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Speed Ratio Prediction and Performance Analysis of Single Ball Traction Drive for CVT

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ABSTRACT
Drives are basically used to transmit power and speed from the prime mover to the machine. The power transmission and speed reduction between the prime-mover and the driven machine can be achieved by using conventional drives like Belt drive, Rope drive, Chain drive, Gears, etc. with their numerous advantages and disadvantages. There are many machines and mechanical units that under varying circumstances make it desirable to be able to drive at a barely perceptible speed, an intermediate speed or a high speed. Thus an infinitely variable (step less) speed variation in which it is possible to get any desirable speed. Some mechanical, hydraulic, drives serve as such step less drives. However the torque versus speed characteristics of these drives do not match torque at low speeds. Hence the need of a step less or infinitely variable speed drive came into existence. The drive presented by the end of this research work is single ball traction drive for continuously variable transmission systems. Dissertation includes the brief history of existing drives, speed prediction methodology and performance analysis of the drive developed.

Keywords – Analysis, Ball, CVT, IVT, Traction

I. INTRODUCTION

Mechanical transmission devices allow energy and power to be transmitted through physical space and enable matching between differing characteristics of energy sources and loads. A lever, for example, converts a small force applied over a long distance to a large force applied over a small distance, or a gearbox converts a small torque over a large angle to a large torque over a small angle [11]. Also, with growing socioeconomic and environmental concern, automobile energy consumption has become a key element in the current debate on global warming. Over the past few decades, vehicles have been increasingly facing stringent performance, emissions, and fuel economy standards driven by regulatory and market forces. Emissions of carbon dioxide (CO_2), the principal greenhouse gas produced by transportation sector, have steadily increased along with travel, energy use, and oil imports. Vehicle fuel economy plays a crucial role in determining the emission of greenhouse gases from an automobile. There are three fundamental ways to reduce greenhouse gas emissions from the transportation sector: (a) increase the energy efficiency of transportation vehicles, (b) substitute energy sources that are low in carbon for carbon-intensive sources (i.e. the use of alternative fuel technologies), and (c) reduce transportation activity. With tremendous growth in consumerism and urbanization, there is little scope for emissions reduction to occur through a decrease in the amount of vehicle use. In order to achieve lower emissions and better performance, it is necessary to capture and understand the detailed dynamic interactions in a CVT system so that efficient controllers could be designed to overcome the existing losses and enhance the fuel economy of a vehicle. There are many kinds of CVTs, each having their own characteristics, e.g. Spherical CVT, Hydrostatic CVT, E-CVT, Toroidal CVT, Power-split CVT, Belt CVT, Chain CVT, Multi-Ball-type toroidal CVT, Milner CVT etc. [7, 16]. With the increasing concerns in the impact of automotive emissions of CO_2 and NO_X on the biosphere combined with today's shortages on oil crude supply and increase of fuel cost, the need to find solutions reducing the fuel consumption and emission of tomorrow's cars is more than ever present. Research and development activities in the torque controlled full toroidal variator are strategically oriented toward these requirements of the society. In principle, CVTs are ideal transmissions as they perform a continuous, step-less change of the speed ratio. This enables the optimization of the engine operation, while ensuring a comfortable driving experience and a high dynamic performance of the vehicle. A CVT can be regarded as a system dedicated to converting the torque delivered by the prime mover to machines being driven [6].

II. PRINCIPLE OF OPERATION OF SINGLE BALL TRACTION DRIVE

There are many machines and mechanical units that under varying circumstances make it desirable to be able to drive at barely perceptible speed, an intermediate speed or a high speed. Thus an infinitely variable (step less) speed variation in which it is possible to get any desirable speed. Some mechanical, hydraulic, drives serve as such step less drives. However the torque versus speed characteristics of these drives do not match torque at low speeds. There are many machines and mechanical units that under varying circumstances make it desirable to be able to drive at barely perceptible speed, an intermediate speed or a high speed. Thus an infinitely variable (step less) speed variation in which it is possible to get any desirable speed. Some mechanical, hydraulic, drives serve as such step less drives. However the torque versus speed characteristics of these drives do not match torque at low speeds.

From Fig. 1, the major components of the drive are steel ball (1) positioned between two axially displaced hollow cone discs (2 & 3) and acts as a power transmission element.

