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Multispeed Right Angle Friction Gear

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***Abstract*— Multispeed right angle friction gear which works on the principle of friction gear. This drives enable us to have a multi speed output at right angles by using a single output at right angles by using a single control lever. The design of the drive is based on the principle of friction, hence slip is inevitable, but in many cases the exact speed ratio is not of prime importance it is the multiple speed that are available from the drive that are to be considered. In this typical drive the power is transmitted from the input to the output at right angle at multiple speed and torque by virtue of two friction rollers and an intermediate sphere. The drive uses a singular control to effect the speed change, thereby making the operation of the drive extremely simple. Another important feature of this drive is its compactness, low weight and obviously its low cost**

***Index Terms*— slip, friction, gear, lever, multispeed**

I. INTRODUCTION

In many applications it is desirable to have a transmission at right angle but at multiple speeds; in these cases the velocity ratio need not be constant .Using bevel gears for such application is not possible because each bevel gear pair will only give an single output where as it desirable to have multiple speeds more ever the design and development of a gear box with multiple speeds incurs considerable cost so also the speeds available will be in certain steps. In order to effect a single speed change one will need a bevel pinion, a bevel gear, and a control lever i.e. three parameters per speed change. More ever it is also not possible to have an in line constant mesh or sliding mesh bevel gear box as in case of spur gears, due to fact that bevel pairs are always generated in pairs, hence every new speed ratio will need an fresh pair of bevel gears.

This makes the construction of a multispeed bevel gear box complicated and bulky. Needless to say the bevel gear box in this case will be high in weight and cost. Hence the need of a multi speed right angle drive with a singular control. The solution to the above problem is a Multispeed right angle friction gear; which works on the principle of friction gear. This drives enable us to have a multi speed output at right angles by using a single output at right angles by using a single control lever. The design of the drive is based on the principle of friction, hence slip is inevitable, but in many cases the exact speed ratio is not of prime importance it is the multiple speed that are available from the drive that are to be considered. In this typical drive the power is transmitted from the input to the output at right angle at multiple speed and torque by virtue of two friction rollers and an intermediate sphere. The drive uses a singular control to effect the speed change, thereby making the operation of the drive extremely simple. Another important feature of this drive is its compactness, low weight and obviously its low cost.

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II. BACKGROUND & HISTORY

A. *Friction Drive*

A Lambert automobile from 1906 with the friction drive revealed. A friction Drive or friction engine is a type of transmission that, instead of a chain and sprockets, uses 2 wheels in the transmission to transfer power to the driving wheels. This kind of transmission is often used on scooters, mainly go-peds, in place of a chain. An example of this system is in an early Turicum automobile. The Turicum's friction drive consisted of a flat steel disc coupled directly to the engine. This primary disc subsequently drove a smaller leather covered wheel oriented normal to its surface. Assuming a constant rotational velocity on the primary wheel, the angular velocity on the disc's surface will increase proportionally to the distance from the center of rotation. Therefore, positioning the smaller wheel at different points along the larger wheel's surface varies the gear ratio. Furthermore, since there are no limitations beyond the minimum and maximum positions, the gear ratios are infinitely adjustable.

The problem with this type of drive system is that they are not very efficient. Since the output wheel (leather covered wheel) has width, the area of contact is spread across various radii on the primary disc. Consequently, since the angular velocity varies as radius varies, the system must overcome these variances. The compromise is slippage of the leather to metal contact area which creates friction, which in turn converts much of the energy transfer of this system into heat. Heat generation also requires a cooling system to keep the transmission working effectively.

B. *Lambert (Automobile)*

The Lambert automobile and Lambert truck were built by the Lambert Automobile Company as an American vehicle from 1905 through 1916. The Lambert automobile motor in the early part of manufacturing moved around on the chassis. It was on the back of the chassis, then in the center, then to the front, and back again to the rear of the automobile. The early motors were built at the Lambert factories of the Buckeye Manufacturing Company and later they were outsourced to other proprietary manufactures.

