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VALIDATION OF PERFORMANCE RESULT FOR AUTOMATED FPCVT USING ANOVA SOFTWARE

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Abstract:* There are many machine and mechanical units that are under varying circumstances make it desirable to be able to drive at barely perceptible speed, intermediate or a high speed .Thus a stepless speed variation in which it is possible to get any desirable speed which is needed . However the torque Vs speed characteristics of drives do not match that of stepless drives at increased driving torque at low speeds. The floating sprocket drive is an innovative solution to above problem where in power is transmitted between two hollow cones fabricated from floating sprocket bars and the stepless power transmission is achieved by movement of the belt via an automated speed change mechanism over these cones. The drive presented in this research work is fixed pitch floating sprocket bar drive for continuously variable transmission systems. The Objective is to present the drive characteristics after automation of floating sprocket bar drive and to study the percentage slip in drive under effect of load. Also validate performance result using ANNOVA Software.

***Keywords:* Validation, Automated Floating Sprocket bar drive, Percent Slip.**

I. INTRODUCTION

The word ‘transmission’ means the whole of the mechanism that transmit both motion and power from the source of energy to the application where it is to be used. However the transmission is also being used very commonly in literature for a mechanism which provides us with suitable variation of engine torque at the application; either in the amplified or reduced form.

The basic drive for any application consists of;

- Source of energy.
- Device for the transmitting power from source to the operating element (Spindles, slides, table etc.)

Machine tools are drive by either of these drives.

- Group drive
- Individual drive.

Each drive is selected on is oven merits, but the individual drives are more advantageous. In ‘electrical drives’ the direct motor drive the machine shaft through the direct coupling. In “Mechanical drive” the transmission elements include “Belts, chains, toothed gearing or some variable speed transmission”. The transmission elements between input & output shafts can perform the following function,

- Convert rotary motion into translatory motion.
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Mechanical drive used for conversion of rotary motion to rotary motion are:

A. Belt Drive

In such drives, a pulley is mounted on the drive shaft and another on the driven shaft and motion is transmitted from the drive pulley to the driven pulley with the help of belts. The section of the belts can be open or crossed. In open drive the driver and driven shafts rotate in same direction is reversed.

$$\text{Transmission ratio (i)} = \frac{\text{RPM of driven shaft}}{\text{RPM of driver shaft}}$$

$$\Rightarrow \quad (i) = \frac{n_2}{n_1} = \frac{D_1}{D_2}$$

In order to achieve multiple speeds there will be a need of stepped pulley drives.

B. Step- Cone Pulley Drive

This drive gives definite steps of speed ranging from driven speed considerably less than the driver to speeds much higher than that of driver.

- The drive is simple and cheap in design but it occupies lot of space.
- Numbers of speed steps are limited.
- Belt drives are not positive, constant velocity ratio is not guaranteed; due to slip.
- Shifting of belt also takes a lot of time.

II. RELEVANCE OF PROJECT

There are many machines and mechanical units that are under varying circumstances make it is desirable to be able to drive at barely perceptible speed, an intermediate or a high speed. Stepless speed variation in which it is possible to get any desirable speed is needed. Some mechanicals hydraulic and electrical devices serve as such stepless drives .The torque Vs speed characteristic of these drives do not match with that of stepless drives at increased driving torque at low speeds.

Hence the need of an stepless drive with the following characteristics

- Stepless or infinitely variable speed.
- Wide range of speed variation i.e (N max to N min).
- Shifting form one speed to another should be shockless.
- Minimum no of controls for speed changing.
- Ease of operation
- Compact construction

III. ANDERSON -CONTINUOUSLY VARIABLE TRANSMISSION

Anderson CVT- It is a technology invented by Lawrence L. Anderson, under US patents. Two cone of variable diameter kept parallel having ‘floating sprocket bars’ mounted in linear groove around perimeter of the every cone. A non-standard chain engaged with the ‘floating sprocket bars’, and it can move along length of cones, with in change in gear ratio. A specially-designed chain or belt meshes with the floating Sprocket bars, and it free to slide along the length of cones, changing the gear ratio at each point. The power input to the system will be through driving cone (RH-cone) to a driven cone (LH-cone) with the help of drive belt. The conical shape of cone has grooves on its perimeter of cone. The grooves are like a channel, with Sprocket bars located in it.

