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DESIGN AND FABRICATION OF CONTINUOUSLY VARIABLE TRANSMISSION SYSTEM

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ABSTRACT
One hardly needs to be an automotive engineer to understand that the less fuel an engine consumes, the fewer pollutants produced, and the cleaner the air we breathe. Unfortunately, improving the variables in that equation is becoming increasingly difficult. To achieve additional fuel economy improvements, we have begun to focus on increasing efficiency in areas where improvements are much more difficult and costly to achieve - largely on power train components such as the transmission. This stems from the fact that transmissions operate over a range of power conditions, such as low speed-high torque to high speed-low torque, as well as through a variety of gear ratios. To achieve gains in this area, we have challenged the conventional thinking associated with power train functions and designs. Conventional power train configurations consist of an internal combustion engine operating across a wide range of torque and speed conditions and a transmission that has, by comparison, only a few discrete gear ratios. The operational philosophy of conventional power trains makes it difficult to reach maximum engine fuel efficiency because the opportunities for operating at the lowest fuel consumption or best "brake specific fuel consumption" are restricted and generally do not agree with the torque and speed conditions imposed on the engine by the vehicle. Using a CVT-configured power train, the engine operates at or near maximum load conditions. This allows the engine to operate at or near its best brake specific fuel consumption rate, which means that the engine is operating at its highest average adiabatic efficiencies. For internal combustion engines this would be 36 percent, while for diesel engines it is 45 percent. This project report evaluates the current state of CVTs and upcoming research and development, set in the context of past development and problems traditionally associated with CVTs. The underlying theories and mechanisms are also discussed.

Keywords: Continuously variable transmission, Variable diameter pulley, infinitely variable transmission (IVT), *Roller-based CVT*

Ratcheting CVT.

INTRODUCTION

A Continuously variable transmission (CVT) is a transmission which can change steplessly through an infinite number of effective gear ratios between maximum and minimum values. This contrasts with other mechanical transmissions that only allow a few different distinct gear ratios to be selected. The flexibility of a CVT allows the driving shaft to maintain a constant angular velocity over a range of output velocities. This can provide better fuel economy than other transmissions by enabling the engine to run at its most efficient revolutions per minute (RPM) for a range of vehicle speeds. In order to enact new regulations for automotive fuel economy and emissions, the continuously variable transmission, or CVT, continues to emerge as a key technology for improving the fuel efficiency of automobiles with internal combustion (IC) engines. CVTs use infinitely adjustable drive ratios instead of discrete gears to attain optimal engine performance. Since the engine always runs at the most efficient number of revolutions per minute for a given vehicle speed, CVT-equipped vehicles attain better gas mileage and acceleration than cars with traditional transmissions. CVTs are not new to the automotive world, but their torque capabilities and reliability have been limited in the past. New developments in gear reduction and manufacturing have led to ever more-robust CVTs, which in turn allows them to be used in more diverse automotive applications. CVTs are also being developed in conjunction with hybrid electric vehicles. As CVT development continues, costs will be reduced further and performance will continue to increase, which in turn makes further development and application of CVT technology desirable. .

HOW CVT WORKS

Traditional transmissions use a gear set that provides a given number of ratios (or speeds). The transmission (or the driver) shifts gears to provide the most appropriate ratio for a given situation: Lowest gears for starting out, middle gears for acceleration and passing, and higher gears for fuel-efficient cruising. Though there are several types of CVTs, most cars use a pair of variable-diameter pulleys, each shaped like a pair of opposing cones, with a metal belt or chain running between them. One pulley is connected to the engine (input shaft), the other to the drive wheels (output shaft). Fig 2.1 A Chain-driven CVT The halves of each pulley are moveable; as the pulley halves come closer together the belt is forced to ride higher on the pulley, effectively making the pulley's diameter larger. Changing the diameter of the pulleys varies the transmission's ratio (the number of times the output shaft revolves for each revolution of the engine), in the same way that a 10-speed bike routes the chain over larger or smaller 7 ears to change the ratio. Making the input pulley smaller and the output pulley larger gives a low ratio (a large number of engine revolutions producing a small number of output revolutions) for better low-speed acceleration. As the car accelerates, the pulleys vary their diameter to lower the engine speed as car speed rises. This is the same thing a conventional automatic or manual transmission does, but while a conventional transmission changes the ratio in stages by shifting gears, the CVT continuously varies the ratio.