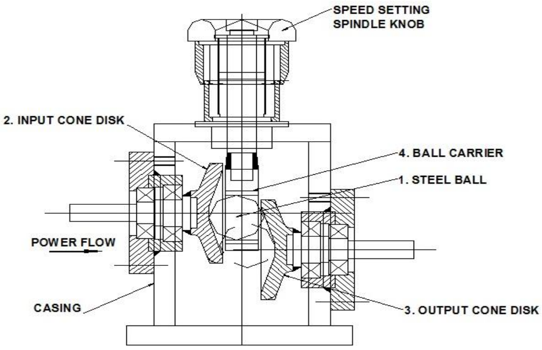


Fig. 1: Principle of Operation of Single Ball Traction Drive

When the load is applied, the transmission ball is pulled into a triangle formed by the two hollow cone disks by an amount equal to the elastic deformation of the parts under load. Thus the contact pressure is directly proportional to the output torque. Torque-dependent pressure devices are unnecessary. Clockwise or counterclockwise rotation is permissible. The output speed of the drive is infinitely variable and it is achieved by adjusting the position of the steel ball rotating the speed-setting spindle knob (4). Speed setting is permissible both at rest and in motion. In the upper adjustment position ratio of 3:1 reduction is created between input and output shaft. In the lower adjustment position the ratio is 1:3. The total speed range covered is up to 9:1. For a speed range of 6:1, higher input horse power is possible since the output horse power is determined by the lower output speed. The movement of the transmission ball is positively controlled when adjusting for high or low speeds. When adjusting to the lower speeds, the transmission ball takes up a position against the speed setting spindle because of its tendency to move toward the middle of the higher cones. Power must be transmitted through the unit only in the direction shown by the arrow on the outer housing. In the case of very low input speeds, a minimum amount of load must be applied at the output shaft to achieve the desired output speed. The drive may be used in any mounting position and can be made hermetically sealed. The test rig required for the Analysis of Performance characteristics can be tentatively constructed as shown in Fig. 2.

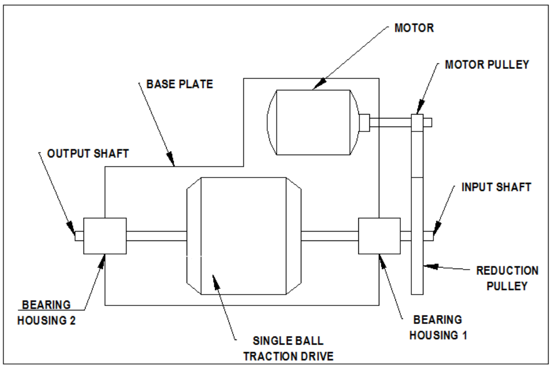


Fig. 2: Test Rig for the Analysis of Performance characteristics

III. METHODOLOGY AND SYSTEM DEVELOPMENT

In the era of development of continuously variable transmission system the development of simple and proficient system would always be considered on priority. The new inventions will be followed in the future only if they possess few or all of the characteristics mentioned earlier. Researchers have been continuously taking efforts towards development of such efficient system. The existing systems could also be developed for better efficiency. It may include the improvements and efforts towards making existing systems, balanced and smooth. The proper working force between the elements of power transmission also plays important role.

The methodology aims towards the development of single ball traction drive with shock-less and singular control and compactness of size. The general methodology for the development of single ball traction drive can be explained with the help of flowchart shown in Figure 3.

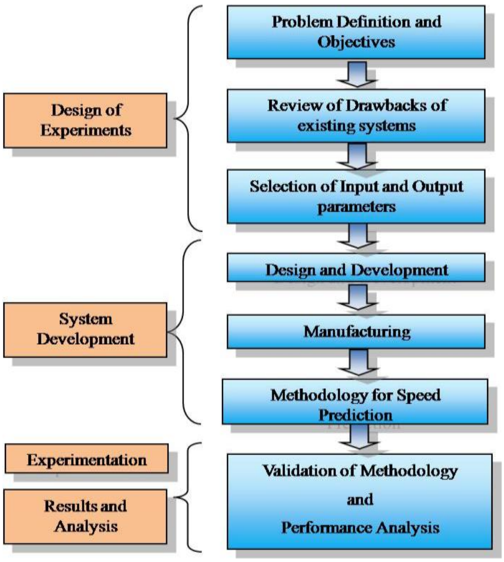


Fig. 3: Test Rig for the Analysis of Performance characteristics

The problem has already been defined precisely in the previous paragraphs. It tends to decide the objectives of the project in appropriate manner. It is much necessary to review the existing continuously variable transmission systems with their drawbacks and advantages. The defined problem could be solved with invention of the new system. This new system should be beneficial than the existing systems. It could be only claimed after the analysis of performance. For measurement of performance analysis input and output parameters of the system should be decided. For given problem and parameters, new system has been designed and developed. The manufacturing requires simple machines and machining operations. For accurate and precise prediction of performance of system the simple method has been developed. The method correlates the relation between 'movement of control element' (Knob) for step-less speed variation and 'transmission element' (Friction Ball). The performance analysis is measured by having the attachment of torque measurement in the system. Use of statistical approaches and computer software in the measurement of performance analysis optimizes calculation efforts. System design mainly concerns with various physical constrains, deciding basic working principle, space requirements, arrangements of various components etc.Following parameters are looked upon in system design.