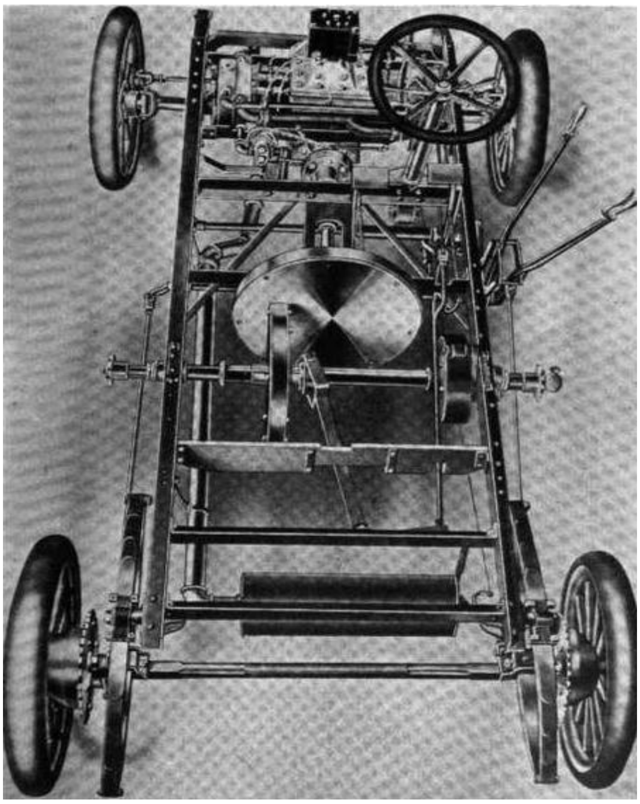

Fig.-1 Lambert automobile chassis

The Lambert chassis of the high end employed a three point suspension to save driving power by decreasing the lift required of the automobile body because of road surface variations. It saved wear and tear on the automobile body and its parts. The others used ordinary suspension. Sometimes a shaft drive was provided on some models, however most Lambert automobile models were with a chain drive to the rear axle. The Lambert automobile chassis with the gearless friction drive speed change transmission was the basis for the Lambert automobiles and trucks built from 1906 through 1916. The valve action of the engines was hardened steel cams that were applied to the cam shaft. The cam faces were slightly convex, and worked on hardened rollers, carried in swinging forks, which beard against square ended sliders. The valves were aluminum heads driven to shoulder on riveted steel stems. The valve action was direct with no side action on the sliders. The compression was between 50 to 55 pounds of pressure. The Lambert opposed cylinder motor had a number of features not usual in that form of gas engine in that era. For example, the oiler was of the precision variety, in which a ratchet actuated worm drive a worm gear carrying a spring actuated oil force pump successively over the oil leads to be supplied, the plunge spring being compressed by a circle of wedges, and the rise from each compression being regulated by an individual temper screw. Oil leads dropped oil on the crank wrist rod ends. The cranks had full disk arms and the crank shaft journals ran in bronze bearings. Lambert came in second in an automobile race conducted in July 1905 from Chicago to St. Paul. There were a total of 53 automobiles entered into the race and Lambert's was the only gasoline powered automobile to finish. The success of Lambert's 16 horsepower (12 kW) automobile against others of 40 horsepower (30 kW) was attributed to the Lambert friction gearing disk drive transmission. Some of the models of the Lambert automobiles and trucks are described below.

C. Lambert Friction Gearing Disk Drive Transmission

The Lambert friction gearing disk drive transmission was invented by John William Lambert originally in 1904.The invention relates to a friction disk drive transmission for automobiles that is gearless. He saw the need for simple transmission of engine power to an automobile's drive wheels. The main or driving disk is faced with a disk of aluminum. The driven disk has a working rim of elastic fiber. Lambert says in the invention, In practice I have found that this combination of aluminum and fiber bearing surfaces gives the maximum degree of friction and durability, thereby especially adapting the gearing for use on motor vehicles of the heavier kind, where the friction surfaces are at times subjected to great strains, and must, therefore, have a frictional contact of a high degree of efficiency in order to avoid slipping. It will be observed that the aluminum is advantageous also, because it will not tarnish or rust appreciably, but will always present a smooth, clean surface to the fiber periphery, so that wear will be reduced to a minimum. The friction disk drive was one of the key features of the Union automobile and Lambert automobile. Lambert started making the friction disk and traversing pinion drive in 1900. The first attempt was with a leather faced disk and an iron friction wheel. It had an eighteen inch diameter with a one and a half inch face. With this first attempt the leather was charred within the first three miles (5 km) of running it. The disk was then made with a wood fiber about a half inch thick. The material had a glossy surface and worked fine for a while, however it broke up after only 200 to 300 miles (480 km) run. Lambert then conducted various experiments on the friction disk to get better performance. In one experiment a cone of cast aluminum was used as one member of a level friction drive with excellent results. Lambert then realizing that the pull was due to the aluminum itself, a disk was faced with it and the traversing wheel with strawboard. This accidental discovery made Lambert automobiles more successful than other cars that attempted at friction driving. The aluminum disk was twenty-two inches in diameter and was faced with an aluminum disk of equal size with a facing of just over a quarter of an inch in thickness. The traversing wheel was eighteen inches in diameter with a 1.5-inch (38 mm) working face, strawboard rings eighteen inches outside diameter by three inches radial dimension. It was clamped between cast iron members supporting the strawboard rings inside and clamping them sideways. This fibrous friction wheel is splined to slide on a sleeve seventeen inches in diameter variably carried on a steel shaft thirteen inches in diameter. It journal in swinging boxes so that the wheel can be pressed against or separated from the iron, aluminum-faced driving disk, which is motor driven. The speed regulation was done by a steel bell crank, forked and carrying a U-shaped shoe to engage the grooved hub on the driving wheel at one end, and having the other end linked to the speed change and reversing lever. The wheel slid freely on the sleeve when moved away from the disk. All the speeds, from the highest to the lowest, could be done in either direction. The Lambert transmission always used side chains to the rear wheels and a balance gear connected to the splined sleeve on which the wheel slide and a steel shaft which supported the sleeve. The key feature of the Lambert automobile was the friction disk drive carried over from the Union automobile.