USES OF CVTs

Many small tractors for home and garden use have simple rubber belt CVTs. For example, the John Deere Gator line of small utility vehicles uses a belt with a conical pulley system. They can deliver an abundance of power and can reach speeds of 10–15 mph (16–24 km/h), all without need for a clutch or shift gears. Nearly all snowmobiles, old and new, and motor scooters use CVTs. virtually all snowmobile and motor scooter CVTs are rubber belt/variable pulley CVTs. Some combine harvesters have CVTs. The CVT allows the forward speed of the combine to be adjusted independently of the engine speed. This allows the operator to slow down and speed up as needed to accommodate variations in thickness of the crop. CVTs have been used in aircraft electrical power generating systems since the 1950s and in SCCA Formula 500 race cars since the early 1970s. More recently, CVT systems have been developed for go-karts and have proven to increase performance and engine life expectancy. The Tomcat range of off-road vehicles also utilizes the CVT system. Some drill presses and milling machines contain a pulley-based CVT where the output shaft has a pair of manually-adjustable conical pulley halves through which a wide drive belt from the motor loops. The pulley on the motor, however, is usually fixed in diameter, or may have a series of given-diameter steps to allow a selection of speed ranges. A hand wheel on the drill press, marked with a scale 8 responding to the desired machine speed, is mounted to a reduction gearing system for the operator to precisely control the width of the gap between the pulley halves. This gap width thus adjusts the gearing ratio between the motor's fixed pulley and the output shaft's variable pulley, changing speed of the chuck; a tensioner pulley is implemented in the belt transmission to take up or release the slack in the belt as the speed is altered. In most cases, however, the drill press' speed must be changed with the motor running. CVTs should be distinguished from Power Sharing Transmissions (PSTs), as used in newer hybrids, such as the Toyota Prius, Highlander and Camry, the Nissan Altima, and newer-model Ford Escape Hybrid SUVs. CVT technology uses only one input from a prime mover, and delivers variable output speeds and torque; whereas PST technology uses two prime mover inputs, and varies the ratio of their contributions to output speed and power. These transmissions are fundamentally different. However the Honda Insight hybrid, the Nissan Versa (only the SL model), Nissan Cube and the Nissan Altima use CVT.

ADVANTAGES AND DISADVANTAGES

Advantages

The main advantage of CVTs is that they allow an engine to run at its ideal RPM regardless of the speed of the vehicle. For low speed special purpose vehicles the RPM is usually set to achieve peak efficiency. This maximizes fuel economy and reduces emissions. Alternatively the CVT can be setup to maximize performance and maintain the engine RPM at the level of peak power rather than efficiency. Automotive CVT's generally attempt to balance both of these functions by shooting for 9 efficiency when the driver is only applying light to moderate amounts of accelerator i.e. Under cruise conditions, and power when the accelerator is being applied more generously. Engines do not develop constant power at all speeds; they have specific speeds where torque (pulling power), horsepower (speed power) or fuel efficiency is at their highest levels. Because there are no gears to tie a given road speed directly to a given engine speed, the CVT can vary the engine speed as needed to access maximum power as well as maximum fuel efficiency. This allows the CVT to provide quicker acceleration than a conventional automatic or manual transmission while delivering superior fuel economy.

Disadvantages

CVT torque-handling capability is limited by the strength of their transmission medium (usually a belt or chain), and by their ability to withstand friction wear between torque source and transmission medium (in friction-driven CVTs). CVTs in production prior to 2005 are predominantly belt- or chain-driven and therefore typically limited to low-powered cars and other light-duty applications. Units using advanced lubricants, however, have been proven to support a range of torques in production vehicles, including that used for buses, heavy trucks, and earth-moving equipment. Some CVTs in production vehicles have seen premature failures. Some CVTs transmit torque in only one direction, rendering them useless for regenerative or engine-assisted vehicle braking; all braking would need to be provided by disc brakes, or similar dissipative systems. The CVT's biggest problem has been user acceptance. Because the CVT allows the engine to rev at any speed, the noises coming from under the hood sound odd to ears accustomed to conventional manual and automatic transmissions. The gradual changes in engine note sound like a sliding 10 transmission or a slipping clutch -- signs of trouble with a conventional transmission, but perfectly normal for CVT. Flooring an automatic car brings a lurch and a sudden burst of power, whereas CVTs provide a smooth, rapid increase to maximum power. To some drivers this makes the car feel slower, when in fact a CVT will generally out-accelerate an automatic.