1. Selection of system based on physical constraints.
2. The mechanical design has direct norms with the system design hence system is designed such that distinctions and dimensions thus obtained in mechanical design can be well fitted in to it.
3. Arrangement of various components made simple to utilize every possible space.
4. Ease of maintenance and servicing achieved by means of simplified layout that enables quick assembly and dismantling of components.
5. Scope of future improvement.
6. The system has to be designed in such manner that, the drive possibly could be sealed hermetically to avoid contamination of foreign particles.

In mechanical design, the components are categorized as follows: Parts to be designed, Selection of standard parts. For parts to be designed detail design has been done. Dimensions obtained are compared to next dimensions which are already available in the market. This simplifies the assembly as well as the post production and maintenance work. The required geometrical and dimensional tolerances were specified .The process sheets are prepared and passed to manufacturing stage. Two dimensional view and a photograph of assembly has been shown in Fig. 4 and Fig. 5. Table 1 shows the details of components of assembly.

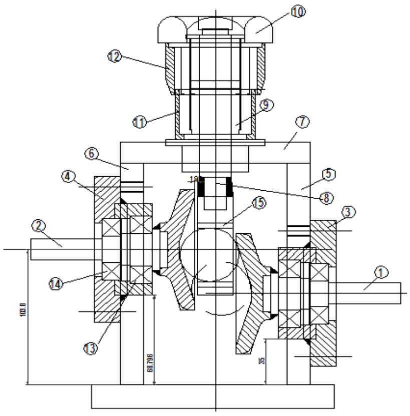


Fig. 4: Assembly of Single Ball traction Drive (2 Dimensional View)

Table 1: Validation of Speed Prediction methodology at 1500 RPM

Sr. No.	Description	Quantity	Material
1	Input Cone Shaft	01	EN24
2	Output Cone Shaft	01	EN24
3	LH Bearing Housing	01	EN9
4	RH Bearing Housing	01	EN9
5	LH Casing Plate	01	EN9
6	RH Casing Plate	01	EN9
7	Top Casing Plate	01	EN9
8	Ball Holder	04	EN9
9	Carrier Nut	01	EN9
10	Carrier	01	EN9
11	Dial	01	EN9
12	Dial Barrel	01	EN9
13	Bearing 6205-ZZ	02	STD
14	Bearing 6204-ZZ	02	STD
15	GM Bush	01	PB
16	Key 6×3×60	01	STD
17	Bolts M8×30	06	STD
18	Belt (6 × 500)	01	STD
19	Motor	01	STD
20	Pulley	01	STD
21	Ball	01	STD

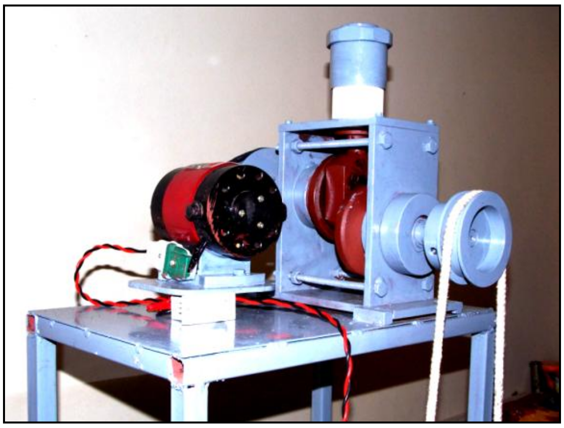


Fig. 5: Photograph of Assembly of Single Ball Traction Drive

IV. PREDICTION OF SPEED RATIOS

For the drive developed the input parameter may be input speed of the electric motor, reduced input speed at the Input cone and displacement of ball within the drive due to position of knob. The output of the drive is continuously variable speed thus power and torque.

