CHAPTER ONE

INTRODUCTION

1.1 General

Every vehicle consists of power source and a power transmission system, which provides controlled application of the power. Transmission is 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 gear box that uses gears and gear train to provide speed and torque conversions from a rotating power source to another device. In the heavy vehicle under study, consist of four driving axles (an eight wheeler vehicle) we need to transfer the power from the transfer gear box to the appropriate axles (two, three or four axles).the transfer gear box is designed to distribute the engine torque between the driving axles, hydro jet and winch and to change tractive force on the driving wheels. Driving shaft installed on bearings in the upper half of the case. The splines of the shaft mount cluster gear of step – up and step – down gears. (Fig1).Cluster gears are a series or (cluster) of spur gears on a shaft or gear blank, each with varying diameters. This type of gear assembly is often used in the automotive industry, and is seen in bicycling as well [1].

1.2 The problem statement

The vehicle under study have (8×8) wheel drive four axles, the two front axles can be engaged when needed through a cluster gear. In the vehicle under study, the cluster gear breaks very frequently, which result in a low reliable performance of the vehicle. Reliability is major importance for heavy vehicles.

1.3 Research Objectives

This research aim to solve the problem of the cluster gear by modifying the design of the cluster gear and the method of engagement of the gears so as to avoid the damage of the gears.

1.4 Methodology

Solving of this problem will be done by:

1. Suggestion of many solutions.
2. Selection of the adequate solution.
3. Performing of a detail design for modification.

CHAPTER TWO

LITERATURE REVIEW

2.1 Preface

In a motor vehicle, the term power train or power plant refers to the group of components that generate power and deliver it to the road surface, water, or air. This includes the engine, transmission, drive shafts, differentials, and the final drive (drive wheels, continuous track, wheel reduction gear as in tanks or caterpillar tractors, propeller, etc.). Sometimes power train is used to refer to simply the engine and transmission, including the other components only if they are integral to the transmission. In a carrying a wagon, running gear designates the wheels and axles in distinction from the body. A motor vehicle drive line or drive train consists of the parts of the power train excluding the engine and transmission. It is the portion of a vehicle, after the transmission, that changes depending on whether a vehicle is front – wheel, rear – wheel, or four – wheel drive, or less – common six – wheel or eight – wheel drive. In a wider sense, the power – train includes all of it is components used to transform stored (chemical, solar, nuclear, kinetic, potential, etc) energy into kinetic energy for propulsion purposes. This includes the utilization of multiple power sources and non – wheel - based vehicles. The manufacturing of powertrain components and systems is important to industry, including the automotive and other vehicle sectors. Competitiveness drives companies to engineer and produce power train systems that over time are more economical to manufacture, higher in product quality and reliability, higher in performance, more fuel efficient, less polluting, and longer in life expectancy. In turns these requirements have led to designs involving higher internal pressures, greater instantaneous forces, and increased complexity of design and mechanical operation. The resulting designs in turn impose significantly more severe requirements on parts shape and dimension; and material surface flatness, waviness, roughness, and porosity.

Quality control over these parameters is achieved through metrology technology applied to all of the steps in power train manufacturing processes [1].

2.2 Transmission

Transmission is an energy transformation unit that takes the power from the engine to the wheels. It is used to transmit engine torque to the driving wheels to drive the vehicle on the road. The main task of the transmission is to:

Ensure that the vehicle starts from the rest, with the engine running continuously.

Allow the speed / torque ratio to vary between the engine and the wheels.

Transmit the drive torque to the wheels.

Allow the driver / system to run the engine in its optimal point based on the driving situation thereby improving fuel efficiency and / or minimize emissions.