TYPES OF CVTs

Variable-diameter pulley (VDP) or Reeves drive

In this most common CVT system, there are two V-belt pulleys that are split perpendicular to their axes of rotation, with a V-belt running between them. The gear ratio is changed by moving the two sections of one pulley closer together and the two sections of the other pulley farther apart. Due to the V-shaped cross section of the belt, this causes the belt to ride higher on one pulley and lower on the other. Doing this change the effective diameters of the pulleys, which changes the overall gear ratio. The distance between the pulleys does not change, and neither does the length of the belt, so changing the gear ratio means both pulleys must be adjusted (one bigger, the other smaller) simultaneously to maintain the proper amount of tension on the belt. The V-belt needs to be very stiff in the pulley's axial direction in order to make only short radial movements while sliding in and out of the pulleys. This can be achieved by a chain and not by homogeneous rubber. To dive out of the pulleys one side of the belt must push. This again can be done only with a chain. Each element of the chain has conical sides, which perfectly fit to the pulley if the belt is running on the outermost radius. As the belt moves into the pulleys the contact area gets smaller. The contact area is proportional to the number of elements, thus the chain has lots of very small elements. The shape of the elements is governed by the static of a column. The pulley-radial thickness of the belt is a compromise between maximum gear ratio and torque. For the same reason the axis between the pulleys is as thin as possible. A film of lubricant is applied to the pulleys. It needs to be thick enough so that the pulley and the belt never touch and it must be thin in order not to waste power when each element dives into the lubrication film. Additionally, the chain elements stabilize about 12 steel bands. Each band is thin enough so that it bends easily. If bending, it has a perfect conical surface on its side. In the stack of bands each band corresponds to a slightly different gear ratio, and thus they slide over each other and need oil between them. Also the outer bands slide through the stabilizing chain, while the center band can be used as the chain linkage.

Pulley-based CVTs

Peer into a planetary automatic transmission, and you'll see a complex world of gears, brakes, clutches and governing devices. By comparison, a continuously variable transmission is a study in simplicity. Most CVTs only have three basic components:

A high-power metal or rubber belt ,A variable-input "driving" pulley ,An output "driven" pulley CVTs also have various microprocessors and sensors, but the three components described above are the key elements that enable the technology to work. The variable-diameter pulleys are the heart of a CVT. Each pulley is made of two 20-degree cones facing each other. A belt rides in the groove between the two cones. V-belts are preferred if the belt is made of rubber. V-belts get their name from the fact that the belts bear a V-shaped cross section, which increases the frictional grip of the belt. When the two cones of the pulley are far apart (when the diameter increases), the belt rides lower in the groove, and the radius of the belt loop going around the pulley gets smaller. When the cones are close together (when the diameter decreases), the belt rides higher in the groove, and the radius of the belt loop going around the pulley gets larger. CVTs may use hydraulic pressure, centrifugal force or spring tension to create the force necessary to adjust the pulley halves. Variable-diameter pulleys must always come in pairs. One of the pulleys, known as the drive pulley (or driving pulley), is connected to the crankshaft of the engine. The driving pulley is also called the 13 input pulley because it's where the energy from the engine enters the transmission. The second pulley is called the driven pulley because the first pulley is turning it. As an output pulley, the driven pulley transfers energy to the driveshaft.

When one pulley increases its radius, the other decreases its radius to keep the belt tight. As the two pulleys change their radii relative to one another, they create an infinite number of gear ratios -- from low to high and everything in between. For example, when the pitch radius is small on the driving pulley and large on the driven pulley, then the rotational speed of the driven pulley decreases, resulting in a lower "gear." When the pitch radius is large on the driving pulley and small on the driven pulley, then the rotational speed of the driven pulley increases, resulting in a higher "gear". Thus, in theory, a CVT has an infinite number of "gears" that it can run through at any time, at any engine or vehicle speed. The simplicity and stepless nature of CVTs make them an ideal transmission for a variety of machines and devices, not just cars. CVTs have been used for years in power tools and drill presses. They've also been used in a variety of vehicles, including tractors, snowmobiles and motor scooters. In all of these applications, the transmissions have relied on high-density rubber belts, which can slip and stretch, thereby reducing their efficiency.
The introduction of new materials makes CVTs even more reliable and efficient. One of the most important advances has been the design and development of metal belts to connect the pulleys. These flexible belts are composed of several (typically nine or 12) thin bands of steel that hold together high-strength, bow-tie-shaped pieces of metal.