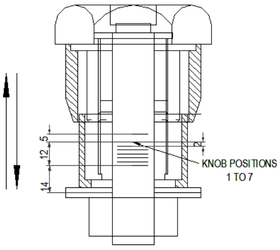


Fig. 6: Knob positions assumed for Speed Prediction

Fig. 6 shows knob positions assumed for speed ration prediction methodology. It moves the traction ball in upward and downward direction causing continuous variation in speed. The pitch of the thread of the knob is 2mm. One rotation of knob covers 2mm of vertical distance. The drive may not give the useful output at all positions of knob. This happens due to imprecise alignment, manufacturing and / or random error. Knob positions which may give the useful output were found out by trial and error. Total 7 positions were found out and they were numbered from 1 to 7. Total vertical distance that could be travelled by the knob is 30mm. From trial and error it was found that, for upper distance of 5mm, drive does not give useful output. Similarly for lower 14mm distance drive does not give useful output. These upper and lower distances have not been considered for prediction of speed ratios and validation of the methodology used. Remaining span of 12mm has been considered. Within this span of 12mm, 7 positions were considered and marked on the knob. These 7 positions were separated by the distance of 2mm.

Now, from Fig. 7, Knob will cause the movement of the traction ball, hence similar positions were marked on the geometry of traction ball, Input and Output cone. For each value of R_1 corresponding value of R_2 is considered. So that value of the output speed could be predicted. One of such a set is shown in Figure 5. If value of R_1 is 10.1mm, then the corresponding value of R_2 to be considered for prediction of output speed is 37.8mm.

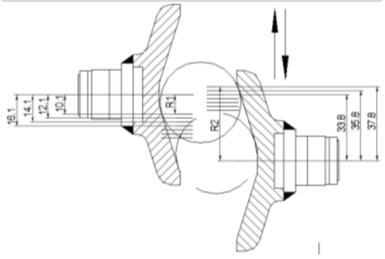


Fig. 7: Geometry of Traction Ball for speed prediction methodology

Sample Calculations:
Let,
V_1 = Input cone speed (m/s)
V_2 = Output cone speed (m/s)
N_1 = Input cone speed (RPM)
N_2 = Output cone speed (RPM)
R_1 = Segment of Radius at Input cone (mm)
R_2 = Segment of Radius at Input cone (mm)
ω_1 = Angular Velocity at input (Rad/s)
ω_2 = Angular Velocity at output (Rad/s)

$$V_1 = \frac{2\pi N_1}{60}$$

$$V_2 = \frac{2\pi N_2}{60}$$

$$\text{Speed Ratio} = \frac{V_1}{V_2}$$

$$= \frac{2\pi N_1}{60} \Big/ \frac{2\pi N_2}{60}$$

$$\frac{R_2}{R_1} = \frac{N_1}{N_2}$$

$$\therefore \quad N_1R_1 = N_2R_2$$

For Motor speed 1500 RPM and Knob position 1,
R_1 = 10.1mm and
R_2 = 37.8mm
N_1 = 454.4RPM and
N_2 = ?

$$\frac{454.4}{N_2} = \frac{37.8}{10.1}$$

Therefore, theoretical value of output speed for specified conditions is,

$$N_{2_{Th}} = 121.5\text{RPM}$$

Now, actual value of output speed measured by using Tachometer at output cone shaft is,

$$N_{2_{Act}} = 121.1\text{RPM}$$

Hence, we can conclude that methodology established for prediction of speed is valid. For various set of Motor RPM and for different positions of knob, methodology is validated. Table 2 shows the observations of validation of Methodology for prediction of speed. Fig. 8 and Fig. 9 show comparison of % Slip with various Knob positions and Input Speeds. It also shows comparison of Actual and Theoretical Speed Ratios with Input Speed (RPM). Comparison was done by using statistical software **Minitab 16.**

Table 2: Validation of Speed Prediction methodology at 1500 RPM

Motor Speed (RPM)	3000							
Positions of Knob	Values of R1 (mm)	Values of R2 (mm)	Input Speed (RPM)	Theoretical Output Speed (RPM)	Actual Output Speed (RPM)	% Slip	Theoretical Speed Ratio	Actual Speed Ratio
1	10.1	37.8	871.9	233.2	232.2	0.43	3.74	3.75
2	12.1	35.9	799.2	269.7	267.3	0.90	2.96	2.99
3	14.1	33.9	726.6	302.6	288.1	4.79	2.40	2.52
4	16.1	31.9	650.0	328.5	315.4	3.98	1.98	2.06
5	18.1	29.9	574.9	348.4	336.6	3.40	1.65	1.71
6	20.1	27.9	502.5	362.5	361.9	0.15	1.39	1.39
7	22.1	25.9	430.1	367.4	367.2	0.07	1.17	1.17

