

# Cone Ring Traction Drive

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## ABSTRACT

CVT's are used for reducing fuel consumption, requiring high efficiency. A transmission which can change through an infinite number of gear ratios between maximum value and minimum value by a continuously variable transmissions (cvt). This is different than other mechanical transmissions that have selected discrete gear ratios. The constant angular velocity is maintained by flexibility of cvt, which is beneficial for fuel economy. Small vehicles can maintain balance between fuel efficiency and cost of manufacturing. Motor scooters and snowmobiles use CVTs. Motor scooter and Snowmobile CVTs are rubber belt pulley CVTs.

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## I. INTRODUCTION

a The introduction of new transmission concepts such as 6-speed stepped automatic, auto-shift manual and dual clutch transmissions places new challenges for a state-of-the-art CVT transmission concept.

### A. Description of KRG:

In comparison with other continuously variable transmissions (CVTs) this causes significant advantages in terms of manufacturing costs and efficiency. Basic Characteristics of the KRG Concept In order to achieve good vehicle driving dynamics, any kind of automatic transmission must have the capability to translate the driver's gas pedal input for a dynamic acceleration into a quick change of transmission gear ratio, but at the same time smooth torque transition. For the KRG concept, quick ratio changes require a high torque capability of the friction contact and the shortest possible delay of the involved dynamic systems. Any control function needed beyond the basic mechanical ratio change system, such as the hydraulic pressure control and very high power requirements for the gear change actuator of conventional CVTs, necessarily leads to unwanted delays in the shifting

process. Thus, avoiding a hydraulic system and using an actuator system with low "shifting" forces were decided very early during the KRG concept development as the basic means to achieve a sporty performance feeling. Today's modern engine fuel island maps are getting "flatter", which means that CVT transmissions can only take benefit of their larger ratio range, if the associated improvement in the engine operating point is not compensated by a low transmission efficiency, particularly at light loads. The demand for applying clamping forces to the power transmission elements has a decisive influence here, because these force levels in friction-wheel transmissions are quite high and must also be applied constantly. As an ideal solution combined torque sensor and actuator was designed for the KRG, as described below. For automotive mass production, robust design and low manufacturing costs are imperative requirements. The design of the KRG variator system is kept very simple and insensitive to manufacturing tolerances. Cost estimations have shown a great potential compared to conventional CVT concepts.

### B. The KRG Design:

The basic components of the KRG variator, such as rollers, clamping and adjustment unit are all purely mechanical, as described in more detail below.

- *Variator*

The variator is built up by an input cone (1), an output cone(2) and a transfer ring (3) which can be positioned around the input or output cone. By changing diameter and angle of the cones, start-up and overdrive ratio as well as the ratio spread can easily be adapted to vehicle requirements and installation space.

- *Clamping Unit*

The required clamping force is obtained through the axial displacement of the output cone. A mechanical torque sensor (4) based on a ball and ramp system, transforms the output torque into an axial pressure force with very high efficiency. By locating this mechanism in the torque path from the output shaft, all load changes such as road induced torque peaks are automatically detected and converted corresponding axial force. The combination of sensor and actuator in a simple mechanical system avoids the need of expensive sensor technology and electronic / hydraulic control systems commonly found in conventional CVTs.

- *Adjustment Unit*

For ratio change, the adjustment unit (5) moves the ring into its new position by a steering motion. Similar to a bicycle, extremely quick lateral movements are possible with low steering forces, by combining the rotation of the ring and a steering angle around the vertical axis. Inside the KRG the steering of the transfer ring is initiated by an angular movement of the control frame (5a). This frame is actuated by a servo motor outside of the transmission, such that all electrical and electronic components are not in contact with fluids. The power of the servo motor is only required to overcome the inertia of the control frame and ring during the steering motion, whereas the energy for the ratio change itself is provided by the cone rotation. During constant ratio driving, the control frame is kept at its neutral position requiring no servo motor power.

#### *Contact Point and Traction Fluid*

All CVT-concepts based on a friction system use one or more points for the power transfer. The power capacity of the friction system is determined by the normal load in the contact point and the friction (traction) coefficient of the tribological system. While the maximum normal load is limited by the permissible bearing loads and maximum allowable contact stress, extensive research work [1] has shown great improvement potential, if the function of the variator fluid can be reduced to torque transfer via shear forces in the oil. To avoid the critical conflict between the contradicting requirements of friction in the contact point and lubrication for the bearings in conventional CVT designs, the KRG uses two different fluids in separated chambers. Whilst the bearings are provided with a commercial lubricant (6), a specially developed traction fluid (7) is used for power transmission in the variator. The traction oil is supplied to the friction contact by splashing from the output cone dipping into the fluid level. Thus, the friction fluid needs no pumpability at low temperatures.