The Channels are circumferentially larger in size than the sprocket bars because to allow the movement of sprocket bars. The bars have one or more compression springs or any other elastic material, attached in between sprocket bar and channel groove. The floating sprocket bars make the Anderson CVT positive-drive, non-friction-dependent. Another advantage of the Anderson CVT is the simple design, as it consists of far fewer components compared to other transmissions. The above design uses conventional spring loaded rubber sprocket bar, made from poly nit rile rubber. These sprocket bars are kept floating in the radial grooves along the generator of the cones mentioned above. At the lower end, sprocket bars carry a spring that keeps them floating where as the top profile engages in special roller chain which acts as a transmission element.

These sprocket bars are subjected to heavy wear and tear while in running condition, hence may have to be replaced frequently. The sprocket bars drive has inherent vibrations due to the floating nature. Chain required for transmission is to be manufactured specially hence increases the cost. Cone cover is made of solid material, due to which, weight increases. So the manufacturing cost of the above device is slightly on the higher side. The study is dedicated to the modification of the existing design in order to design new, reliable, less weighed and minimizing cost of full system by using the alternative material for both the cones, replacing floating sprocket bars by alloy steel bars, changing material of the input and output shafts of both the cones and drive system specially design (non-standard) belt to standard timing belt. The sprocket bars are made round in shape and made integral with the cone, which reduces the problem of vibration and chatter. The simple round shape of the sprocket bars make engagement and disengagement with the transmission belt easy and vibration free, so offering a positive engagement, unlikely of any slip. The simple shape of the sprocket bars makes the manufacturing process easy and at the low cost, as shown in fig.1,

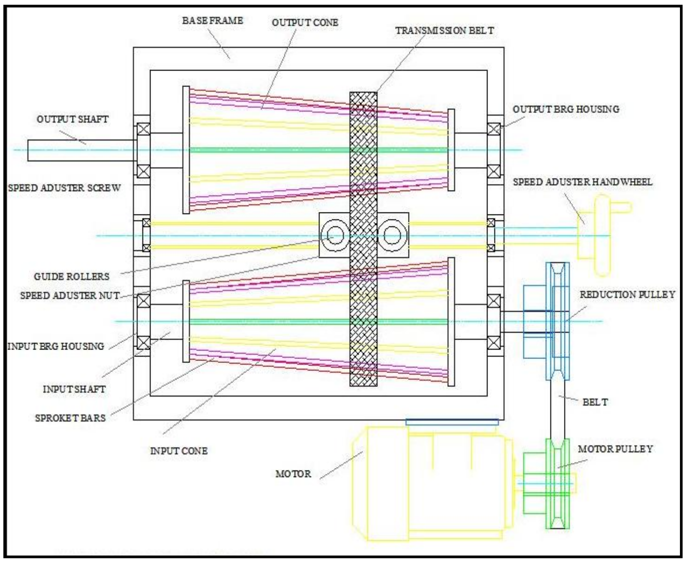

Fig.1. Layout of Fixed Pitch CVT

Material used for input shaft of cone and LH Cone Ring is alloy steel with grade EN24. Ultimate Tensile Strength is 850-1000 N/mm2 and Yield Strength is 650-700 N/mm2. Material used in system for Sprocket Bars is alloy steel with grade EN9. Ultimate Tensile Strength of EN9 is 600 N/mm2 and Yield Strength is 480-500 N/mm2.

IV. AUTOMATION OF FLOATING SPROCKET BAR DRIVE

The floating sprocket drive is an innovative solution to above problem where in power is transmitted between two hollow cones fabricated from floating sprocket bars and the Stepless power transmission is achieved by movement of the belt via an automated speed change mechanism over these cones .
The automation of the floating sprocket drive is done using a gear pair where in the pinion is integral with the motor and the gear is mounted on the speed changing mechanism screw. The specifications of the device are as follows:

On the exterior the power window motor is structured, it comprises of three main parts:

- The drive motor , 12 volt DC
- The gear box that provides the necessary amplification of motor torque and reduction in speed in order to operate the power window mechanism
- The driver gear or the output gear from the power window motor that drives the power window mechanism.