Toroidal or roller-based CVT

Toroidal CVTs are made up of discs and rollers that transmit power between the discs. The discs can be pictured as two almost conical parts, point to point, with the sides dished such that the two parts could fill the central hole of a torus. One disc is the input, and the other is the output (they do not quite touch). Power is transferred from one side to the other by rollers. When the roller's axis is perpendicular to the axis of the near-conical parts, it contacts the near-conical parts at same-diameter locations and thus gives a 1:1 gear ratio. The roller can be moved along the axis of the near-conical parts, changing angle as needed to maintain contact. This will cause the roller to contact the near-conical parts at varying and distinct diameters, giving a gear ratio of something other than 1:1. Systems may be partial or full toroidal. Full toroidal systems are the most efficient design while partial toroidals may still require a torque converter, and hence lose efficiency.

Toroidal CVTs

Another version of the CVT -- the toroidal CVT system -- replaces the belts and pulleys with discs and power rollers

Although such a system seems drastically different, all of the components are analogous to a belt-and-pulley system and lead to the same results -- a continuously variable transmission. Here's how it works:
One disc connects to the engine. This is equivalent to the driving pulley. Another disc connects to the drive shaft. This is equivalent to the driven pulley. Rollers, or wheels, located between the discs act like the belt, transmitting power from one disc to the other.

The wheels can rotate along two axes. They spin around the horizontal axis and tilt in or out around the vertical axis, which allows the wheels to touch the discs in different areas. When the wheels are in contact with the driving disc near the center, they must contact the driven disc near the rim, resulting in a reduction in speed and an increase in torque (i.e., low gear). When the wheels touch the driving disc near the rim, they must contact the driven disc near the center, resulting in an increase in speed and a decrease in torque (i.e., overdrive gear). A simple tilt of the wheels, then, incrementally changes the gear ratio, providing for smooth, nearly instantaneous ratio changes.

INFINITELY VARIABLE TRANSMISSION (IVT) A specific type of CVT is the infinitely variable transmission

(IVT), in which the range of ratios of output shaft speed to input shaft speed includes a zero ratio that can be continuously approached from a defined "higher" ratio. A zero output speed (low gear) with a finite input speed implies an infinite input-to-output speed ratio, which can be continuously approached from a given finite input value with an IVT. Low gears are a reference to low ratios of output speed to input speed. This low ratio is taken to the extreme with IVTs, resulting in a "neutral", or non-driving "low" gear limit, in which the output speed is zero. Unlike neutral in a normal automotive transmission, IVT output rotation may be prevented because the back driving (reverse IVT operation) ratio may be infinite, resulting in impossibly high back driving torque; ratcheting IVT output may freely rotate forward, though. The IVT dates back to before the 1930s; the original design converts rotary motion to oscillating motion and back to rotary motion using roller clutches. The stroke of the intermediate oscillations is adjustable, varying the output speed of the shaft. This original design is still manufactured today, and an example and animation of this IVT can be found here. Paul B. Pires created a more compact (radially symmetric) variation that employs a ratchet mechanism instead of roller clutches, so it doesn't have to rely on friction to drive the output. An article and sketch of this variation can be found here Most IVTs result from the combination of a CVT with a planetary gear system (which is also known as an epicyclic gear system) which enforces an IVT output shaft rotation speed which is equal to the difference between two other speeds within the IVT. This IVT configuration uses its CVT as a continuously variable regulator (CVR) of the rotation speed of any one of the three rotators of the planetary gear system (PGS). If two of the PGS rotator speeds are the input and output of the CVR, there is a setting of the CVR that results in the IVT output speed of zero. The maximum output/input ratio can be chosen from infinite practical possibilities through selection of additional input or outputgear, pulley or sprocket sizes without affecting the zero output or the continuity of the whole system. The IVT is always engaged, even during its zero output adjustment. IVTs can in some implementations offer better efficiency when compared to other CVTs as in the preferred range of operation because most of the power flows through the planetary gear system and not the controlling CVR. Torque transmission capability can also be increased. There's also possibility to stage power splits for further increase in efficiency, torque transmission capability and better maintenance of efficiency over a wide gear ratio range. An example of a true IVT is the SIMKINETICS SIVAT that uses a ratcheting CVR. Its CVR ratcheting mechanism contributes minimal IVT output ripple across its range of ratios. Another example of a true IVT is the Hydristor because the front unit connected to the engine can displace from zero to 27 cubic inches per revolution forward and zero to -10 cubic inches per revolution reverse. The rear unit is capable of zero to 75 cubic inches per revolution.