D. *Lambert Applied For A Patent On This Transmission Which Became No. 761,384 Finalized May 31, 1904. The Patent Has Six Claims:*

1. In a power-transmitting mechanism, the combination, of a pair of shafts, a friction-disk carried by each shaft, one disk having a bearing part of aluminum and the other a fiber part bearing upon said aluminum bearing part.
2. In power-transmitting mechanism, the combination of a drive-shaft and a driven shaft, a friction-disk carried by each shaft, the face of one disk being provided with an aluminum bearing-plate detachably secured thereto and the attaching means being outside of the usual working area of the bearing-plate against which the periphery of the Other disk bears.
3. In a power-transmitting, mechanism, the combination of a driving-shaft, a friction-disk on said shaft bearing a face of aluminums, and a driven shaft carrying a friction-disk, a fiber periphery secured to said disk and adapted to bear on the aluminum face of the driving-disk.
4. In a power-transmitting mechanism, the combination with a driving-shaft, a friction-disk carried thereby, a bearing-plate of aluminum for said disk, means for detachably securing said aluminum plate to the face of said driving-disk, a driven shaft, the means for attaching the aluminum plate to the driving-disk being outside of the usual working area of the disk, a disk mounted there on, a fiber periphery secured to said disk and adapted to bear on the aluminum face of said driving-disk.
5. in a friction-transmitting mechanism, a wheel having a frictional surface of aluminum.
6. In a frictional gearing, the combination with a friction-disk having a surface of aluminum, of a transmitting-disk having an elastic frictional surface bearing upon said aluminums surface.

E. *1910 Invention*

Lambert 1910 friction driving mechanism – patent 954,977. The improved 1910 invention, patent No. 954,977, made additional improvements to the original friction driving mechanism and had the following claims:

1. Power transmission mechanism including a power transmitting wheel, rigid pins projecting from the side thereof parallel with the axis of the wheel; a longitudinally movable shaft independent of and coaxial with said wheel, rigid arms projecting radially from said shaft near said wheel and provided with ball sockets, balls fitting in said sockets so as to be slid able on said pins, and means invertible in each socket for tightening the ball therein, whereby said shaft may have longitudinal movement and the parts have no angular play.
2. Friction power transmission mechanism including a power transmitting wheel, a longitudinally movable shaft independent of and coaxial with said wheel, rigid pins projecting from the side of said wheel, rigid arms extending radially from said shaft near said wheel with their outer ends apertured and split, one end of the apertured portion of each arm being contracted and having a concave bearing surface, a ball adapted to fit in the aperture of each arm against said bearing surface and surrounding said pin so as to be slidable thereon, a tubular plug screwed into each arm with a concave bearing surface on the inner end to engage said ball, and means for clamping the split end of each arm.

III. TRANSMISSION SYSTEM

A machine consists of a power source and a power transmission system, which provides controlled application of the power. Merriam-Webster defines transmission as an assembly of parts including the speed-changing gears and the propeller shaft by which the power is transmitted from an engine to a live axle. Often transmission refers simply to the gearbox that uses gears and gear trains to provide speed and torque conversions from a rotating power source to another device. In British English, the term transmission refers to the whole drive train, including clutch, gearbox, prop shaft (for rear-wheel drive), differential, and final drive shafts. In American English, however, a gearbox is any device that converts speed and torque; whereas a transmission is a type of gearbox that can be "shifted" to dynamically change the speed-torque ratio such as in a vehicle. The most common use is in motor vehicles, where the transmission adapts the output of the internal combustion engine to the drive wheels. Such engines need to operate at a relatively high rotational speed, which is inappropriate for starting, stopping, and slower travel. The transmission reduces the higher engine speed to the slower wheel speed, increasing torque in the process. Transmissions are also used on pedal bicycles, fixed machines, and anywhere rotational speed and torque must be adapted. Often, a transmission has multiple gear ratios (or simply "gears"), with the ability to switch between them as speed varies. This switching may be done manually (by the operator), or automatically. Directional (forward and reverse) control may also be provided. Single-ratio transmissions also exist, which simply change the speed and torque (and sometimes direction) of motor output. In motor vehicles, the transmission generally is connected to the engine crankshaft via a flywheel and/or clutch and/or fluid coupling, partly because internal combustion engines cannot run below a particular speed. The output of the transmission is transmitted via driveshaft to one or more differentials, which in turn, drive the wheels. While a differential may also provide gear reduction, its primary purpose is to permit the wheels at either end of an axle to rotate at different speeds (essential to avoid wheel slippage on turns) as it changes the direction of rotation. Conventional gear/belt transmissions are not the only mechanism for speed/torque adaptation. Alternative mechanisms include torque converters and power transformation (for example, diesel-electric transmission and hydraulic drive system). Hybrid configurations also exist.

