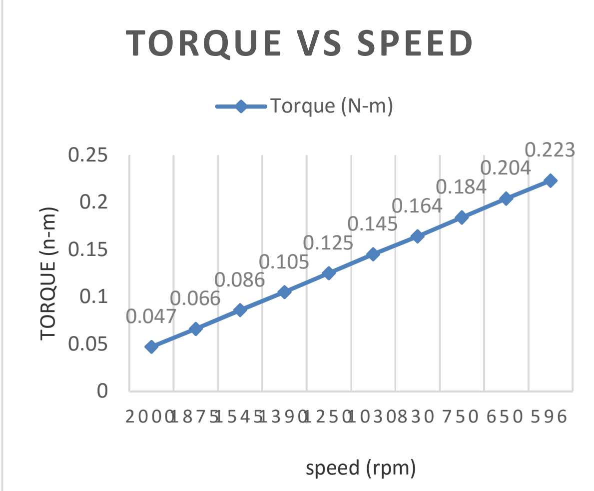
TABLE3: SUMMARY OF RESULT CORRELATION

Sr. No	Speed	Analytical Results Torque (N-m)	Experimental results Torque (N-m)	% error
1	1875	0.2339	0.066708	4
2	1390	0.13	0.105948	3
3	1545	0.16	0.086328	7

The error in prediction of IVT by theoretical analysis is the range of 3 to 4% and experimental analysis 5 to 20%. The propose method is confirmed by the comparing it with result of FEA and Experimental result. This is an in well agreement the acceptable limit ±10%.

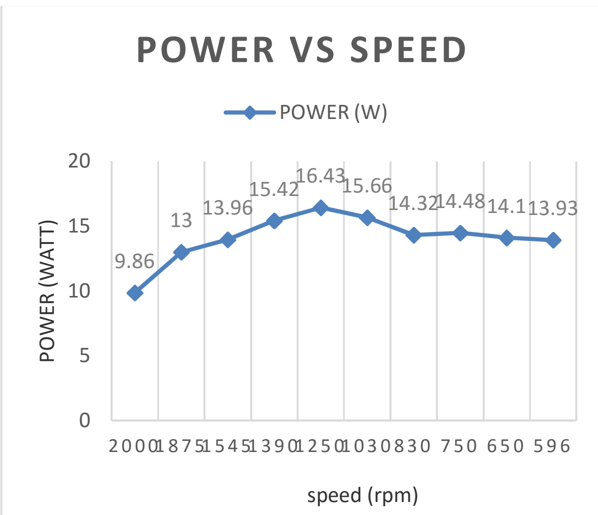
The following test results will be derived from the test and trial on CVT Drive

1] Torque Vs Speed Characteristics:



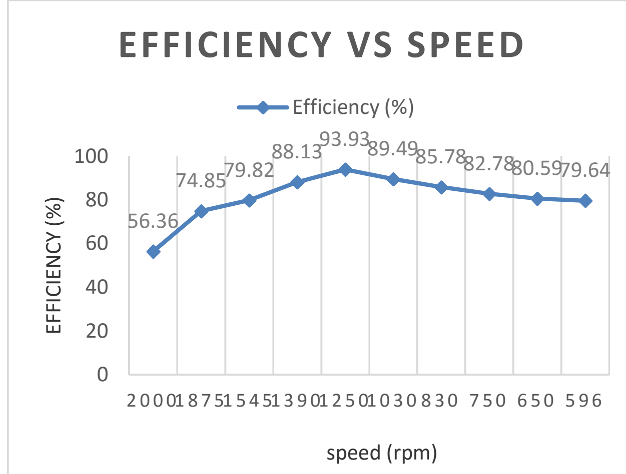
Above graph shows torque Vs speed characteristic. As speed increases torque decreases. At low speed torque is high.

2] Power Vs Speed Characteristic



At low speed torque is high power is increases with decrease in speed which is inversely varies with speed. When speed ranges in 1000 rpm it slowly decreases and after that speed increases power decreases suddenly.

3] Efficiency Vs Speed Characteristics



At low speed efficiency is high and a speed increases efficiency decrease which is inversely varies with speed.

7. CONCLUSION

Power transmission system is very important in industril application.To carry out various production work at various speed e require the stepless, shockless speed variation. Therefore it is necessary to design and develop the power transmission system in compact size, most efficient withminimum cost.

The error in prediction of torque converter by theoretical analysis is in the range of 3 % to 15% and experimental analysis it is the range of 5 % to 20 %. The proposed method is confirmed by comparing it with results of FEA results and experimental results.The proposed method is foundto be simple and accurate.The CVT is newly concept in Light and Medium vehicle on automobile industries is development research they are torque convertor in various masses with different input speed to very output speed to give the more Transmissions, Methods, Assemblies, Subassemblies and efficient in output power.

From graphs shows that the low speed power, torque Efficiency increases and decrease as speed increases which is inversly proportional with speed.

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