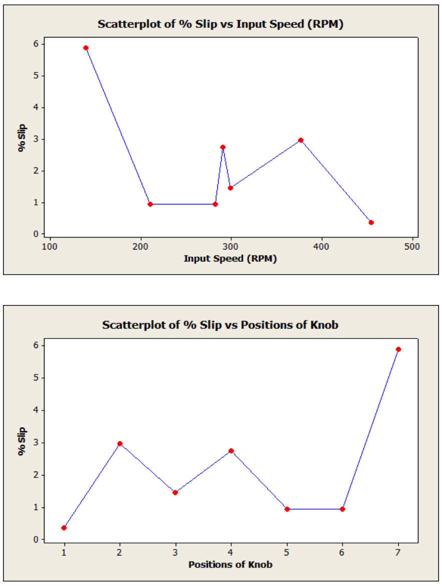


Fig. 8: %Slip Vs Input Speed at no load and 1500 RPM and % Slip Vs Positions of Knob at no load and 1500 RPM

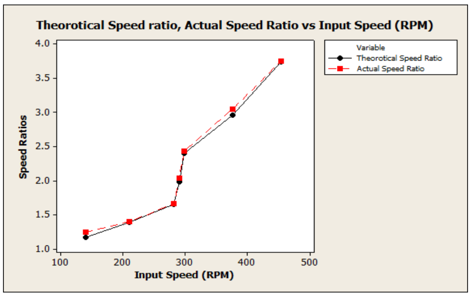


Fig. 9: Speed Ratios Vs Input Speed at no load and 1500 RPM for Validation of Methodology

Similar validation of methodology has been done for 2000, 2500, 3000 and 3500 RPM. Graphs of % Slip versus Speed indicate that maximum value of %Slip does not exceed beyond 5.89%. Exact prediction of %Slip against changing input speed is difficult but variation of %Slip occurs within the specified range i.e. from 0.18% to 5.89%. Similar conclusion about the %Slip against Knob Position could be drawn. Graphs of Speed Ratios versus Input Speed imply that the predicted values of Speed ratios resemblance with actual measured values. Minor variation in the speed ratios causes due to small amount of slip.

V. EXPERIMENTATION

For performance analysis and Experimentation below mentioned procedure has been used:

1. Before starting the experimental procedure make ensure that Knob is at position 1, no weights in pan and Motor speed regulator is OFF.
2. Turn on the AC power supply of 230V, 50Hz.
3. Set the Motor speed at specific value say 1500RPM by using Motor Speed Regulator.
4. Set the Knob at position 1.
5. Put specific weight in pan say 0.15Kg.
6. Measure input speed by using tachometer at Input cone Shaft.
7. Measure output speed at output cone shaft pulley.
8. Repeat the same procedure for range of values of RPM (1500, 2000, 2500, 3000, 3500), Weights in Kg. (0.15, 0.2, 0.25, 0.3, 0.35) and Knob positions (1, 2, 3, 4, 5).

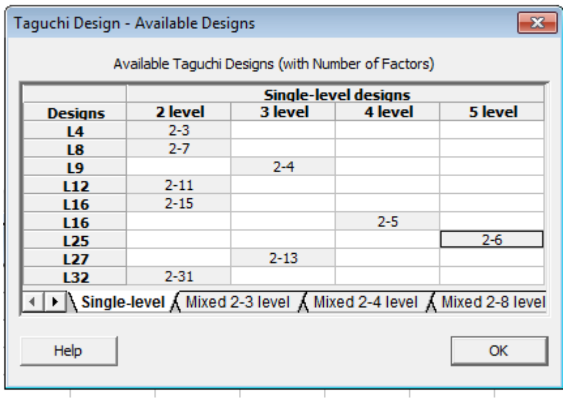
5.1 Process Parameters and Levels

The process parameters are Knob positions, Motor speed, Pan Weight, with four levels is shown in Table 3. For experimentation, three parameters-Motor speeds, Pan Weight and Knob Positions-were selected with five levels.

Table 3: Process Parameters and Levels

Sr. No.	Parameters	Levels				
		1	2	3	4	5
1	Knob Positions	1	2	3	4	5
2	Electric Motor Speed (RPM)	1500	2000	2500	3000	3500
3	Pan Weights (Kg)	0.15	0.2	0.25	0.3	0.35

For experimentation, three parameters-Motor speeds, Pan Weight and Knob Positions-were selected with five levels. The design of experiments was done by Taguchi's Method on Minitab 16. With respect to the process parameters and levels Taguchi's available designs were checked and required design was selected. Refer Fig. 10 and Fig. 11.