OVERVIEW OF THE IVT SYSTEM

A generic simplified layout of the IVT is shown below, this represents a layshaft layout, and a coaxial layout is also possible. Beneath the diagram a brief description of each component is given.

The variator - is how the Torotrak IVT creates its continuous variation of ratio.

The input gearset - transmits the power from the engine via the low regime clutch to the planet gear in the epicyclic gear train.

The epicyclic gearset - is the means by which the running engine can be connected to the stationary road wheels without a slipping clutch or torque converter, learn more.

Fixed ratio chain - takes the drive from the output discs and transmits it to the sun gear of the epicyclic gearset and the input of the high regime clutch. An idling gear can be used instead of a chain.

High regime clutch - engaged for all forward speeds above the equivalent of a second gear.

The IVT facilitates the optimum management of the engine by use of computer control.

RATCHETING CVT

The ratcheting CVT is a transmission that relies on static friction and is based on a set of elements that successively become engaged and then disengaged between the driving system and the driven system, often using oscillating or indexing motion in conjunction with one-way clutches or ratchets that rectify and sum only "forward" motion. The transmission ratio is adjusted by changing linkage geometry within the oscillating elements, so that the summed maximum linkage speed is adjusted, even when the average linkage speed remains constant. Power is transferred from input to output only when the clutch or ratchet is engaged, and therefore when it is locked into a static friction mode where the driving & driven rotating surfaces momentarily rotate together without slippage. These CVTs can transfer substantial torque, because their static friction actually increases relative to torque throughput, so slippage is impossible in properly designed systems. Efficiency is generally high, because most of the dynamic friction is caused by very slight transitional clutch speed changes. The drawback to ratcheting CVTs is vibration caused by the successive transition in speed required to accelerate the element, which must supplant the previously operating and decelerating, power transmitting element. Ratcheting CVTs are distinguished from VDPs and roller-based CVTs by being static friction-based devices, as opposed to being dynamic friction-based devices that waste significant energy through slippage of twisting surfaces. An example of a ratcheting CVT is one prototyped as a bicycle transmission protected under U.S. Patent 5,516,132 in which strong pedalling torque causes this mechanism to react against the spring, moving the ring gear/chainwheel assembly toward a concentric, lower gear position. When the pedaling torque relaxes to lower levels, the transmission self-adjusts toward higher gears, accompanied by an increase in transmission vibration.

HYDROSTATIC CVTS

Hydrostatic transmissions use a variable displacement pump and a hydraulic motor. All power is transmitted by hydraulic fluid. These types can generally transmit more torque, but can be sensitive to contamination. Some designs are also very expensive. However, they have the advantage that the hydraulic motor can be mounted directly to the wheel hub, allowing a more flexible suspension system and eliminating efficiency losses from friction in the drive shaft and differential components. This type of transmission is relatively easy to use because all forward and reverse speeds can be accessed using a single lever. An integrated hydrostatic transaxle (IHT) uses a single housing for both hydraulic elements and gear-reducing elements. This type of transmission, most commonly manufactured by Hydro-Gear, has been effectively applied to a variety of inexpensive and expensive versions of ridden lawn mowers and garden tractors. Many versions of riding lawn mowers and garden tractors propelled by a hydrostatic transmission are capable of pulling a reverse tine tiller and even a single bladed plow. One class of riding lawn mower that has recently gained in popularity with consumers is zero turning radius mowers. These mowers have traditionally been powered with wheel hub mounted hydraulic motors driven by continuously variable pumps, but this design is relatively expensive. Hydro-Gear, created the first cost-effective integrated hydrostatic transaxle suitable for propelling consumer zero turning radius mowers. Some heavy equipment may also be propelled by a hydrostatic transmission; e.g. agricultural machinery including foragers, combines, and some tractors. A variety of heavy earth-moving equipment manufactured by Caterpillar Inc., e.g. compact and small wheel loaders, track type loaders and tractors, skid-steered loaders and asphalt compactors use hydrostatic transmission. Hydrostatic CVTs are usually not used for extended duration high torque applications due to the heat that is generated by the flowing oil. The Honda DN-01 motorcycle is the first road-going consumer vehicle with hydrostatic drive that employs a variable displacement axial piston pump with a variable-angle swash plate.