The need of transmission come from the physics behind an engine – vehicles have to produce sufficient power to overcome the road resistance forces in order to start the vehicle from rest or to be in continuous motion. The road resistance forces are in the form of gradient force, aerodynamic force and rolling resistance of the tires. The engines have a wide band of revolutions per minute (RPM) where the power and torque are maximum at the particular region. The transmission functions by changing the gear ratio between the engine and wheels of the vehicle so that it tries to stay within this wide band there by producing maximum performance and efficiency. 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, the term refers more specifically to the gearbox alone, and the usage details are different. The most common use 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 in appropriate 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 where different rotational speeds and torques are adapted. In motor vehicles, the transmission generally is connected to the engine crankshaft via a flywheel 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 exit [2].

2.2.1 Transmission Types

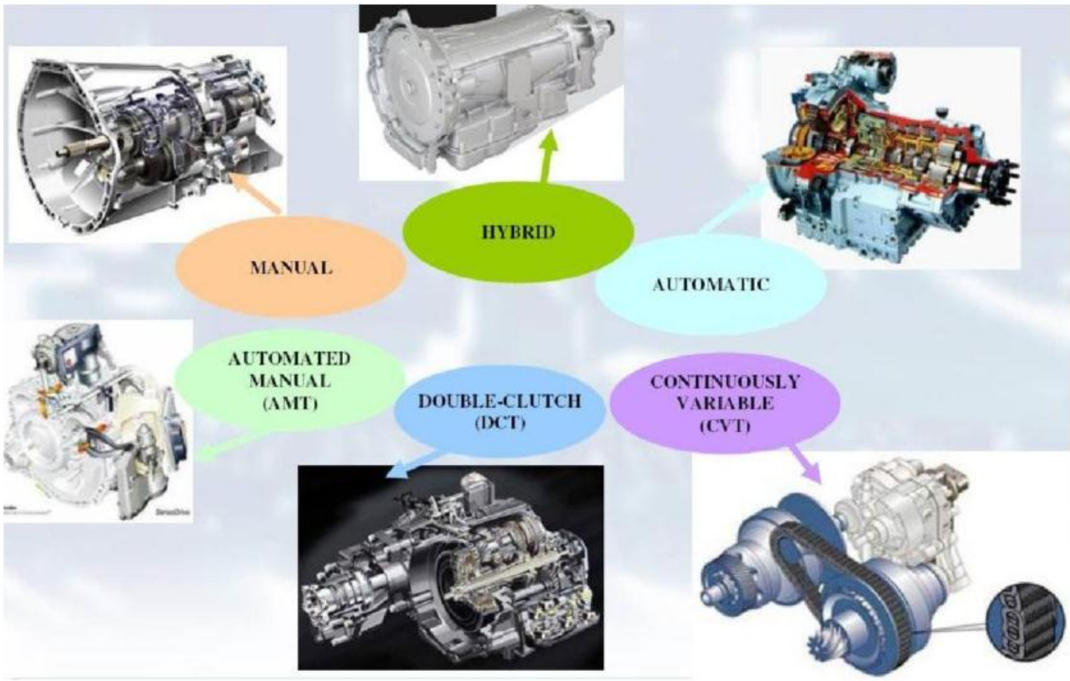

Figure 2.1 Transmission Types1. Manual[3].