A. *Types of Transmission*

Manual

- Sequential manual
- Non-synchronous
- Preselector
- Friction gear

Automatic

- Manumatic
- Semi-automatic
- Electrohydraulic

- Saxomat
- dual clutch
- Continuously variable

Bicycle gearing

- Derailleur gears
- Hub gears

B. *Manual Transmission*

Manual transmissions often feature a driver-operated clutch and a movable gear stick. Most automobile manual transmissions allow the driver to select any forward gear ratio ("gear") at any time, but some, such as those commonly mounted on motorcycles and some types of racing cars, only allow the driver to select the next-higher or next-lower gear. This type of transmission is sometimes called a sequential manual transmission. The way a manual transmission works is that the flywheel is attached to the engine, the clutch disk is in between the pressure plate and the flywheel. When running, the clutch disk is spinning with the flywheel and when pressure is applied to the clutch pedal the throw out bearing is pushed in and it makes the pressure plate stop applying pressure to the clutch disk and making it stop receiving power from the engine so the gear can be shifted without any problems and when pressure stops being applied to the clutch pedal the clutch disk is allowed to start receiving power from the engine. Manual transmissions are characterized by gear ratios that are selectable by locking selected gear pairs to the output shaft inside the transmission. Conversely, most automatic transmissions feature epicyclic (planetary) gearing controlled by brake bands and/or clutch packs to select gear ratio. Automatic transmissions that allow the driver to manually select the current gear are called Manumatics. A manual-style transmission operated by computer is often called an automated transmission rather than an automatic. Contemporary automobile manual transmissions typically use four to six forward gears and one reverse gear, although automobile manual transmissions have been built with as few as two and as many as eight gears. Transmission for heavy trucks and other heavy equipment usually have at least 9 gears so the transmission can offer both a wide range of gears and close gear ratios to keep the engine running in the power band. Some heavy vehicle transmissions have dozens of gears, but many are duplicates, introduced as an accident of combining gear sets, or introduced to simplify shifting. Some manuals are referred to by the number of forward gears they offer (e.g., 5-speed) as a way of distinguishing between automatic or other available manual transmissions. Similarly, a 5-speed automatic transmission is referred to as a "5-speed automatic."

C. *Automatic Transmission*

An automatic transmission (also called automatic gearbox) is a type of motor vehicle transmission that can automatically change gear ratios as the vehicle moves, freeing the driver from having to shift gears manually. Most automatic transmissions have a defined set of gear ranges, often with a parking pawl feature that locks the output shaft of the transmission stroke face to keep the vehicle from rolling either forward or backward. Similar but larger devices are also used for heavy-duty commercial and industrial vehicles and equipment. Some machines with limited speed ranges or fixed engine speeds, such as some forklifts and lawn mowers, only use a torque converter to provide a variable gearing of the engine to the wheels. Besides automatics, there are also other types of automated transmissions such as a continuously variable transmission (CVT) and semi-automatic transmissions, that free the driver from having to shift gears manually, by using the transmission's computer to change gear, if for example the driver were redlining the engine. Despite superficial similarity to other transmissions, automatic transmissions differ significantly in internal operation and driver's feel from semi-automatics and CVTs. An automatic uses a torque converter instead of a clutch to manage the connection between the transmission gearing and the engine. In contrast, a CVT uses a belt or other torque transmission scheme to allow an "infinite" number of gear ratios instead of a fixed number of gear ratios. A semi-automatic retains a clutch like a manual transmission, but controls the clutch through electrohydraulic means. A conventional manual transmission is frequently the base equipment in a car, with the option being an automated transmission such as a conventional automatic, semi-automatic, or CVT. The ability to shift gears manually, often via paddle shifters, can also be found on certain automated transmissions (manumatics such as Tiptronic), semi-automatics (BMW SMG), and CVTs (such as Lineartronic). The first automatic transmission was invented in 1921 by Alfred Horner Munro of Regina, Saskatchewan, Canada, and patented under Canadian patent CA 235757 in 1923. (Munro obtained UK patent GB215669 215,669 for his invention in 1924 and US patent 1,613,525 on 4 January 1927). Being a steam engineer, Munro designed his device to use compressed air rather than hydraulic fluid, and so it lacked power and never found commercial application. The first automatic transmissions using hydraulic fluid were developed by General Motors during the 1930s and introduced in the 1940 Oldsmobile as the "Hydra-Matic" transmission. They were incorporated into GM-built tanks during World War II and, after the war; GM marketed them as being "battle-tested"