VARIABLE TOOTHED WHEEL TRANSMISSION

A variable toothed wheel transmission is not a true CVT that can alter its ratio in infinite increments, but rather approaches CVT capability by having a large number of ratios, typically 49. This transmission relies on a toothed wheel positively engaged with a chain where the toothed wheel has the ability to add or subtract a tooth at a time in order to alter its ratio relative to the chain it is driving. The "toothed wheel" can take on many configurations including ladder chains, drive bars and sprocket teeth. The huge advantage of this type of CVT is that it is a positive mechanical drive and thus does not have the frictional losses and limitations of the roller-based or VDP CVT's. The challenge in this type of CVT is to add or subtract a tooth from the toothed wheel in a very precise and controlled way in order to maintain synchronized engagement with the chain. This type of transmission has the potential to change ratios under load because of the large number of ratios, resulting in the order of 3% ratio change differences between ratios, thus a clutch or torque converter is necessary only for pull-away. No CVTs of this type are in commercial use, probably because of above mentioned development challenge.

CONE CVTS

This category comprises all CVTs made up of one or more conical bodies that function together along their respective generatrices in order to achieve the variation. In the single-cone type, there is a revolving body (a wheel) that moves on the generatrix of the cone, thereby creating the variation between the inferior and the superior diameter of the cone. In a CVT with oscillating cones, the torque is transmitted via friction from a variable number of cones (according to the torque to be transmitted) to a central, barrel-shaped hub. The side surface of the hub is convex with a specified radius of curvature, smaller than the concavity radius of the cones. In this way, there will be only one (theoretical) contact point between each cone and the hub.

A new CVT using this technology, the Warko, was presented in Berlin during the 6th International CTI Symposium of Innovative Automotive Transmissions, on 3-7 December 2007. A particular characteristic of the Warko is the absence of a clutch: the engine is always connected to the wheels, and the rear drive is obtained by means of an epicyclic system in output. This system, named "power split", allows the condition of geared neutral or "zero Dynamic": when the engine turns (connected to the sun gear of the epicyclic system), the variator (which rotates the ring of the epicyclic system in the opposite sense to the sun gear), in a particular position of its range, will compensate for the engine rotation, having zero turns in output (planetary = the output of the system). As a consequence, the satellite gears roll within an internal ring gear.

Component used

1. 2-Special design spokes type pulley 2. Electric motor. 3. Bearing 4. Mild steel design shafts 5. Rubber belt. 6. Frame **Component Details - Pulley** In cvt each pulley consists of two half pulleys, one of which is stable and the other one is movable. The stable half pulley is assumed as a half pulley which is fixed to a separate shaft . Then, the thickness of half pulley and its root which is fixed to an assumptive separate shaft are obtained experimentally by finite element software, considering local stresses concentrations to be a safe region. The other part of stable half pulley is designed as a separate shaft. In order to calculate the forces applied by the belt to surfaces of pulleys, it should be noted this kind of belt is composed of several steel bands which have passed through the metal block. The bending strength of these bands is almost zero. Therefore, when the blocks are under pressure in order to prevent buckling of the bands the resultant forces at any point of the belt must be positive or zero. In this regard, by considering CVT at low ratio status as its most critical situation which leads to the maximum compressive force in the metal blocks, the minimum force which is necessary to stretch the bands is obtain. Fig 4.2.1 Tapered disc Disks are made up of mild steel. The density of the mild steel is 7860kg/m3. Disks have tapered surface of 5 degrees on one side to work as pulley when came in contact. Diameter of the disk is 150 mm and has the thickness of 10mm.