2. Hybrid.
3. Automatic.
4. Automated manual (AMT).
5. Double – clutch (DCT).
6. Continuously variable (CVT).

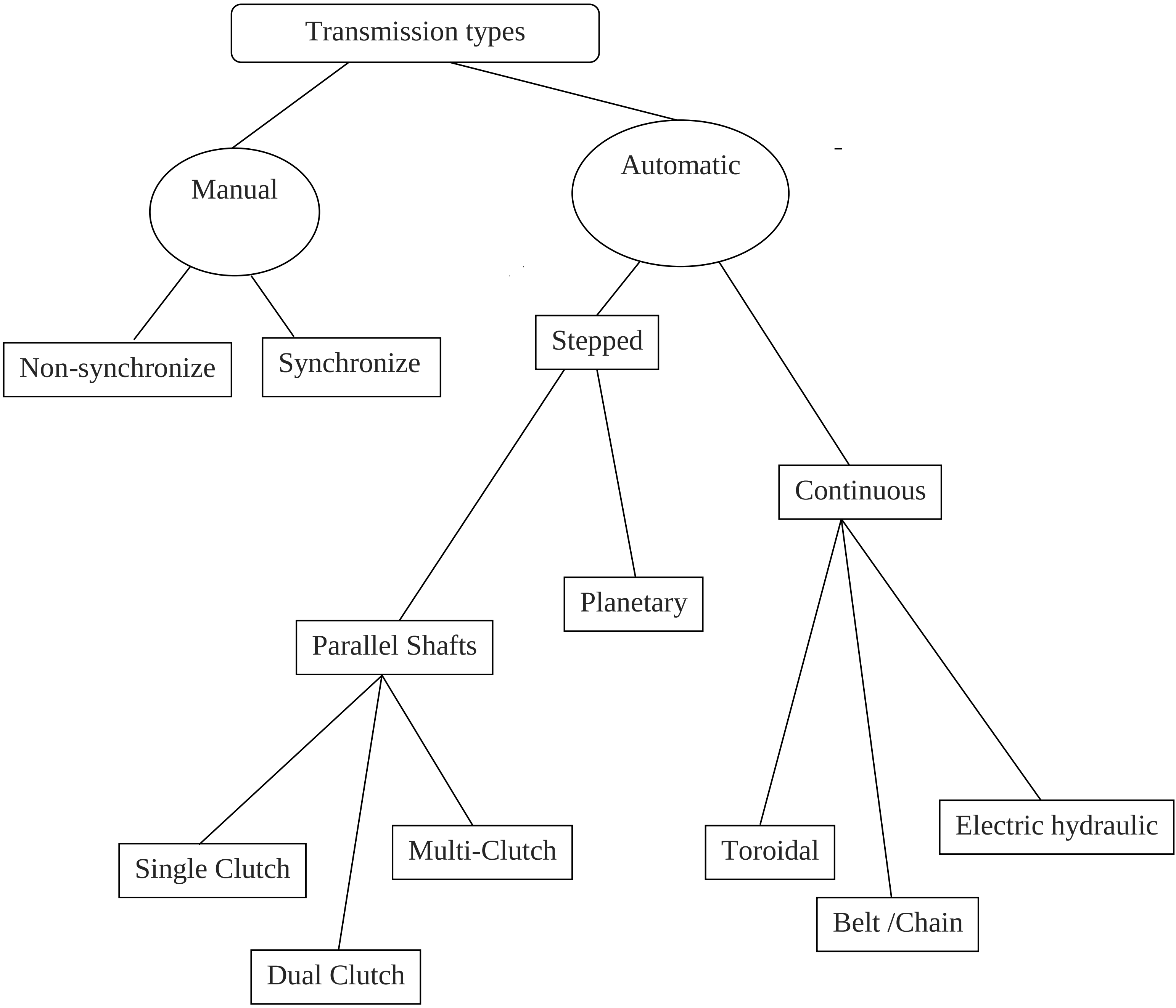

Figure 2.2 Transmission type chart [3].

2.2.2 Transmission system

A machine consists of a power source and power transmission system, which provides controlled application of the power.

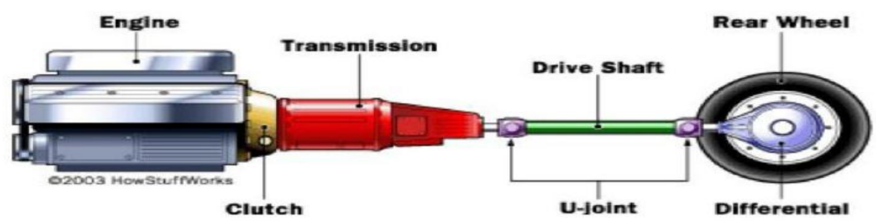

Figure 2.3 Transmission system

Requirement of transmission system;

-To provide for disconnecting the engine from the driving wheels and provide relative movement between them.