D. *Friction Drive*

A friction drive or friction engine is a type of transmission that, instead of a chain and sprockets, uses 2 wheels in the transmission to transfer power to the driving wheels. This kind of transmission is often used on scooters, mainly go-peds, in place of a chain. The problem with this type of drive system is that they are not very efficient. Since the output wheel (leather covered wheel) has width, the area of contact is spread across various radii on the primary disc. Because the tangential velocity varies as radius varies, the system must overcome velocity differentials across the surface. The compromise is slippage of the leather to metal contact area which creates friction, which in turn converts much of the energy transfer of this system into heat. Heat generation also requires a cooling system to keep the transmission working effectively.

E. Applications of Friction Drive

a) Phonographs

Friction drive has been most successfully used in low-power applications, such as driving phonograph turntables.

b) Old Automobiles

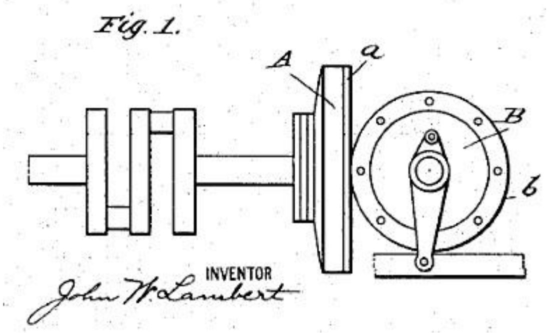

Fig.-2 Lambert friction gearing transmission patent 761384

Automobiles using this drive system included the Anglo-Dane, the Arista, the Armadale, the Astra, the Allvelo, the Bukh & Gry, the Cartercar, the Crown 12HP Model Two (1905-1906), the Davis Totem, the Kelsey, the Lambert, the LuLu, the Metz, the Ner-a Car, and the Turicum. The Turicum's friction drive consisted of a flat steel disk coupled directly to the engine. This primary disk subsequently drove a smaller leather covered wheel oriented normal to its surface. Assuming a constant rotational velocity on the primary wheel, the angular velocity on the disk's surface will increase proportionally to the distance from the center of rotation. Therefore, positioning the smaller wheel at different points along the larger wheel's surface varies the gear ratio. Furthermore, since there are no limitations beyond the minimum and maximum positions, the gear ratios are infinitely adjustable. The Lambert's friction drive (illustrated) was similar but used an aluminium-faced driving disk and a fiber-faced driven wheel.

c) Railway Locomotives

Plymouth Locomotive works's first three models, the AL, BL and CL were equipped with a friction drive. Early models of the permanent way maintenance ganger's Wickham trolley used a vee-twin JAP engine. This drove through a large flat flywheel and a friction drive.

d) Belt Drives

A belt drive is a form of friction drive but is usually categorized separately from the "disk and wheel" type of friction drive.

IV. PRINCIPLE OF WORKING

Multispeed right angle friction drive works on the principle of friction gear. This drives enable us to have Multi speed output at right angles by using a Single input with the help of a simple control lever. The output can be obtained in both directions (Clockwise & Anticlockwise). In this typical drive the power is transmitted from the input to the output at right angle at multiple speed and torque by virtue of two friction rollers and an intermediate sphere. The drive uses a singular control to effect the speed change, thereby making the operation of the drive extremely simple.