DESIGN OF BELT Having the necessary capacity for the required torque as well as create a required range of torque variation according to the specification of the target car are the most important factors in the selection of CVT belt. Among all gear ratios we consider one gear ratio (low torque and high speed condition) Input speed = 840 rpm Power (P) = 746 watts Center distance (C) = 762 mm Input diameter (D) = 280 mm (driver) Outlet diameter (d) = 150 mm (driven)Input speed = N1 = 840 rpm **Output speed**: N2 rpm N1d1=N2d2 N2= 840*280/150 N2 = 1568 rpm **Velocity (V):** V **=** πDN11000 m/s = π×280×8401000 m/s V = 12.31 m/s 27 **Angle of contact(αs):** αs= 180-2sin−1($D-d2c$) = 180-2sin−1(280−1502×762) αs=2.97 rad Depending on the availability, we select C-series belt. Fig:4.2.2 v-belt Density of belt (ρ) = 0.97 gm/cm3 Area of belt (A) = 236.67 cm2 **Mass of belt** (m) = ρ×A 28= 0.97× 236.67 m = 0.11 kg/m m×v2 =0.11 × (12.31)2 = 16.66 N We know that, T1−mv^{2}T2−mv^2= eμ×αssin(θ2) Where T1 = tension at tight side in N T2 = tension at slack side in N μ= co-efficient of friction =0.2 (Assume) Θ= v belt angle = 40° T1−16.66T2−16.66= e(0.2×2.97sin20) Maximum tension at tight side = 850 N (depending on material of the belt) 850−16.66T2−16.66=5.678 29 T2 = 130.1 N Maximum power transmitted = (T1-T2) ×V Watt = 8863.2 Watt **No. of belts:** n = required power / maximum power transmitted = 786 / 8863.2 = 0.082 (Approx 1 belt) **DESIGN OF SHAFT** Weight of disc = 8.8 N Weight of pulley = 8.8 × 2 = 17.6 N This weight of pulley acts as a point load on shaft (neglecting the weight of other components). Bending moment due to this point load M = wl/4 = (17.6*0.470)/4 M = 2.07 N m Power of the motor used = 1 HP = 786 watt Speed of the motor = 860 rpm (approx.) Torque produced by motor T = (P*60)/(2πN) = (746*60)/(2π*860) T = 1.27 Nm 30 Equivelent bending moment Me = [M+(M2+T2)1/2]/2 Me = 2.24 Nm For mild steel, Allowable bending stess = 56 MpaAllowable shear stress = 42 Mpa Factor of safety = 6 Me = (π/32)*(σb/6) *d3 2.24 = (π/32)*(56*106/6) *d3 d = 25 mm Equivelent torque Te = (M2+T2)1/2 Te = (2.072+1.272)1/2 Te = 2.43 Nm Now, Te = (π/16)*(τ/6)*d3 2.43 = (π/16)*(42*106/6)*d3 d = 23.2 mm For the safe design of shafts we take the larger diameter i. e. d = 25 mm **Dc motor** One of the first electromagnetic rotary motors was invented by Michael Faraday in 1821 and consisted of a free-hanging wire dipping into a pool of mercury. A permanent magnet was placed in the middle of the pool of mercury. When a current was passed through the wire, the wire rotated around the magnet, showing that the current gave rise to a circular magnetic field around the wire. This motor is often demonstrated in school physics classes, but brine(salt water) is sometimes used in place of the toxic mercury. This is the simplest form of a class of electric motors called homopolar motors. A later refinement is the Barlow's Wheel. Another early electric motor design used a reciprocating plunger inside a switched solenoid; conceptually it could be viewed as an electromagnetic version of a two stroke internal combustion engine. The modern DC motor was invented by accident in 1873, when Zénobe Gramme connected a spinning dynamo to a second similar unit, driving it as a motor. The classic DC motor has a rotating armature in the form of an electromagnet. A rotary switch called a commutator reverses the direction of the electric current twice every cycle, to flow through the armature so that the poles of the electromagnet push and pull against the permanent magnets on the outside of the motor. As the poles of the armature electromagnet pass the poles of the permanent magnets, the commutator reverses the polarity of the armature electromagnet. During that instant of switching polarity, inertia keeps the classical motor going in the proper direction. (See the diagrams below.) In a simple DC electric motor. When the coil is powered, a magnetic field is generated around the armature. The left side of the armature is pushed away from the left magnet and drawn toward the right, causing rotation. The armature continues to rotate. A simple DC electric motor. When the coil is powered, a magnetic field is generated around the armature. The left side of the armature is pushed away from the left magnet and drawn toward the right, causing rotation. The armature continues to rotate. When the armature becomes horizontally aligned, the commutator reverses the direction of current through the coil, reversing the magnetic field. The process then repeats. **Bearing** Have you ever wondered how things like inline skate wheels and electric motors spin so smoothly and quietly? The answer can be found in a neat little machine called a bearing.A tapered roller bearing from a manual transmission .The bearing makes many of the machines we use every day possible. Without bearings, we would be constantly replacing parts that wore out from friction. In this article, we'll learn how bearings work, look at some different kinds of bearings and explain their common uses, and explore some other interesting uses of bearings. **The Basics** The concept behind a bearing is very simple: Things roll better than they slide. The wheels on your car are like big bearings. If you had something like skis instead of wheels, your car would be a lot more difficult to push down the road. That is because when things slide, the friction between them causes a force that tends to slow them down. But if the two surfaces can roll over each other, the friction is greatly reduced. Bearings reduce friction by providing smooth metal balls or rollers, and a smooth inner and outer metal surface for the balls to roll against. These balls or rollers "bear" the load, allowing the device to spin smoothly. **Bearing Loads** Bearings typically have to deal with two kinds of loading, **radial** and **thrust**. Depending on where the bearing is being used, it may see all radial loading, all thrust loading or a combination of both.The bearings that support the shafts of motors and pulleys are subject to a radial load.The bearings in the electric motor and the pulley pictured above face only a radial load. In this case, most of the load comes from the tension in the belt connecting the two pulleys. The bearing above is like the one in a barstool. It is loaded purely in thrust, and the entire load comes from the weight of the person sitting on the stool **The bearings in a car wheel are subject to both thrust and radial loads.** fig: The bearing above is like the one in the hub of your car wheel. This bearing has to support both a radial load and a thrust load. The radial load comes from the weight of the car, the thrust load comes from the cornering forces when you go around a turn. **Types of Bearings** There are many types of bearings, each used for different purposes. These include ball bearings, roller bearings, ball thrust bearings, roller thrust bearings and tapered roller thrust bearings. **Ball Bearings** Ball bearings, as shown below, are probably the most common type of bearing. They are found in everything from inline skates to hard drives. These bearings can handle both radial and thrust loads, and is usually found in applications here the load is relatively small.