- When engine is running, connect the driving wheels to engine smoothing without shock.
- Leverage between engine and driving wheels to be varied.
- Enable the driving wheels to rotate at different speeds[3].

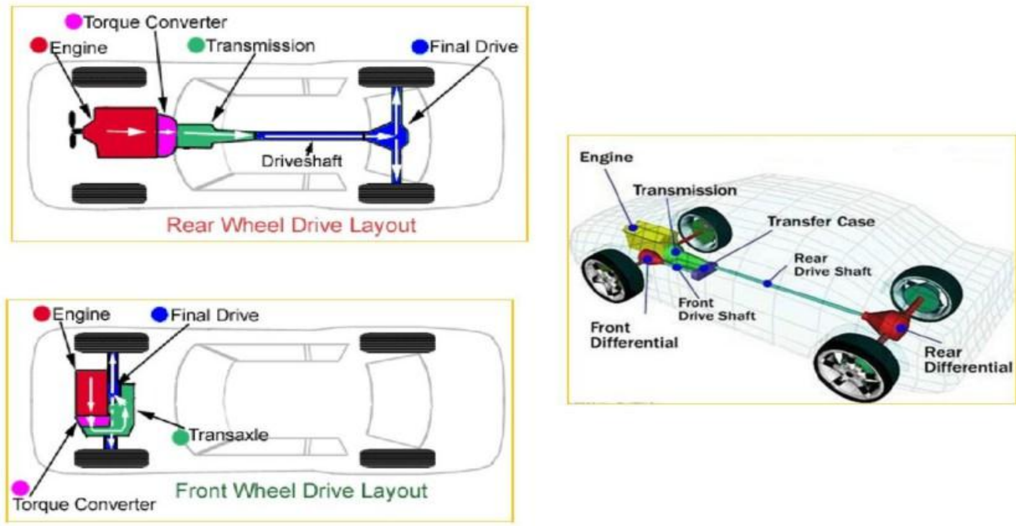

Figure 2.4 Transmission system – layout[3].

2.2.3 Manual transmission

The manual transmission as the name suggests involves the driver to regulate torque from the engine to the wheels via the transmission and this is done with the help of user operated clutch pedal, and gear shift fork. A manual transmission, also known as manual gear box, stick shift (for vehicle with hand-leaver shifters), standard transmission, n-speed manual (depending on gears) or colloquially a stick (for hand shifters, is a type of transmission used in motor vehicle applications).

Advantages of manual transmission;

-Cheap to make.

-Durable, efficient.

-Easy to install.

-Established in market place and with manufacturing infrastructure.

-Gives control to the driver.

-But driver comfort an issue with increasing traffic density. Hence automation must be considered.

- Disadvantages of manual transmission;

-The manual transmission locks and unlocks different sets of gears to the output shaft to achieve the various gear ratios.

-Manual gears are difficult to operate on steep climbs. Stopping on a hill and starting again can be inconvenient as well as scary. Since the vehicle rolls back, drivers have rolled into traffic or stalled.

-Manual systems require better driving skills, whereas difficult to change gears every second. Traffic situation the driver has to be more alert while driving and better coordinate.

-We must have clutch pedal and gear shift.

-Pain from the clutch. The driver left leg will be in constant use when driving a stick shift vehicle.

-Damage of gears of manual transfer gearbox in this vehicle under study.

Manual transmission comes in two basic types;

-A simple but rugged sliding-mesh or unsynchronized /non - synchronous system. Where straight-cut spur gear sets spin feely, and must be synchronized by the operator matching engine revs to road speed, to avoid noisy and damaging clashing of the gears.

-The now common constant-mesh gear boxes, which can include non – synchronized, or synchronized/ synchromesh systems, where typically diagonal and helical (or sometimes either straight-cut or double-helical) gear sets are constantly (meshed) together and a dog clutch is used for changing gears.