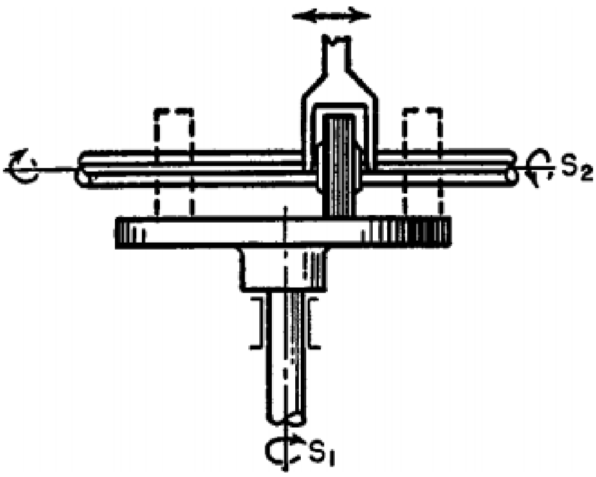

Fig.-3 Diagram of Basic principle

Motor is switched on, which makes the motor shaft to drive the input shaft. Input shaft rotates the Input friction disk at a high speed. The friction disk rotates the friction roller which in turn rotates the output shaft. The speed of the output shaft depends upon the radius of rotation. This radius of rotation can be controlled by regulating the rotation of the feed screw. The feed screw when rotated about its own axis moves the fork up or down thereby changing the radius of rotation. The pitch of the screw is 2mm thus per rotation the roller moves by two mm, the working range of the disk is 75 mm on either side of the center of the disk. The direction of rotation of the output shaft can be reversed by moving the roller on the opposite side of the center of the input friction disk. Important feature of this drive is its compactness, low weight and obviously its low cost.

V. CONSTRUCTION & EFFECTING SPEED CHANGE

Motor drives input friction disk .The input friction disk is horizontally mounted in bearing housing At the other end output shaft carries an circular friction roller keyed to it . This friction disk is lined with friction material .As input friction disk is rotated the friction roller starts rotating by virtue of friction between the two members thereby the output shaft rotates. The speed change is achieved by changing the radial position of the friction roller on the input friction disk by means of the screw and fork arrangement.

The construction of this multispeed right angle friction gear is analyzed as a complete solution to variable speed transmission. It consists of following elements

A. Input Friction Disk

Input friction disk is a high grade steel (EN 24) construction coupled to motor at one end by pulley and belt and is held in heavy duty ball bearing (6204) and (6203) at the input bearing housing end.

B. *Friction Roller*

Friction roller is modified in construction that a spherical radius is turned on the face of this disc whose outer surface serves as the friction surface. This friction roller is driven by the input friction disk and its face is lined with friction material feredo.

C. *Fork*

The fork is the member that houses the friction roller and moves it up or down with respect to the input friction disk. It is mounted on the feed screw.

D. *Feed Screw*

The adjuster screw carries the fork and it is held on the casing in two bearing housings. The feed screw serves to adjust the position between the input friction disk and the friction roller, as so it serves as a speed changer.

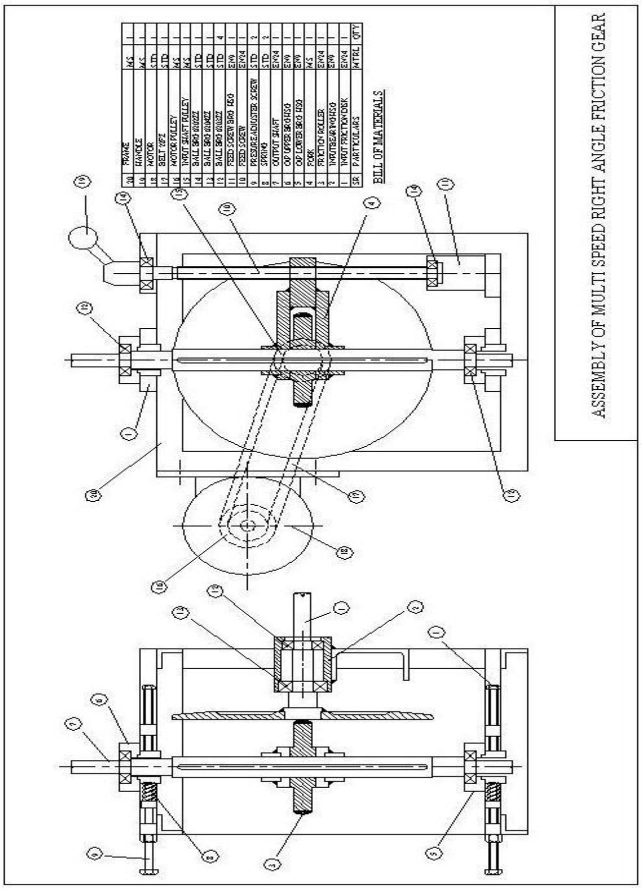

Fig.-4 Assembly drawing

E. *Contact Pressure Mechanism*

The contact pressure mechanism is in the form of an adjuster screw held in a nut in the casing and a helical compression spring that rests against the output shaft bearing housing. One such set is provided at each end of the output shaft. The compression of the spring results in the contact pressure between the friction disk and roller. This can be duly adjusted by mean of the adjuster screw.

