Speed Variation using Cone Ring Traction Drive

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***Abstract* - For years, CVTs have been targeted at reducing vehicle fuel consumption and emissions, requiring high efficiency an sufficient ratio spread. A fun to drive is important for customer acceptance in Europe. 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. Effective gear ratio can be changed through infinite numbers through continuously variable transmission (cvt) between maximum and minimum values. This is overcome on others which allow few gear ratio selections. The angular velocity of driving shaft is maintained by the flexibility of cvt. So the economy of fuel is enabling the engine speedily with most efficient resolution per minute. A belt-driven design offers approximately 88% efficiency by enabling the engine to run at its most efficient revolutions per minute (RPM) for a range of vehicle speeds. Thus this technique is useful to balance between fuel efficiency and cost of manufacturing.**

***Index Terms* - continuously variable transmission; driving shaft; revolutions per minute.**

I. INTRODUCTION

For years, CVTs have been targeted at reducing vehicle fuel consumption and emissions. 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.

Introduction of cone ring transmission

For wide performance spectrum, cone-ring transmission is continuously variable friction wheel. The hydraulic pump is not used and is constructed with simple components. Manufacturing costs and efficiency is better in comparison to other. Basic Characteristics of 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 KRG, change in quick requires 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. 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. Today's modern engine fuel island maps are getting "flatter", which means that CVT transmissions can only take benefit of their larger ratio range. Because these force levels in friction-wheel transmissions are quite high and must also be applied constantly. Design of Cone Ring Traction Drive

The basic components are 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

a. input cone,
b. an output cone,
c. a transfer ring which can be positioned around the input/output cone. Start-up and overdrive ratio as well as the ratio spread can easily be adapted as per vehicle requirements and installation space by changing diameter and angle of cone.

Clamping Unit

The required clamping force is obtained through the axial displacement of the output cone. A mechanical torque sensor 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 into a 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 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. 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 has shown great improvement potential, if the function of the variator fluid can be reduced to torque transfer via shear forces in the oil.

II. LITERATURE REVIEW

Wherever 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. Konstantin Ivanov addresses Motor-wheel of transport machine demands a using of step gear box. Recently the theory of adaptive continuously variable transmission (CVT) in the form of gear differential with mobile closed contour has been developed. 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 [1].

The motor-wheel represents the complex assembly which is containing wheel, electric motor, brake and power transmission. Motors-wheels are used for the drive of the transport machine. The basic problems at creation of motors-wheels: 1) Necessity to use a step switching power transmission that complicates a design of a motor-wheel and increases its sizes, 2) Necessity to coordinate the forces of simultaneously working motors-wheels that demands complex control system. The electric drive with the hydrodynamic gear box is very complex and has big sizes. The direct-current motor for regulating of rotational speed also is bulky. Recently the Ivanov's theory of adaptive continuously variable transmission (CVT) with two degrees of freedom has been developed. Harries's and Ivanov's patents on CVT were created. Such transmission possesses property of force adaptation. It is capable to be independently adjustable for external loading without use of any control system and has small gabarits because does not demand the switching of transfers. Such transfer allows to create the simple and reliable small-size adaptive motor-wheel with ideal adaptation to conditions of simultaneously movement of all wheels without any control system. The present work is devoted to design of a motor-wheel with CVT and to development of the basic analytical regularities for designing of self-adjusting motors-wheels 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 [1]. 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 [2]. The hollow rollers were found to live more than 30 times the solid ones under same loading circumstances. Flugrad and Qamhiyah proposed model simulation and validate results and practical application. Two traction drives were made from aluminum with the optimum dimensions found numerically. The hollow rollers were made with 60% percentage of hollowness, means the ratio of internal to external diameter was 60%. As the rubber has minimum modulus of elasticity, the hollowness was filled with rubber to show hollow space. Successfully transmit motion and reduce speed is observed by with two friction drive models. Traction drives with cylindrical rollers have high radial load capacity. Most or all of these causes may be avoided or reduced by careful system design and manufacture. Even so, the system may then fail eventually by fatigue. The sign of the crack propagation is formation of some damage in the contact surface known as pitting or spalling. Since the stress distribution within the machine element is a main factor of determining fatigue life, some design changes should be made to redistribute the contact stresses of the rolling elements. Making rollers hollow might be a good technique to redistribute those contact stresses. Using hollow rollers in the roller bearings had the interest of some designers because of their advantages over solid rollers. Hollow roller bearings are single or double row radial bearings with an inner and outer ring and hollow/ thin wall rollers. In traction drives, two or more sets of rollers are used in contact between the inner race and the outer ring.

Traction Drive Selection

Most speed reducer in use today utilizes gears to produce an output speed different than the input speed. There are, however, other types of speed reducers in use, including traction drive speed reducer. These depend on friction between rolling elements to transmit torque from the input member to the output member. The rolling elements are held together with a prescribed normal force to generate the required friction force based on the power to be transmitted by the device. However, these devices are not self-actuating, these devices require a separate clutch to allow the output to be disengaged from the input. So objective of this invention proposed by Flugrad and Qamhiyah is to provide a traction drive speed reducer which is self-actuating. A further object of this invention is to provide a self-actuating traction drive speed reducer wherein the normal force on the roller members is only present when needed to permit the rolling elements to be operationally disengaged. A still further object of this invention is to provide a self-actuating traction drive speed reducer which can be easily engaged and disengaged in response to changing speed requirements.