On synchromesh boxes, friction cones or “synchro-rings” are used in addition to the dog clutch to closely match the rotational speeds of the two sides of the (declutched) transmission before making a full mechanical engagement.

Unsynchronized transmission:

The earliest form of a manual transmission is thought to have been inverted by Louis Rene Panhard and Emile Levassor in the late 19^{th} century [3]. This type of transmission offered multiple gear ratios and in most cases reverses.

The gears where typically engaged by sliding them on their shafts (hence the phrase shifting gears), which required careful timing and throttle manipulation when shifting, so the gears would be spinning at roughly the same speed when engaged; otherwise, the teeth would refuse to mesh. These transmissions are called sliding mesh transmissions or sometimes crash boxes, because of difficulty in changing gears and the loud grinding sound that often accompanied. Newer manual transmissions on cars have all gears mesh at all times and are referred to as constant –mesh transmissions, with “synchro-mesh’’ being a further refinement of the constant mesh principle. In both types, a particular gear combination can only be engaged when the two parts to engage (either gears or clutches) are the same speed. To shift to a higher gear, the transmission is put in neutral and the engine allowed slowing down until the transmission parts for the next gear are at a proper speed to engage. The vehicle also slows while in neutral that slows other transmission parts, so the time in neutral depends on the grade, wind, and other such factor. To shift to a lower gear, the transmission is put in neutral and the throttle is used to speed up the engine and thus the relevant transmission parts, to match speeds for engaging the next lower gear. For both upshifts and downshifts, the clutch is released (engaged) while in neutral. Some drivers use the clutch only for starting from a stop, and shifts are done without the clutch. Other drivers will depress (disengage) the clutch, shift to neutral, then engage the clutch momentarily to force transmission parts to match the engine speed, then depress the clutch again to shift to the next gear, a process called double clutching. Double clutching iseasier to get smooth, as speeds that are close but not quite matched need to speed up or slow down only transmission parts, whereas with the clutch engaged to the engine, mismatched speeds are fighting the rotational inertia and power of the engine. Even though automobile and light truck transmission are now almost universally synchronized, transmission for heavy trucks and machinery, motorcycle, and for dedicated racing are usually not. Non-synchronized transmission designs are used for several reasons. The friction material, such as brass, in synchronizer is more prone to wear and breakage than gears, which are forged steel, and the simplicity of the mechanism improves reliability and reduces cost. In addition, the process of shifting a synchromesh transmission is slower than that of shifting a non-synchromesh transmission. For racing of production-based transmissions, sometimes half the teeth on the dog clutches are removed to speed the shifting process, at the expense of greater wear. Heavy duty trucks often use un synchronized transmissions, allowing untrained personnel to operate them in emergencies. In the United States, traffic safety rules refer to non-synchronous transmissions in classes of targer commercial motor vehicles. In Europe, heavy duty trucks use synchronized gearboxes as standard. Similarly, most modern motorcycles use unsynchronized transmissions; their low gear inertias and higher strength mean that forcing the gears to alter speed is not damaging, and the pedal operated selector on modern motorcycles, with no neutral position between gears (except, commonly, 1st and 2nd), is not conducive to having the long shift time of a synchronized gearbox. On bikes with a first gear-Neutral-second gear (-third-fourth…..) transmission, it is necessary either to stop, slow down, or synchronize gear speeds by blipping the throttle when shifting from 2nd into 1st.[3].

Synchronized Transmission:

Most modern manual-transmission vehicles are fitted with a synchronized gearbox. Transmission gears are always in mesh and rotating, but gears on one shaft can freely rotate or be locked to the shaft. The locking mechanism for a gear consists of a collar (or dog collar) on the shaft which is able to slide sideways so that teeth (or dog) on its inner surface bridge two circular rings with teeth on their outer circumference: one attached to the gear, one to the shaft. When the rings are bridged by the collar, that particular gear is rotationally locked to the shaft and determines the output speed of the transmission. The gearshift lever manipulates the collars using a set of linkages, so arranged so that one collar may be permitted to lock only one gear at any one time; when "shifting gears", the locking collar from one gear is disengaged before that of another is engaged. One collar often serves for two gears; sliding in one direction selects one transmission speed, in the other direction selects another. In a synchromesh gearbox, to correctly match the speed of the gear to that of the shaft as the gear is engaged the collar initially applies a force to a cone-shaped brass clutch attached to the gear, which brings the speeds to match prior to the collar locking into place. The collar is prevented from bridging the locking rings when the speeds are mismatched by synchro rings (also called blocker rings or baulk rings, the latter being spelled balk in the U.S.). The synchro rings rotates slightly due to the frictional torque from the cone clutch. In this position, the dog clutch is prevented from engaging. The brass clutch ring gradually causes parts to spin at the same speed. When they d0 spin the same speed, there is no more torque from the cone clutch and the dog clutch is allowed to fall into engagement. In a modern gearbox, the action of all of these components is so smooth and fast it is hardly noticed. The modern cone system was developed by Porsche [4] and introduced in the 1952 Porsche 356; cone synchronizers were called Porsche-type for many years after this. In the early 1950s, only the second-third shift was synchromesh in most cars, requiring only a single synchro and a simple linkage; drivers' manuals in cars suggested that if the driver needed to shift from second to first, it was best to come to a complete stop then shift into first and start up again. With continuing sophistication of mechanical development, fully synchromesh transmissions with here speeds, then five became universal by the 1980s. Many modern manual transmission cars, especially sports cars, now offer six speeds. The 2012 Porsche 911 offers a seven-speed manual transmission, with the seven-speed manual transmission, with the seventh gear intended for cruising- top speed being attained on sixth. Reverse gear is usually not synchromesh, as there is only one reverse gear in the normal automotive transmission and changing gears into reverse while moving is not required - and often highly undesirable, particularly at high forward speed. Additionally, the usual method of providing reverse, with an idler gear sliding into place to bridge what would otherwise be two mismatched forward gears, is necessarily similar to the operation of a crash box. Among the cars that have synchromesh in reverse are the 1995-2000 Ford Contour and Mercury Mystique, '00-'05 Chevrolet Cavalier, Mercedes 1902.3-16, the V6 equipped Alfa Romeo GTV/Spider (916), certain Chrysler, Jeep, and GM products which use the New Venture NV3550 units, the European Ford Sierra and Granada/Scorpio equipped with the MT75 gearbox, the Volvo 850, and almost all Lamborghinis, Hondas and BMWs.Technology Madras.

2.3 CLUTCH

A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft. Clutches are used whenever the transmission of power or motion must be controlled either in amount or over time (e.g., electric screwdrivers limit how much torque is transmitted through use of a clutch; clutches control whether automobiles transmit engine power to the wheels).A clutch thus provides an interruptible connection between two rotating shafts. Clutches allow a high inertia load to be stated with a small power. A popularly known application of clutch is in automotive vehicles where it is used to connect the engine and the gear box. Here the clutch enables to crank and start the engine disengaging the transmission and change the gear to alter the torque on the wheels. Clutches are also used extensively in production machinery of all types. The components of a clutch assembly can be grouped into two basic categories: driving members and driven members. Driving members include the flywheel, clutch cover, pressure plate, pressure springs and levers, intermediate plate, adapter ring, and adjustment mechanisms. Driven members include friction discs and the transmission input shaft. A clutch can be released or disengaged by one of two methods: push-type clutch or pull-type clutch. Clutch brakes are found in some pull type clutches and can be grouped into four types: conventional, limited torque, torque-limiting and two-piece clutch brakes. The clutch linkage, which connects the clutch pedal to the release fork or yoke, can be one of three types: mechanical, hydraulic, and air control [4].