F. *Wear Compensating Mechanism*

This is in the form of a wear compensating screw that is mounted in a nut in the casing and it rests against the output bearing housing at each end of shaft. This screw is adjusted to adjust the wear.

G. *Output Shaft*

Output shaft is a high grade steel (EN24) which is keyed to output friction disk at one end and to the load at the ether end. It is housed in the heavy duty ball bearing (6203) housed in the casing.

H. *Pulleys*

The pulleys are mounted on the input shaft and the motor and are connected via v-belt.

I. *Frame*

The frame is an open construction fabricated from ms angle, the other members in the form of bearing housing (1, 2, and 3) and the holding block being welded to it. It is robust construction and encloses all moving members inside it. [3]

VI. HERTZ'S CONTACT PRESSURES IN FRICTION DRIVES

At friction drives the circumference power is transmitted by friction from one rolling body to the second. Always the thrust is necessary. At most designs of friction drives it deduces high forces to shafts and bearings. Therefore the high surface pressures result on the contact joists. These pressures are one of main factors which influence the friction drives. The basic condition of friction drive is based on the equilibrium of circumference power $F0$ and friction power Ft. When we speculate about the degree of safety k (starting, turning-out, impact influences etc.) we get the basic condition in the form

$$F0 \times k = Ft \quad (1)$$

When we express the friction power as the product of the thrust Fn and coefficient of friction f and introduce it in the foregoing equation we get the basic condition of the friction drive (Figure 5).

$$F0 \times k = f \times Fn \quad (2)$$

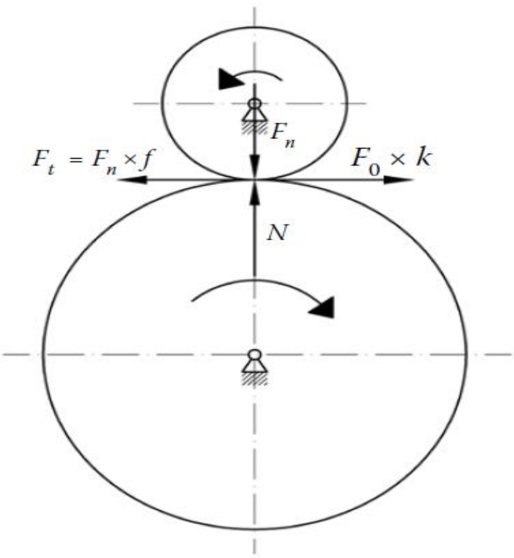

Fig.-5 Hertz's contact pressures in friction drives

According to the contact we can classify the surface pressures as the surface contact, line contact, and point contact. According to the material elasticity we can classify the surface pressures in: Hertz's pressures – the modulus of elasticity in tension of both materials is constant, owing to load it does not vary. Stribeck's pressures – the modulus of elasticity in tension of one of materials is not constant, it varies according to the load (rubber, plastic etc.). In friction drives operation the Hertz's pressures are in foreground and they influence considerably the drive, namely pressures with line and point contact. As early as in the year 1881 Heinrich Hertz formulated the relation between the load value of projected area of surface pressures and the bringing near at the contact of generally curved bodies. The solution derived by Heinrich Hertz gives only the orientation values of contact pressures. The in this way calculated contact pressures can vary in some cases as much as 50% from real values (Klaprodt 1980). Later much authors tried to describe the contact pressures theory. But till now the accurate solution of the contact pressures calculation was not found. (Klaprodt 1980, Bolek & Kochman 1990). Heinrich Hertz introduced several simplified premises. The place of the highest stress is under the middle of the upper surface of function of both bodies and near the front surface is the accumulation of stress. The modulus of elasticity in tension of both materials is constant. It does not vary according to the load. Strains are regarding to the bodies sizes very low and their profile is in one plane (Hertz 1896).

For the calculation these four laws defined by Heinrich Hertz are valid.

(1) Isotropy and homogenity of projected area material.

(2) In the course of deformation the Hooke´s law must be valid.

(3) Shear stress is equal to zero. The influence about friction is not speculated.

(4) Projected areas are equal. [1]

VII. COMPARISON BETWEEN GEARBOX AND FRICTION GEAR

Sr. No.	Parameter	Gearbox	Friction Gear
1	Cost	High	Low
2	Weight	High	Low
3	Size	Bulky	Compact
4	Slip	No	Significant at high torque
5	Torque Transmission Capacity	High	Medium & low
6	Exact speed ratio	Yes	No
7	Number of Speed ratio	Limited	Infinite
8	Speed change	Shocking	Gradual & shockproof
9	Dissipation of Heat generated	Simple	Difficult as dry friction
10	Noise	High	Low
11	Application	Automobiles	Conveyor line, wire winding, balancing m/c, assembly line