The optimization of this oil can be focused on price, traction coefficient and temperature stability. Compared with

conventional CVT fluids, an increase in friction value of more than 50% has been achieved during development and appears to have not yet reached the limits of feasibility. This friction value increase translates directly into a significant improvement of the power density and package of the transmission.

#### *Vehicle Installation*

The cone-ring concept has been developed for both front (FWD) and rear wheel drive (RWD) applications. Whereas RWD installations have been investigated in various studies, the present emphasis in development is on the FWD derivatives because of their higher potential market volume. Due to the opposite location of the large cone diameters, the KRG has a small distance between variator input and output shaft and as a result a small centre distance between transmission input and output shaft. For an engine torque up to 180 Nm, axle distances around 160 mm are possible with a start-up ratio greater than 16, which covers the majority of current FWD installations.

#### *Starting Device*

In principle, the KRG can be driven with a converter, wet clutch or dry clutch. While an automatic dry clutch makes sense for small vehicle applications due to cost pressures and lower comfort demands, comfort-oriented vehicles tend to be equipped with a converter.

#### *Control System*

The control strategy is divided into the different hierarchies of low level internal transmission control and high level drive train control strategy. While the high level logic selects the appropriate transmission ratio set point in line with performance and fuel economy requirements for the particular driving condition, the low level control applies this ratio in a closed loop control for the electromechanical actuation system. The shorter the time delay is to respond to step changes in transmission ratio set point, the more freedom is available for the "right" driving strategy. This strategy is highly dependent on regional customer preferences as well as the OEM's "brand identity". The current KRG vehicle demonstrator with a 85 kW gasoline engine offers three driving modes, an economy CVT-mode with emphasis on vehicle fuel consumption, a sporty CVT-mode with high acceleration performance, and a manual 6-speed tip-mode operated by the driver. The control system design of the KRG and the launch clutch have been designed by using MATLAB SIMULINK and dSPACE. Together with the models for the vehicle and the power train, this approach enables a complete CAE based dynamic system simulation and optimization before the first hardware tests.

## II. LITERATURE SURVEY

a The literature review has been carried out in the areas of cone ring traction drive used for numerous power utility industrial applications and many more.

**1. Konstantin Ivanov** addresses Motor-wheel of transport machine demands a using of step gear box. Necessity of the controlled coordination of forces on different wheels takes place. Recently the theory of adaptive continuously variable transmission (CVT) in the form of gear differential with mobile closed contour has been developed. The patents on the simplest adaptive transmission were created. Such

transmission allows creating the small-size adaptive motor-wheel with ideal adjustable to conditions of joint movement of all wheels of the transport machine without any control system. The work is devoted to working out of self-adjusting motor-wheel on the basis of theory of mechanisms and machines.

#### *DESIGN OF A SELF-ADJUSTING MOTOR-WHEEL*

The basic parts of motor-wheel with the adaptive mechanical redactor are: 1. Frame. 2. Hub.

#### 2. **Wisam M. Abu-Jadayil and Mousa S. Mohsen**

*Addresses* the friction drive speed reducer proposed by Flugrad and Qamhiyah in 2005 was mainly investigated in this paper. That self actuating traction drive uses six intermediate cylindrical rollers to transmit motion. Those rollers fail by fatigue. So, this research built a numerical simulation model to find the optimum size of those rollers which give the least contact stresses and so the longest fatigue life. Then those rollers were replaced by hollow ones.

#### *Traction Drive Selection*

Most speed reducer produces an output speed different than the input speed. There are, however, other types of speed reducers in use, including traction drive speed reducer.

#### *Problem Statement and Solution Technique*

Problem Statement: Much of the research has been centered on the use of hollow rollers in roller bearings. Research in this area has shown hollow rollers to have advantages in accuracy of rotation and stiffness, even at high speeds. A related area of interest is the use of hollow rollers in pure rolling contact with another roller. One main advantage of using hollow rollers in a roller bearing is the additional sharing of load between rollers as the rollers deflect more than solid rollers do under the same load, the reduction in stress is seen when the area of contact between the rollers expands under load. One of the main disadvantages of friction drive systems compared to gear drive systems is the size required. The size of a friction drive system must be larger to account for the stress induced due to the normal force required to prevent slip.