The worm is made of case hardened steel 14C6 whereas the worm wheel is made of Nylon-66. Motor is 12 V DC motor gear box ratio to be 1:55 reduction output of the gear box will be a direct shaft with dynamometer pulley arrangement to carry out the testing of the gear box under various load conditions.

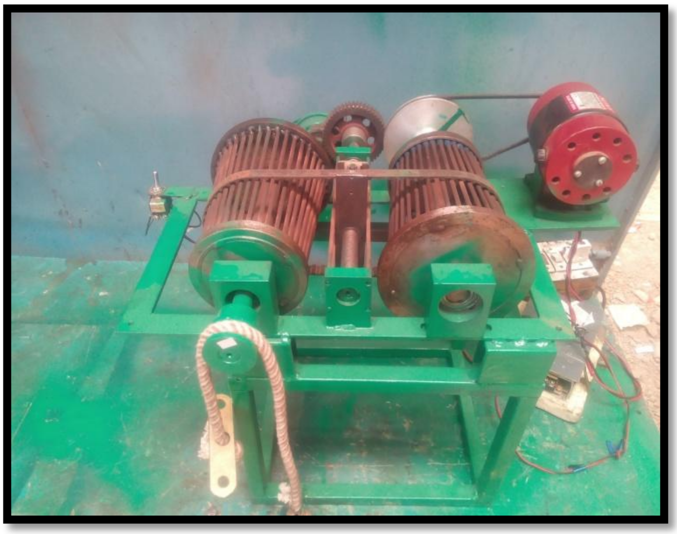

Fig.2. Photograph of assembly of automated fixed pitch CVT

TABLE.1. BILL OF MATERIAL

No	DESCRIPTION	QTY	MATERIAL
1	Motor	02	STD
2	Belt	01	STD
3	Reduction pulley	01	MS
4	Input shaft	01	EN24
5	LH_IP BRG HSG	01	EN9
6	RH_IP BRG HSG	01	EN9
7	Output shaft	02	EN24
8	OP_LH_ BRG HSG	01	EN9
9	OP_RH_ BRG HSG	01	EN9
10	LH_Screw bearing housing	01	EN9
11	RH_Screw bearing housing	01	EN9
12	Speed adjuster knob	01	EN9
13	Speed adjuster nut	01	EN9
14	Speed adjuster screw	01	EN24
15	Speed variator belt	02	Polymer
16	Belt holder	02	EN9
17	Bearing 6005ZZ	01	STD
18	Bearing 6201ZZ	02	STD
19	Bearing 6003 ZZ	02	STD
20	Bearing 6016ZZ	01	STD
21	Frame	01	MS
22	Belt guide plates	04	EN9

A. Testing Procedure

Test and trial on the automated floating sprocket drive for drive transmission ability at ratio 1:1 to derive drive characteristics:

Diameter (Effective) of Dyno-brake input pulley = 76mm

1. Start motor
2. Let mechanism run & stabilize at certain speed (say 2000 rpm)
3. Note speed at no load condition
4. Apply loading load pan
5. Tabulate the readings in the observation table
6. Plot the following characteristic
    a) Driven Pulley Speed Vs Load
    b) Torque Vs Load
    c) Percentage Slip Vs Load

B. Sample Calculations

Output Torque = W x 9.81 x Radius of dyno-brake pulley

= 0.2x9.81 x 0.038 =0.075 N-m

% slip $= (n_s - n/ n_s) \times 100$

$= (1900-1895 /1900) \times 100$

= 0.26316

TABLE.2. OBSERVATION TABLE

SR No	LOAD (KG)	DRIVER PULLEY SPEED (RPM)	DRIVEN PULLEY SPEED (RPM)	TORQUE (N-m)	% SLIP
1	0	1900	1895	0	0.263158
2	0.2	1860	1852	0.18639	0.430108
3	0.4	1780	1764	0.37278	0.898876
4	0.6	1710	1694	0.55917	0.935673
5	0.8	1600	1580	0.74556	1.25
6	1.0	1530	1506	0.93195	1.568627
7	1.2	1465	1438	1.11834	1.843003
8	1.4	1405	1376	1.30473	2.064057
9	1.6	1340	1309	1.49112	2.313433
10	1.8	1290	1258	1.67751	2.48062