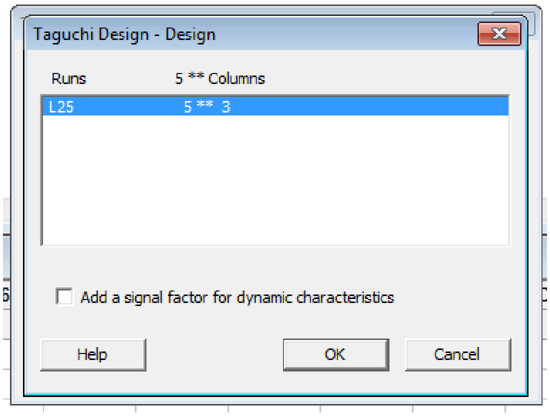
Taguchi Design - Available Designs

Available Taguchi Designs (with Number of Factors)

Designs	2 level	3 level	4 level	5 level
	Single-level designs			
L4	2-3			
L8	2-7			
L9		2-4		
L12	2-11			
L16	2-15			
L16			2-5	
L25				2-6
L27		2-13		
L32	2-31			

Fig. 10: Selection of design for Experimentation from Taguchi's Available Design

From selected process parameters and levels, we have achieved 25 runs of experimentation. For convenience, third parameter i.e. Pan Weight has been shuffled little to obtain proper nature of graphical results. Table 4 shows the details of experimentation to be conducted.



Taguchi Design - Design

Runs	5 ** Columns
L25	5 ** 3

☐ Add a signal factor for dynamic characteristics

Fig. 11: Appeared number of Runs and Array

Table 4: Details of Experimentation

Run No.	Knob Position	Speed (RPM)	Pan Weight (Kg)
1	1	1500	0.15
2	1	1500	0.2
3	1	1500	0.25
4	1	1500	0.3
5	1	1500	0.35
6	2	2000	0.15
7	2	2000	0.2
8	2	2000	0.25
9	2	2000	0.3
10	2	2000	0.35
11	3	2500	0.15
12	3	2500	0.2
13	3	2500	0.25
14	3	2500	0.3
15	3	2500	0.35
16	4	3000	0.15
17	4	3000	0.2
18	4	3000	0.25
19	4	3000	0.3
20	4	3000	0.35
21	5	3500	0.15
22	5	3500	0.2
23	5	3500	0.25
24	5	3500	0.3
25	5	3500	0.35

5.2 Sample Calculation for Performance Analysis

Theoretical Output Speed,

$$N_{Output\ Th} = \frac{N_{Input}}{Speed\ Ratio}$$

Theoretical Speed Ratios,

$$= \frac{N_{Input}}{N_{Output}}$$

Input Torque,

$$T_{Input} = \text{Motor Torque (N-m)}$$

Output Torque,

$$T_{Ouput} = w \times r$$

$$= m.g \times r \quad \text{(N-m)}$$

Power Output,

$$P_{Output} = \frac{2\pi N T_{Ouput}}{60} \quad \text{(N-m)}$$

Power Input,

$$P_{Input} = \frac{2\pi N T_{Input}}{60} \quad \text{(N-m)}$$

Efficiency,

$$\eta = \frac{Output\ Power}{Iput\ Power}$$

Where,

w = Weight (N)
m = Mass (Kg)
g = Gravitational Acceleration (m/s^2)
r = Radius of Output Cone Shaft Pulley (mm)

VI. RESULTS AND DISCUSSION

Table 5 shows Observation table for all runs of experimentation. From these observations graph indicating performance analysis of the Single Ball Traction Drive have been plotted.