Cutaway view of a ball bearing In a ball bearing, the load is transmitted from the outer race to the ball, and from the ball to the inner race. Since the ball is a sphere, it only contacts the inner and outer race at a very small point, which helps it spin very smoothly. But it also means that there is not very much contact area holding that load, so if the bearing is overloaded, the balls can deform or squish, ruining the bearing.

CONSTRUCTION DETAILS

As per our model we divide our project in two sections:

1.Section- A DRIVE PULLEY (ENGINE)

2. Section-B WHEEL SHAFT PULLEY

Our design and working of model is discribe belowsteps:

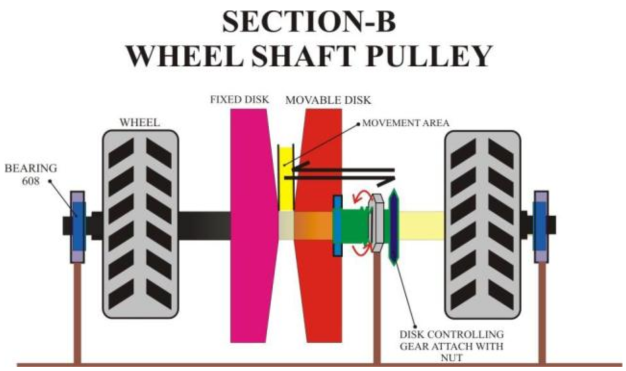

Fig: Construction details

As the above diagram opposite rotation turn transmit to the section-B rotate red pulley with the help of thread and nut system as shown below. In this section our pink pulley is fixed with wheel opposite turning can be seen in section-B and how increase space and decrease in between two pulleys one rubber pulley is inserted in between two sections to show complete working.

RESULT(OBSERVATIONS)

	Rpm of Drive pulley	Rpm of Driven pulley
At low gear	840	450
	840	549
	840	730
At high gear	840	1284
	840	1417

From the above observation we have analyze that the rpm of the driven pulley can be varied continuously.

CONCLUSION

The project has been tested efficiently. By this project we explored vast vistas of knowledge in the field of Automobile and its components. It is also provided valuable experience on power transmission etc. we became aware of challenges, work criterion, teamwork and other activities performed during the project analysis and its implementation.

The exercise has helped us to gain lot of technical and practical knowledge. We are sure that it will serve as an important experience in our professional career. Today, only a handful of cars worldwide make use of CVTs, but the applications and benefits of continuously variable transmissions can only increase based on today's research and development. As automakers continue to develop CVTs, more and more vehicle lines will begin to use them. As development continues, fuel efficiency and performance benefits will inevitably increase; this will lead to increased sales of CVT-equipped vehicles. Increased sales will prompt further development and implementation, and the cycle will repeat ad infinitum. Moreover, increasing development will foster competition among manufacturers—automakers from Japan, Europe, and the U.S. are already either using or developing CVTs—which will in turn lower manufacturing costs. Any technology with inherent benefits will eventually reach fruition; the CVT has only just begun to blossom.

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