3. **Ryan R. Dalling** addresses A Positive Engagement, Continuously Variable Transmission (PECVT) allows for a continuously variable transmission ratio over a given range using positively engaged members, such as gear teeth, to transmit torque. This research is an investigation of PECVTs to establish a classification system and governing principles that must be satisfied for an embodiment to overcome the non-integer tooth problem. Results of an external patent search are given as examples of different concepts and PECVT embodiments that have been employed to negate the effects of the non-integer tooth problem.

4. **Kevin R. Lang** addresses the U.S. government enacts new regulations for automotive fuel economy and emissions.

5. **Todd J. Furlong Judy M. Vance, Pierre M. Larochelle, Erdman and Sandor (1991)** defines a mechanism as “a mechanical device that has the purpose of transferring motion. Mechanical engineers are often required to design mechanisms to perform tasks separately or as part of a larger machine.

6. **H. Komatsubara, T. Yamazaki, S. Kuribayashi** have given traction drive CVT is a low noise and a low vibration.

7. **Neil Sclater, Nicholas P. Chironis** addresses input and output functions always rotate in the same direction, irrespective of the number of bearings, and different results can be achieved by slight alterations in bearing characteristics. All these factors lead to specific advantages:

- **Space saving:** The outside diameter, bore, and width of the bearings set the envelope dimensions of the unit.

The housing needs by only large enough to hold the bearings. In most cases the speed-reducer bearings can be builds into the total system, conserving more space.

- **Quiet operation.** The traction drive is between nearly perfect concentric circles with component roundness and concentricity, controlled to precise tolerances of 0.00005 in. or better. Moreover, operation is not independent in any way on conventional gear teeth. Thus quiet operation is inherent.

- **High speed ratios.** As a result of design ingenuity and use of special bearing races, virtually any speed reducing or speed-increasing ratio can be achieved. MPB studies showed that speed ratios of 100,000- to-1 are theoretically possible with only two bearings installed.

- **Low backlash:** Backlash is restricted mainly to the clearance between backs and ball retainer. Because the balls are preloaded, backlash is almost completely eliminated. The three MPB units variety of designs possible:

- **Torque increaser:** This simple torque increaser boosts the output torque in an air-driven dental hand pieces, provide a 2 1/2-to-1 speed reduction. The speed reduces as the bearing's outer ring is kept from rotating while the inner ring is driven; the output is taken from a coupling that is integral with the ball retainer. The exact speed ratio depends on the bearing's pitch diameter, ball diameter, or contact angle. By stiffening the spring, the amount of torque transmitted increases, thereby increasing the force across the ball's normal line of contact.

- **Differential drive:** This experimental reduction drive uses the inner rings of a preloaded pair of bearings as the driving element. The ball retainer of one bearing is the stationary element, and the opposing ball retainer is the driven element. The common outer ring is free to rotate. Keeping the differences between the two bearings small permits extremely high speed reductions. A typical test model has a speed reduction ratio of 200-to-1 and transmits 1 in.-oz of torque.

- **Multi-bearing reducer:** This stack of four precision bearings achieves a 26-to-1 speed reduction to drive the recording tape of a dictating machine. Both the drive motor and reduction unit are housed completely within the drive capstan. The balls are preloaded by assembling each bearing with a controlled interference or negative radial play.

8. **Wisam M. Abu-Jadayil, Mousa S. Mohsen** had used the friction drive speed reducer proposed by Flugrad and Qamhiyah in 2005 was mainly investigated in this paper. In Design and Manufacturing of Self Actuating Traction Drives with Solid and Hollow Rollers, That self actuating traction drive uses six intermediate cylindrical rollers to transmit motion. Those rollers fail by fatigue. So, this research built a numerical simulation model to find the optimum size of those rollers which give the least contact stresses and so the longest fatigue life. Then those rollers were replaced by hollow ones. The numerical simulation results showed that the contact stresses values decreased in case of having the rollers hollow, which means longer fatigue lives of those rollers. The hollow

rollers were found to live more than 30 times the solid ones under same loading conditions.

### III.METHODOLOGY

#### Types of CVT

The types of CVT are as given below:

#### Variable-diameter pulley:

This is most common CVT system in which two V-belt pulleys split perpendicular to their axes of rotation.

#### Toroidal CVT :

These are also called as roller CVT's which are made up of rollers discs.

#### Cone Ring Transmission KRG

With the KRG GIF has a promising transmission under development that offers the driver a multifunctional power train with various driving programmes.