Table 5: Details of Experimentation

Knob Position	Speed (RPM)	Pan Weight (Kg)	Input Speed (RPM)	Theoretical Output Speed (RPM)	Actual Output Speed (RPM)	Theoretical Speed Ratio	Actual Speed Ratio	Output Torque (N-m)	Output Power (N-m)	Input Torque (N.m)	Input Power (N-m)	Efficiency (%)	%Slip
1	1500	0.15	382.8	129.3	125.3	2.96	3.06	0.06	0.77	0.119	4.77	16.19	3.1
1	1500	0.2	255.2	86.2	84.2	2.96	3.03	0.08	0.69	0.119	3.18	21.76	2.3
1	1500	0.25	191.4	64.7	64.5	2.96	2.97	0.10	0.66	0.119	2.38	27.78	0.3
1	1500	0.3	153	51.7	50	2.96	3.06	0.12	0.62	0.119	1.91	32.33	3.3
1	1500	0.35	127.3	43.0	42	2.96	3.03	0.14	0.60	0.119	1.59	38.08	2.3
2	2000	0.15	509.3	212.2	210	2.4	2.43	0.06	1.29	0.119	6.34	20.39	1.0
2	2000	0.2	339.3	141.4	138	2.4	2.46	0.08	1.13	0.119	4.23	26.82	2.4
2	2000	0.25	254.4	106.0	99	2.4	2.57	0.10	1.02	0.119	3.17	32.08	6.6
2	2000	0.3	203.5	84.8	79.6	2.4	2.56	0.12	0.98	0.119	2.53	38.69	6.1
2	2000	0.35	169.6	70.7	68	2.4	2.49	0.14	0.98	0.119	2.11	46.27	3.8
3	2500	0.15	636.6	321.5	320	1.98	1.99	0.06	1.97	0.119	7.93	24.86	0.5
3	2500	0.2	424.4	214.3	209	1.98	2.03	0.08	1.72	0.119	5.29	32.48	2.5
3	2500	0.25	318.1	160.7	150	1.98	2.12	0.10	1.54	0.119	3.96	38.87	6.6
3	2500	0.3	254.5	128.5	122	1.98	2.09	0.12	1.50	0.119	3.17	47.42	5.1
3	2500	0.35	210	106.1	104	1.98	2.02	0.14	1.49	0.119	2.62	57.16	1.9
4	3000	0.15	764	463.0	419	1.65	1.82	0.06	2.58	0.119	9.52	27.13	9.5
4	3000	0.2	510	309.1	273	1.65	1.87	0.08	2.24	0.119	6.35	35.30	11.7
4	3000	0.25	382	231.5	215.5	1.65	1.77	0.10	2.21	0.119	4.76	46.51	6.9
4	3000	0.3	305.6	185.2	170	1.65	1.80	0.12	2.09	0.119	3.81	55.03	8.2
4	3000	0.35	220	133.3	125	1.65	1.76	0.14	1.80	0.119	2.74	65.57	6.3
5	3500	0.15	891	641.0	610	1.39	1.46	0.06	3.76	0.119	11.10	33.86	4.8
5	3500	0.2	445.5	320.5	299.1	1.39	1.49	0.08	2.46	0.119	5.55	44.28	6.7
5	3500	0.25	334.1	240.4	210.1	1.39	1.59	0.10	2.16	0.119	4.16	51.84	12.6
5	3500	0.3	267.3	192.3	162.2	1.39	1.65	0.12	2.00	0.119	3.33	60.03	15.7
5	3500	0.35	222	159.7	125	1.39	1.78	0.14	1.80	0.119	2.77	64.98	21.7

Performance of the drive from Torque, Power and Efficiency point of view has been discussed with help of graphs.

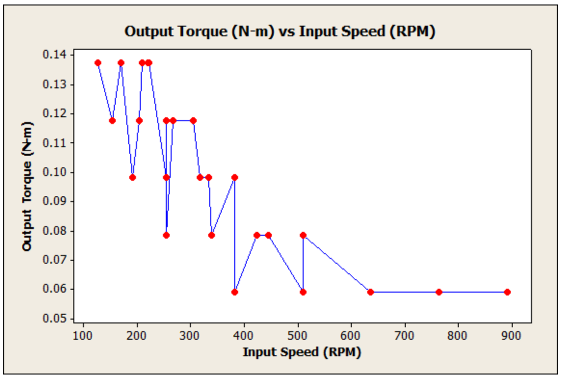


Fig. 12: Torque (N-m) Vs Input Speed (RPM) (For all positions of Knob)

It is understood from the graph of Torque (N-m) versus Speed (RPM) that with increment in speed output torque decreases. While understanding the nature of curve it is also necessary to take into account the various positions of the knob for which the plot is obtained. Due to this curve might get converted into sinusoidal form with continuous decrement. Fig. 13 shows the graph of Output Power in N-m versus Input Speed in RPM.

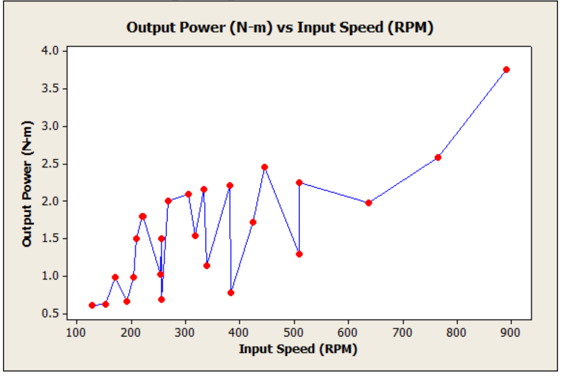


Fig. 13: Output Power (N-m) Vs Input Speed (RPM) (For all positions of Knob)

The plot of Output Power (N-m) Vs Input Speed in (RPM) implies that Output power increases with increase in speed and then decreases again. Power reaches maximum extent with maximum value of speed. Fig. 14 shows Efficiency of the drive in % versus Input Speed in RPM.