The speed reducer proposed here is designed so that the configuration of the rolling elements creates the needed normal force in response to the torque exerted back on the system by the downstream loading. Thus the device is self-actuating. A cone roller toroidal traction drive was developed by Tanaka in 1988. In that work the a traction drive CVT of toroidal rolling elements changes its speed ratio by the control of the attitude angle of the power roller of which control force is induced from a little side slip. Design scheme for multidisk Beier traction variators was produced by Younes in 1992. The unique design feature of the Beier traction

variator is that it can provide a higher power capacity per unit volume by using multiple thin disk pairs in a planetary system. Compared to these traction drive designs, the self actuating traction drive of Flugrad and Qamhiyah has unique characteristics; mainly being self actuating, that rollers do not need to be in contact all the time. That would result in significant increase in the fatigue life of the rollers. The list of products in which this new self-actuating traction drive speed reducer might be used is seemingly endless. Since this new traction drive design consists of cylindrical-shaped rollers rather than complex shaped gear teeth, it will be simpler to manufacture, easier to assemble, and will run quieter.

Problem Statement and Techniques

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. Stress is decreased by using hollow rollers. Since the need for all inherent advantages in traction drive speed reducer instead of geared one, the configuration must be studied very well, installed and assembled in such a way that all these benefits and improvements in the design can be implemented and provided. The study here will discuss every improvement in the traction drive, how can we implement it and the needed design and configuration in order to be exploited. 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. Two classes of PECVTs are defined: 1) the problem correction class and 2) the alternate device class [3]. General principles that must be satisfied for a promising PECVT embodiment to exist in each class of PECVTs are developed. A product development phase integrated with TRIZ methodology is implemented to generate several concepts that satisfy the newly developed general principles and the product specifications that were also created [3]. Kevin R. Lang addresses the U.S. government enacts new regulations for automotive fuel economy [4]. H. Komatsubara, T. Yamazaki, S. Kuribayashi have given traction drive CVT is a low noise and a low vibration. One of the authors invented a new type of traction drive CVT. The purpose of this research aimed at practical use of CTC-CVT In this report, Secondly, the description of design of CTC-CVT is given [6]. Finally, the mechanical efficiency of power transmission is examined. In the traction drive, mechanical power is transmitted between two rotors via an elasto hydrodynamic lubrication (EHL) oil film. Neil Sclater, Nicholas P. Chironis addresses input and output functions always rotate in the same direction. All these factors lead to specific advantages [7]:

- **Space reduction:** The outside diameter, and width of the bearings set the envelope dimensions of the unit. The housing need by only large enough to hold the bearings.
- **Operating Process:** The traction drive is between nearly perfect concentric circles with component roundness and concentricity. Thus quiet operation is inherent.
- **Ratio of speed:** As a result of design ingenuity and use of special bearing races, virtually any speed reducing or speed-increasing ratio can be achieved.
- **Improves Torque:** This simple torque increaser boosts the output torque in an air-driven dental hand piece, provide a 2 1⁄2-to-1 speed reduction. 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.
- **Comparison of 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.
- **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.

III. METHODOLOGY

The types of CVT are as given below:

1. This is most common CVT where two V-belt pulleys are separated perpendicularly to the axes to the rotation and V-belt is running between them. By moving two sections of one pulley closer and two sections of other pulley far, the gear ratio is changed. Cause of these changes effective diameter of these pulleys causes to change overall gear ratio. Toroidal or roller-based CVT :
   Toroidal CVTs are made up of discs and rollers that transmit power between the discs. The discs are as two conical parts, point to point, with the sides such that the two parts will fill the central hole of a torus. One disc acts as an input, and other as an output (they do not quite touch). The power transmission takes place by rollers between one side to the other. Roller's axis is perpendicular to the axis of the near-conical parts, at the same time it contacts the near-conical parts at same-diameter locations and that's why it gives a 1:1 gear ratio.

2. Cone CVTs

In this type of CVTs one or more conical bodies are constituted.

Cone Ring Transmission KRG

Automatic transmissions with high performance and low production costs for low and middle class cars are hardly available on the current transmission market. 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).

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. 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.

Cone Ring Taction Drive

This is used in this project. Automatic transmissions with high performance and low production costs for low and middle class cars are hardly available on the current transmission market. 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 cab be displaced axially. The quick ratio change to the required ratio position is effected via little translation motions on the transfer ring by the adjusting speed changing knob. Due to immersion lubrication of variator and a simple mechanical pressure unit (2) for generating, the clamping force the cone needs no hydraulics. Therefore, a high efficiency and a low weight are achieved.

IV. CONCLUSION

CVTs can compensate for changing vehicle speeds, allowing the engine speed to remain at its level of peak efficiency. This improves fuel economy and by effect, exhaust emissions. CVTs operate smoothly since there are no gear changes which cause sudden jerks. Many small tractors for home and garden use have simple hydrostatic or rubber belt CVTs. For example, the John Deere Gator line of small utility vehicles use a belt with a conical pulley system. They can deliver a lot of power and can reach speeds of 10-15 MPH, all without need for a clutch or shift gears. Many new snowmobiles and motor scooters use CVTs. Virtually all snowmobile and motor scooter CVTs are rubber belt/variable pulley CVTs.

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