- Continuously variable ratio change (CVT-Mode)
- 6- or 7-Gear Automatic
- Simulated manual shifting service (Step-Mode).

Benchmark investigations regarding manufacturing costs show clear advantages for the KRG since basic functions are realized by simple mechanical solutions. Low tolerance requirements on transfer parts generate even more advantages for the system and price comparison.

#### Description:

The continuously ratio change is performed by two cones and one ring. These transfer parts are separated via an oil film from each other. Therefore the traction characteristic of this oil has a great importance. To improve the oil optimally with regard to power transfer, the oil storages for the bearings and the continuously variable friction power transfer are separated from each other. As a start element all common systems in the automotive industry are possible in principle. As the KRG needs no hydraulic-oil pump due to its mechanical pressure unit an automated dry clutch with its high efficiency is best qualified. The quick ratio change to the required ratio position is effected via little steering motions on the transfer ring by the adjusting unit. This basic principle allows to the - similar to the steering motion of a bike -high adjustment dynamics with low adjustment power.

#### Cone Ring Traction Drive

This is used in this project. With the Cone Ring traction Drive has a promising transmission under development that offers the driver a multifunctional power train with various driving programmes.

- Continuously variable ratio change (CVT-Mode)
- 60 Gear Automatic/manual Shifting

The cone ring principle is not only unique to front wheel drive configurations, but also offers promising options for rear wheel drive arrangements and for high torques.

#### Principle of Operation

The continuously ratio change is performed by two cones and one ring. These transfer parts are in constant contact with each other. Therefore the traction characteristic of this drive has a great importance. To improve the torque characteristics with regard to power transfer, the output cone can be displaced axially.

**Setup:** Construction of cone ring traction drive is as given below:

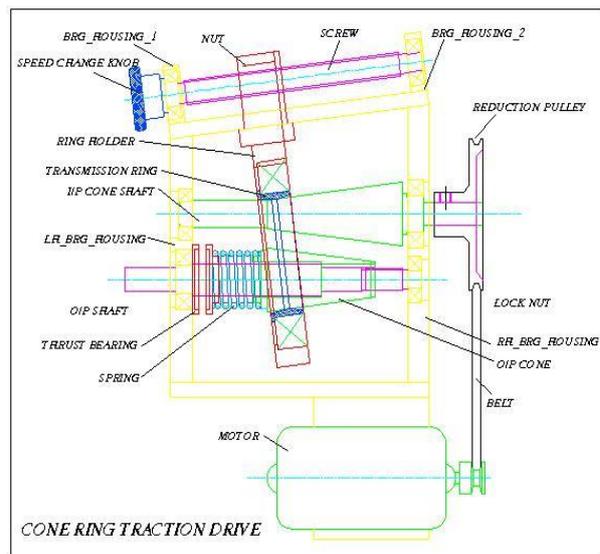


Fig. Cone Ring Traction Drive

The Cone ring traction drive consists of the following parts:

1. Motor (1 phase Ac motor, 50 watt, 230 Volt, 0-6000 rpm(variable):

Motor is a Single phase AC motor, Power 50 watt, Speed is continuously variable from 0 to 6000 rpm. The speed of motor is varied by means of an electronic speed variator. Motor is a commutator motor i.e., the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator, thereby the speed is also changes. Motor is foot mounted and is bolted to the motor base plate welded to the base frame of drive.

2. Belt Drive

The power from the motor is supplied to the input shaft of the mechanism by means of an open belt drive. The drive comprises of the motor pulley mounted on the motor shaft, the belt FZ 6x 500, and reduction pulley mounted on the input shaft.

3. L H Bearing Housing

The L H Bearing housing is a structural steel member (EN9), that supports bearings 6003 zz and 6004 zz. The upper end of

the baign housing is milled at angle of  $7^{\circ}$ , to receive the slide arrangement, where as the bottom end receives the casing support plates.

#### 4. RH Bearing Housing

The R H Bearing housing is an structural steel member (EN9), that supports bearings 6005 zz and 6201 zz . The upper end of the bearing housing is milled at angle of  $7^{\circ}$ , to receive the slide arrangement, where as the bottom end receives the casing support plates.

#### 5. Input cone shaft

The input cone shaft is an high grade steel (EN24) member held in ball bearings 6003zz and 6005 zz , in the L H & R H bearing housings respectively. The input cone shaft carries the reduction pulley at one end.