VIII. FUTURE SCOPE

A variable speed forward and reverse friction drive mechanism composed of a driving disc which has a lateral friction surface for selective engagement with either one of a pair of driven friction discs, which are supported on an output drive shaft for transmittal of rotational driving power from the driving disc to the driven discs when engaged by the drive disc; the improved construction of the arrangement is such that:

- Either one or both of the driven discs are shift able along the output drive shaft for varying the drive engaging position on the driving disc to obtain infinite variations in speed ratio,
- The driven discs are pivotally supported relative to a stationary axis of the driving disc for selective engagement of one driven disc at a time and
- The driving disc may be pivotally supported relative to a stationary axis around which the driven discs rotate for selective drive engagement with either one of the driven discs.
- We can use multispeed right angle friction drive instead of Gearbox for low & medium load transmission system.

In a further embodiment of the present improved friction drive transmission instead of pivotally moving the driven disc into or out of engagement with the driving disc, the driving disc is pivotally supported in a stationary member and attached to a rod linkage, bell crank linkage, push-pull cable or the like, to selectively pivotally move the driving disc into or out of engagement with a selected driven disc supported on the drive shaft, which is stationary along its axis. In this arrangement, likewise, either or both forward and/or reverse driven disc can be made shift able along the drive shaft for speed ratio change in the forward drive direction or in both forward and reverse drive direction. [2]

IX. ADVANTAGES

- Easy to maintain proper pressure between the contact surfaces thereby resulting in trouble frees operation.
- Multiple speeds can be obtained; where as regular clutches are of ON-OFF type where only one speed is available.
- Infinitely variable speed available over a given range.
- Ease of operation; the speed changes are gradual, without any shock.
- Singular control:-Entire range of speeds is covered by a single hand wheel control.
- Low cost.
- Compact size.
- Bi-directional power transmission, thereby enabling to also reverse the direction of the drive.

X. DISADVANTAGES

- Drive is an actually a friction type drives which automatically limits the torque that can be transmitted by the drive hence it can be used satisfactorily for light to medium duty application.
- The amount of slip becomes significant of high torque conditions, which reduces the velocity ratio making

in-accuracies in power and motion.

- Friction surfaces generate a lot of heat, being a dry friction drive; proper ventilation preferably forced ventilation must be provided for satisfaction application at any loads.

XI. APPLICATIONS

- **SPEED DRIVES FOR MACHINE TOOLS SPINDLES:-MACHINE TOOL SPINDLES ARE REQUIRED TO BE DRIVEN AT VARIOUS SPEEDS DEPENDING UPON THE SIZE OF WORK AND MATERIAL TO BE CUT IN SUCH CASES THE GEAR LESS VARIABLE SPEED REDUCER CAN BE USED ALONG WITH ALL GEARED HEAD STOCK TO GIVE AN INFINITELY VARIABLE SPEED CONDITION.**
- **BY COMBINATION THE ADJUSTABLE SPHERICAL DRIVE AND A THREE STAGE ALL GEAR HEAD STOCK A STILL WIDE RANGE OF SPEEDS CAN BE OBTAINED FOR THE MAIN SPINDLE OF LIGHT DUTY MACHINE TOOLS.**
- **FEED DRIVES FOR MACHINE TOOL SLIDES. MACHINE TOOL SLIDES CAN BE MOVED AT DIFFERENT SPEEDS TO IMPART FEEDING MOTION TO THE CUTTING TOOL.**
- **VARIABLE SPEED DRIVES FOR CONVEYORS IN ASSEMBLY LINE AND AUTOMATIC ASSEMBLY PLANTS.**
- **VARIABLE SPEED DRIVES IN AUTOMATIC TRANSFER LINES AND PICK AND PLACE ROBOTIC DEVICES.**
- **VARIABLE SPEED DRIVE FOR COIL WINDING MACHINES**
- **VARIABLE SPEED DRIVE FOR BALANCING MACHINES IN TESTING EQUIPMENT**

XII. CONCLUSION

There are some advantages that we have observed in Multispeed right angle friction drive due to which it is useful in certain applications where exact speed ratio is not of prime importance it is the multiple speed that are available from the drive that are to be considered. Multispeed right angle friction drive overcomes the limitations of normal gearbox such as low cost, light weight, compact size, infinitely variable speed ratio, gradual speed change without shock, bidirectional power transmission. So these merits are useful in some applications where medium and low load capacity is required such as conveyor, assembly line, wire winding machine, balancing machine. But there are still some limitations which limit its applications such as torque transmission capacity, significant amount of slip, variable contact pressure, and heat dissipation due to dry friction at high speed. Hence it is desirable to have this drive in certain applications where variable speed is required without much importance of torque transmission capacity.

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