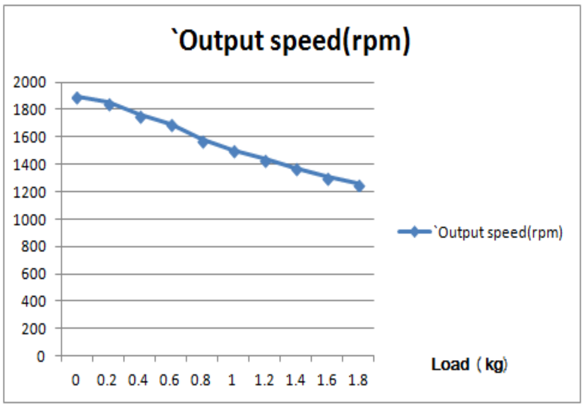

Fig.3. Output speed vs Load

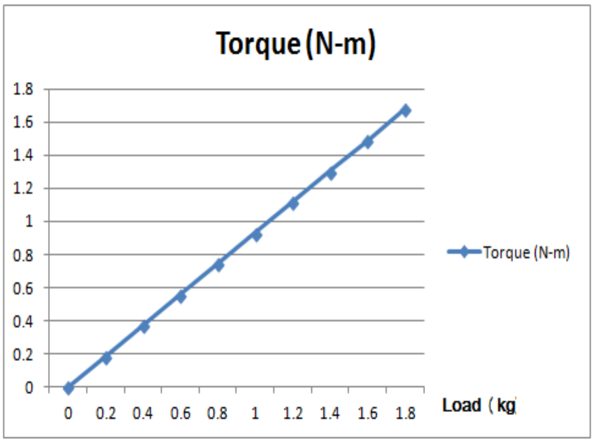

Fig.4. Output torque vs Load

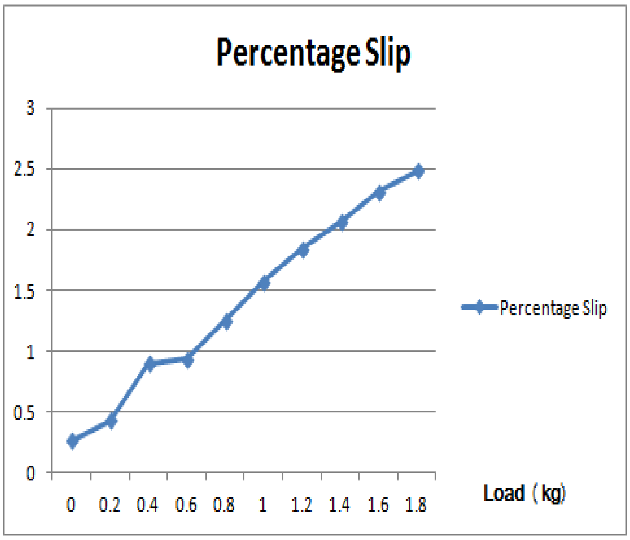

Fig .5. % slip vs load

V. VALIDATION OF % SLIP WITH ANNOVA

Result validation of 5% ANNOVA of automated floating sprocket bar drive. ANNOVA between two subject factors load and speed with percentage slip as the derivable for variance of 5% ANNOVA by taking speed ratio 1:1, 1:1.25 and 1.25:1. One of the powerful aspects of ANOVA is that you can tease apart how different factors influence your data. For analysis of result done by the "ezANNOVA" software for the basics of Analysis of Variance by using "Design 2 within Subject Factors".