#### 6. Output shaft

The output shaft is an high grade steel (EN24) member held in ball bearings 6004zz and 6201 zz , in the L H & R H bearing housings respectively. The output shaft carries the output cone at the center which is keyed to it, where as the output shaft is provided external threading M15x1.5 pitch which receives KM-2 locknut for torque adjustment.

#### 7. Output cone

The output cone is a high grade steel (EN24) member keyed to the output shaft. Provision is made to slide the output cone axially to adjust the torque.

#### 8. Helical Compression spring

The helical compression spring is held at one end of the output cone while its other end is supported on the thrust bearing holder. The helical compression spring provides with the axial fore required for the appropriate torque.

#### 9. Thrust bearing

Thrust bearing is held between the helical compression spring and the LH bearing housing. It is held in the thrust bearing holders supported on the output shaft.

#### 10. Variator Cone Ring

The variator cone ring is a high grade steel (EN24) member held in ball bearings 6017 zz in the ring holder. It overlaps the input and output cone. It is translated along the slant edges of these cones to achieve the changes in speed, by changing the effective radii in contact.

#### 11. Ring Holder

Ring holder is an structural steel member (EN9), that holds the variator cone ring in ball bearing 6017zz, whereas carries the speed adjustment nut at its top end.

#### 12. Speed Adjustment screw

The speed adjustment screw is a high grade steel member (EN24), which is held in ball bearing supported in the LH and RH screw bearing housings which are welded to the slide arrangement on the LH and RH bearing housings as mentioned above.

#### 13. Speed Adjuster nut

The adjuster nut is held on the ring holder and screw, the rotation of the screw effects the translation of the nut thereby changing the contact radii between the input and output cones, and thus the speed changes.

#### 14. Speed Adjuster knob

The speed adjuster knob is mounted on the screw, rotation of this knob effects the speed changes.

#### Working of Cone Ring Traction Drive

Motor is connected to the Input Cone Shaft via Reduction Pulley and Belt arrangement. The input cone shaft is integral and is mounted in ball bearings in the LH & RH bearing housing respectively. The output cone shaft is mounted in ball bearings in the LH & RH bearing housing respectively and output cone is keyed to it. The output cone can slide axially and the displacement is governed by KM3 locknut. The preload in the system is maintained by the helical compression spring and the thrust bearing arrangement. The variator cone ring connects the two cones and it freely rotates in ball bearing mounted in the ring holder. The speed changing arrangement comprises of the speed adjuster nut mounted on the speed adjuster screw held in ball bearings in the bearing housings 1&2 respectively.

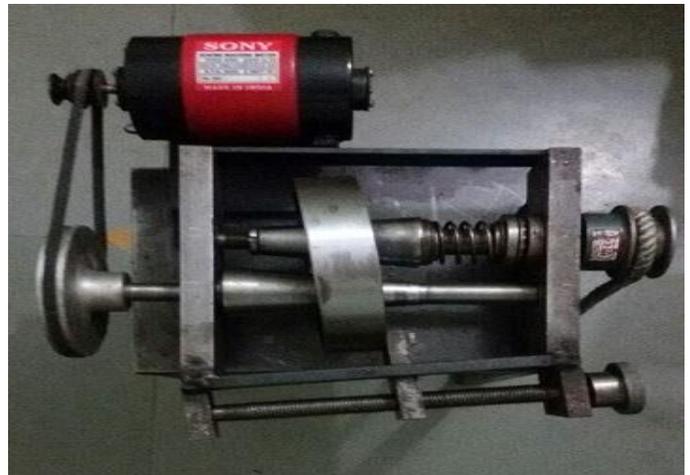


Fig1. Top view of designed model



Fig2. Side view of designed model

**A) General:** When motor is started it drives the input cone shaft via open belt drive. The input cone transmits this motion to the variator cone ring which in turn drives output cone and thereby the output shaft.

**B) Speed Changing:**

The speed changing knob when turned rotates the speed changing screw thereby effecting the translation of the nut and thereby that of the ring holder and the variator cone ring. This translation changes the contact ratio between the two cones thereby effecting speed change. Minimum 60 different speed changes are possible considering the effective slant edge length on either cone. The speed changes are continuous and can be made without stopping or disconnecting the drive.

				9	
	800	1150	0.1962	23.63098	52.5132933
	1000	1142.5	0.24525	29.34608	65.2135192
	1200	1135	0.2943	34.98413	77.742506
	1400	1115	0.34335	40.09561	89.1013597
	1600	915	0.3924	37.60408	83.564632

**C) Torque Adjustment:**

The output cone can slide axially and the displacement is governed by KM3 locknut. The preload in the system is maintained by the helical compression spring and the thrust bearing arrangement. The variator cone ring connects the two cones and hence when the output cone is axially displaced it changes the radial load and thereby the torque transmitted.