2.3.1 Friction clutches

Frictional Contact axial or Disc Clutches, An axial clutch is one in which the mating frictional members are moved in a direction parallel to the shaft. A typical clutch is illustrated in figure 2.5, It consists of a driving disc connected to the drive shaft and a driven disc connected to the driven shaft. A friction plate is attached to one of the members. Actuating spring keeps both the members in contact and power/motion is transmitted from one member to the other. When the power of motion is to be interrupted the driven disc is moved axially creating a gap between the members as shown in the figure. The vast majority of clutches ultimately rely on frictional forces for their operation. The purpose of friction clutches is to connect a moving member to another that is moving at a different speed or stationary, often to synchronize the speeds, and/or to transmit power.

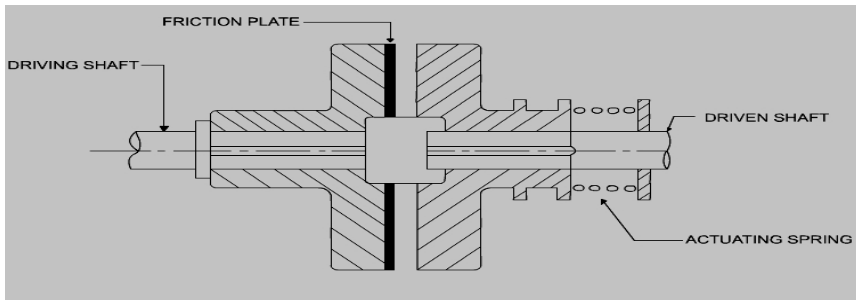

Figure 2.5 Single plate dry Clutch – Automotive application[4].

Usually, as little slippage (difference in speeds) as possible between the two members is desired.The clutch used in automotive applications is generally a single plate dry clutch. In this type the clutch plate is interposed between the flywheel surface of the engine and pressure plate

1. Positive clutch (Dog clutch)

In the positive clutch, grooves are cut either into the driving member or into to driven member and some extracted parts are situated into both driving and driven member. When the driver release clutch pedal then these extracted parts insert into a grooves and both driving and driven shaft revolve together. When he push the clutch pedal these extracted parts come out from grooves and the engine shaft revolve itself without revolving transmission shaft.

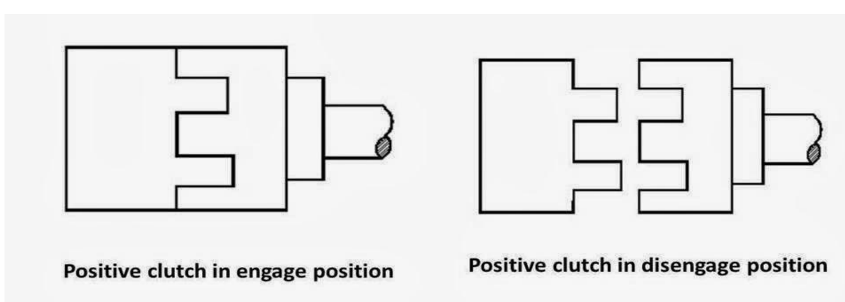

Figure 2.6 positive clutch [4].

2. Friction clutch

In this type of clutches, friction force is used to engage and disengage the clutch. A friction plate is inserted between the driving member and the driven member of clutch. When the driver releases the clutch pedal, the driven member and driving member of clutch, comes in contact with each other. A friction force works between these two parts. So when the driving member revolves, it makes revolve the driven member of clutch and the clutch is in engage position. This type of clutch is subdivided into four types according to the design of the clutch.

A.) Cone clutch:

It is a friction type of clutch. As the name, this type of clutch consist a cone mounted on the driven member and the shape of the sides of the flywheel is also shaped as the conical. The surfaces of contact are lined with the friction lining. The cone can be engage and disengage form flywheel by the clutch pedal [5].