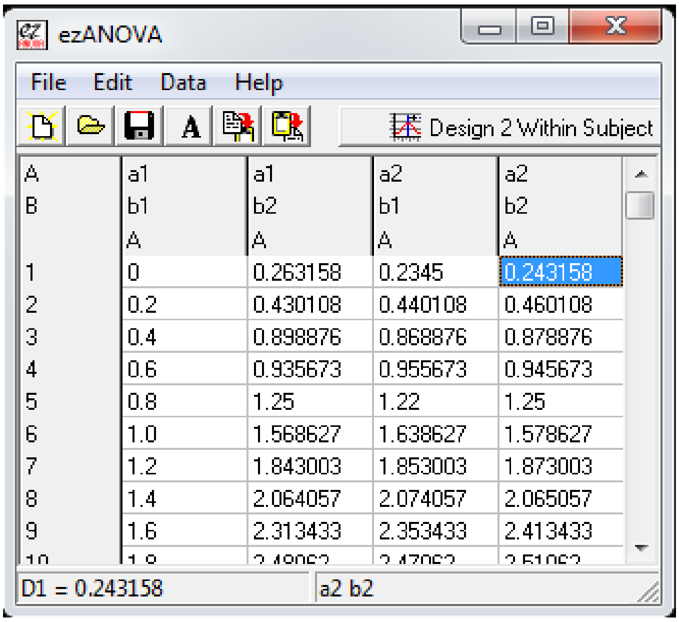

Fig.6. Selection of Design for Validation From ezANOVA Available Design

In the results window, note that the top of the window shows an ANOVA results and the lower portion of the results window shows descriptive statistics: the mean, standard deviation (StDev), variance (var), number of observations (N), Skew and Z-Soce for the Skew (zSkew) are all shown.

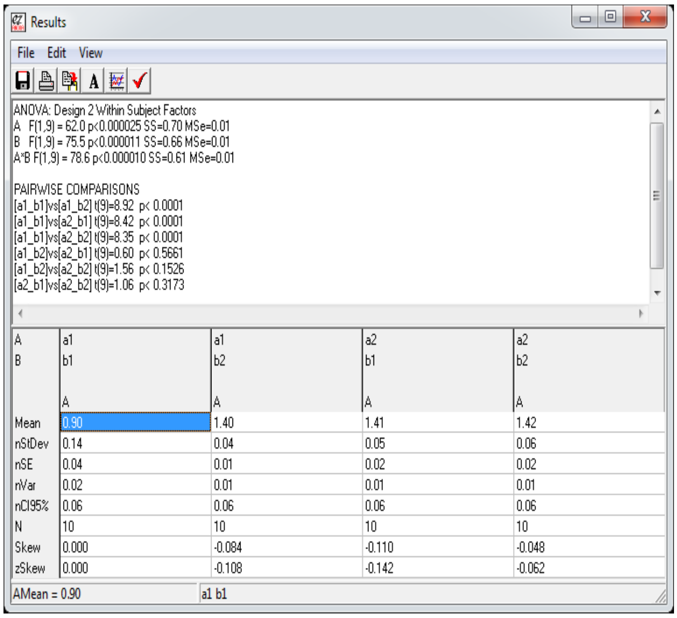

Fig.7. Result window

This software can also show a graph of the mean results for each condition with confidence interval error bars. Standard deviation, variance confidence interval and No error bar graph of mean result are shown below.