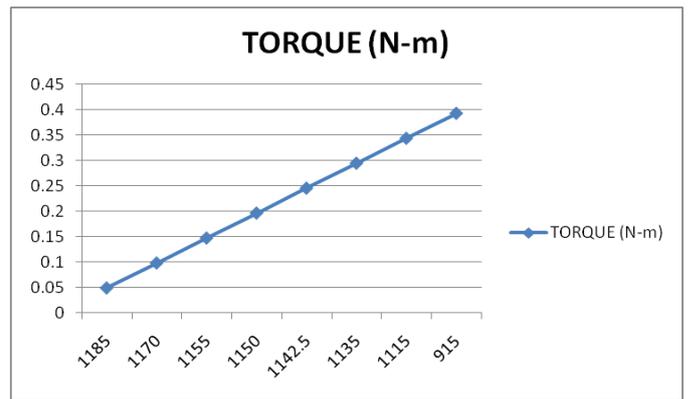


Fig3. Torque Vs Speed Characteristics

**IV. OBSERVATION TABLE**

The observations during experimentation are as follows:

Table: Observation Table

S R N O	LOADING		UNLOADING		MEAN SPEED
	WEIGH T (gm)	SPEE D rpm	WEIGH T (gm)	SPEE D rpm	
	200	1190	200	1180	1185
	400	1175	400	1165	1170
	600	1160	600	1150	1155
	800	1155	800	1145	1150
	1000	1145	1000	1140	1142.5
	1200	1136	1200	1134	1135
	1400	1116	1400	1114	1115
	1600	910	1600	920	915

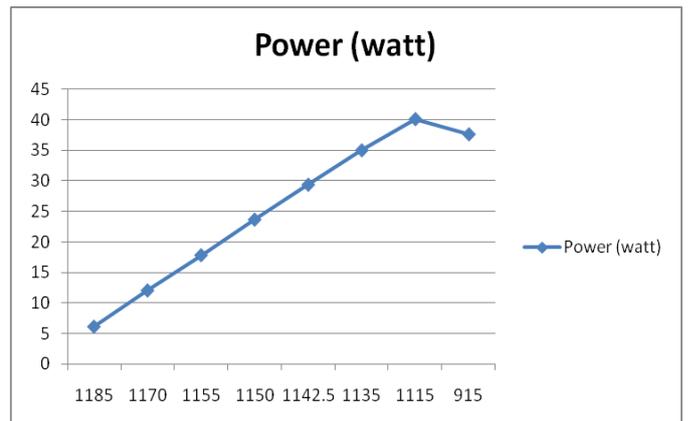


Fig4. Power Vs Speed Characteristics

**V.RESULT ANALYSIS**

The results observed during experimentation are as follows:

Table: Result Table

S R N O	LOA D (gms)	SPEE D (rpm)	TORQUE (NM)	POWE R (watt)	EFFICICEN CY
	200	1185	0.04905	6.087546	13.527881
	400	1170	0.0981	12.02098	26.713284
	600	1155	0.14715	17.8002	39.556209

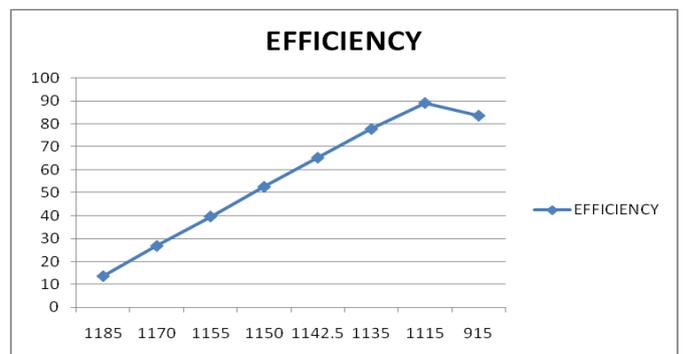


Fig5. Efficiency Vs Speed Characteristics

**VI.CONCLUSION**

CVTs are used for changing the speed and allows engine to remain at its highest efficiency. Fuel economy is improved by this system. CVTs operate smoothly so there are no gear

changes which cause sudden jerks. Small tractors uses simple hydrostatic or rubber belt CVTs. A lot of power 10-15 MPH can be delivered by them without need of clutch. Motor scooter and snowmobile CVTs is rubber belt or variable pulley CVTs.

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