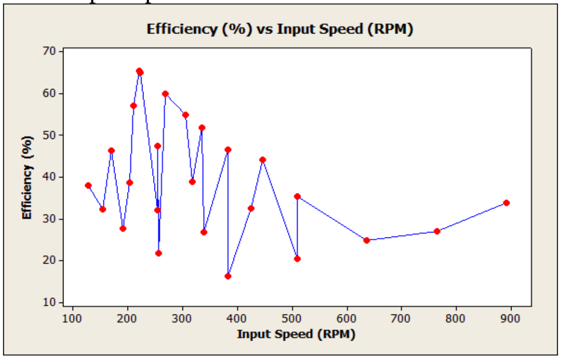


Fig. 14: Efficiency (%) Vs Input Speed (RPM) (For all positions of Knob)

From Fig. 14 it is understood that within the range of 200 RPM to 400 RPM efficiency achieves maximum value which is within 60% to 70%. Efficiency decreases later on for rest of the Input speeds. Fig. 15 shows the graph of % Slip versus Torque in N-m.

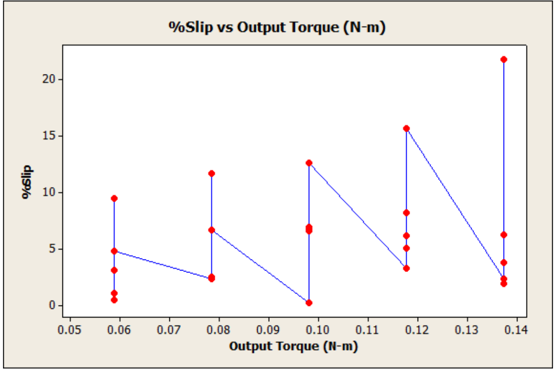


Fig. 15: Slip (%) Vs Torque (N-m) (For all positions of Knob)

From Fig. 15, it is understood %Slip increases with increase in value of torque. This may cause due slippage of traction ball during increasing values of Torque. Fig. 16 shows Efficiency against Torque. Efficiency goes on increasing with the increment in Torque.

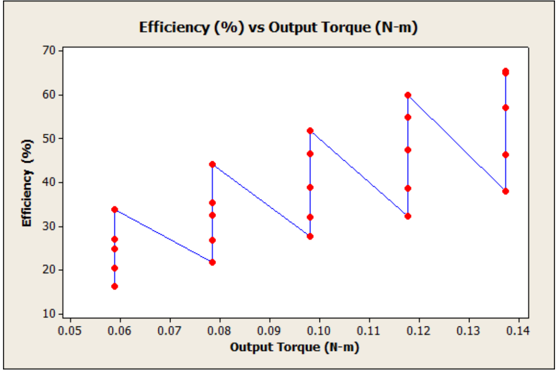


Fig. 16: Efficiency (%) Vs Torque (N-m) (For all positions of Knob)

VII. CONCLUSION

The drive is a constant horse power device, but can be used as a constant torque at maximum output speeds over the entire speed range. From methodology used for speed ratio prediction it is observed that Speed ratios up to 4:1 have been achieved. Efficiency of the drive was found 64.98% at the highest value of Input speed i.e. 3500RPM.

% Slip of the drive increases only at higher values of torque. Within the moderate values of torque Slip does not exceed beyond 12% which is within acceptable range. It is observed during validation of Methodology for speed prediction that the lowest value of accuracy of the drive is 94% at the input speed of 119 RPM. It is also seen that during number of runs of experimentation that speed adjustment at rest or while running does not affect the overall performance of the drive. The input and output shafts are offset but parallel to each other.

Smooth and balanced transmission of torque and power within the Motor Speed range of 1500 RPM to 3500 RPM is achieved. Knob i.e. Single control element for speed variation plays vital role in achieving continuously variable speeds.

For the development of drive simple manufacturing methods have been used. Drive could be made more precise and accurate by using modern methods of manufacturing. Precise and accurate drive might reduce the slip so as to have output speeds as intended. Drive could be converted for transmission of higher values of torques with more efficient prime mover at the Input.

Instead of Knob, a spur gear can be used to transmit the power and motion to another system. E.g. For modern machines like CNC Lathe, interconnection of motion between lead screw and chuck can be done with the help of single ball traction drive.

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