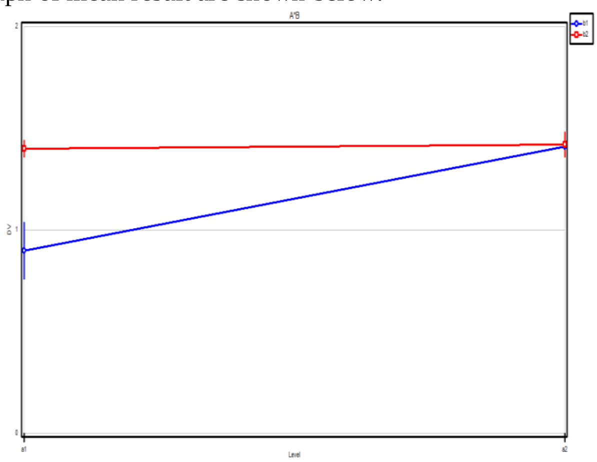

Fig.8.Graph of Standard Deviation

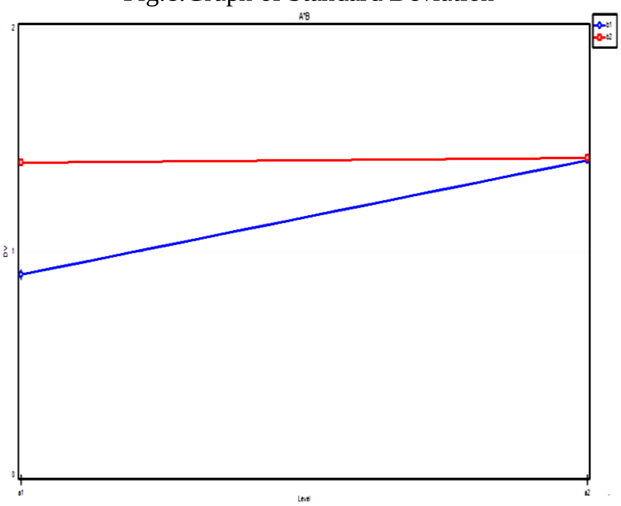

Fig.9. Graph of Variance

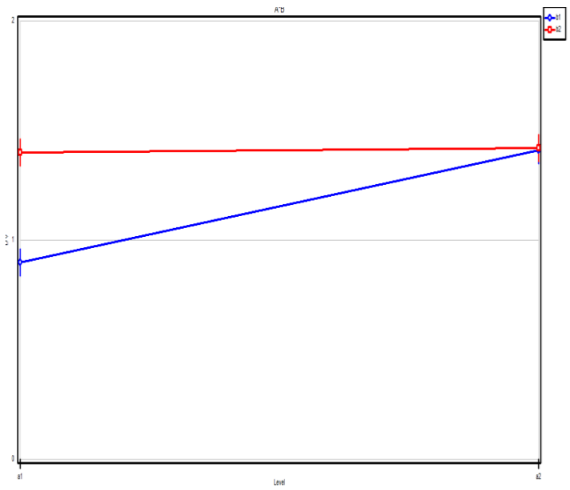

Fig.10. Graph of Confidence Interval

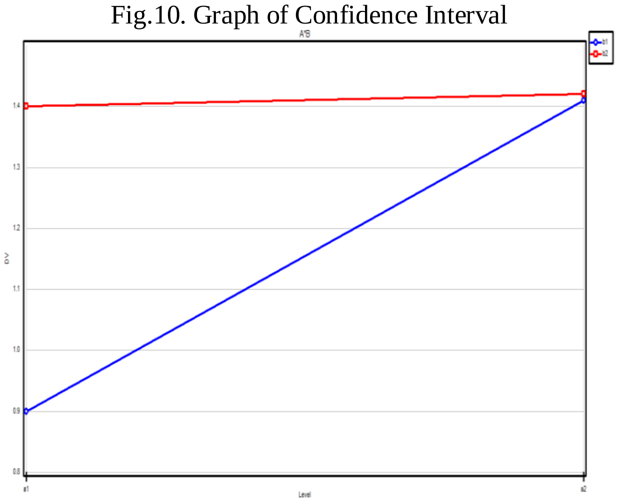

Fig.11. Graph of No Error Bar

VI. RESULT AND DISCUSSION

- The graph shows that the maximum variance in case of the variation in load is configuration is 0.01 % indicating that the drive shows variance well below the target level (5%).
- The Drive shows a characteristic of drop in speed with increase in load
- The Drive shows a characteristic of increase in torque with increase in load.

VII. CONCLUSION

From the experimental analysis it was found that the Percentage slip increases with increase in load marginally and maximum value of slip lies below 2.5% indicating good drive efficiency, and good characteristic of velocity ratio maintenance under given load % Slip of the drive increases only at higher values of torque.
1. The output speed drops with increase in load, though the drop is not significant thereby indicating good drive characteristics of speed transmission.
2. The output torque with increase in load indicating good torque transmission ability under given load
3. Percentage slip increases with increase in load marginally and maximum value of slip lies below 2.5% indicating good drive efficiency, and good characteristic of velocity ratio maintenance under given load.
4. Drive shows less speed flutter under given loading condition indication shudder free transmission.
5. The graph of mean result in ezANNOVA software shows that the maximum variance in case of the variation in load is configuration is 0.01 % indicating that the drive shows variance well below the target level (5%).

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