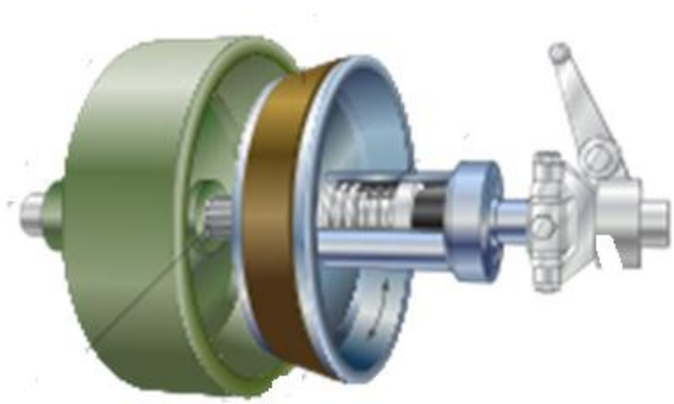

Figure 2.7 cone clutch

B) Single plate clutch:

In the single plate clutch a flywheel is fixed to the engine shaft and a pressure plate is attached to the gear box shaft. This pressure plate is free to move on the spindle of the shaft. A friction plate is situated between the flywheel and pressure plate. Some springs are inserted into compressed position between these plates. When the clutch pedal releases then the pressure plate exerts a force on the friction plate due to spring action. So clutch is in engage position. When the driver pushes the clutch pedal it due to mechanism it serves as the disengagement of clutch.

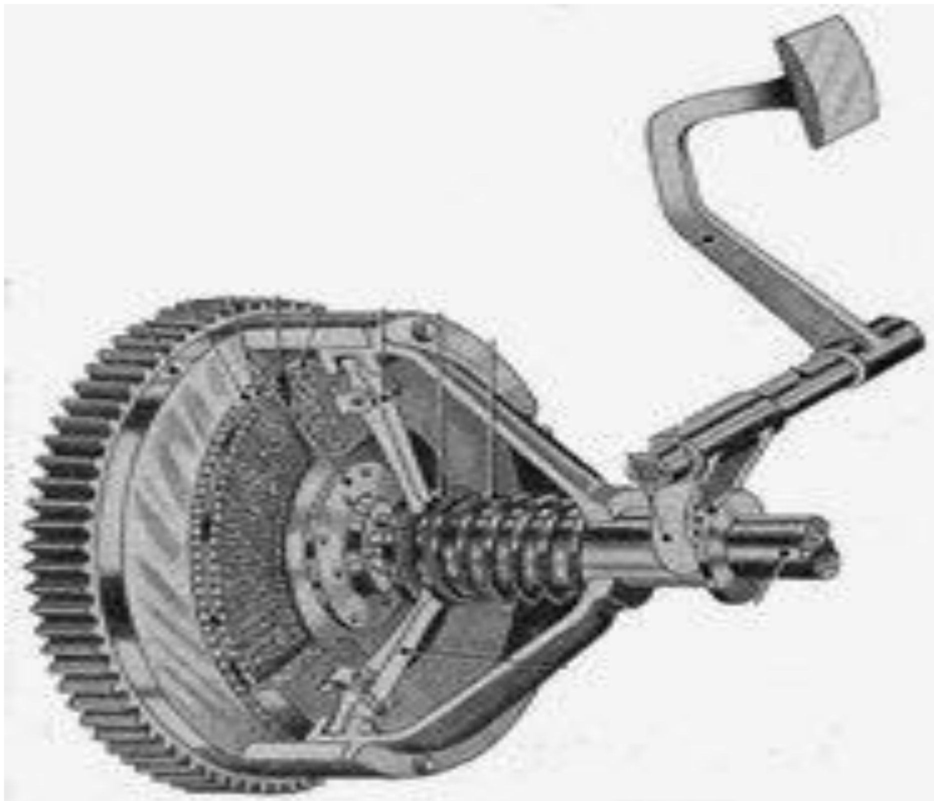

Figure 2.8 single plate clutch

C.) Multi-plate clutch:

Multi-plate clutch is same as the single plate clutch but there is two or more clutch plates are inserted between the flywheel and pressure plate. This clutch is compact then single plate clutch for same transmission of torque.

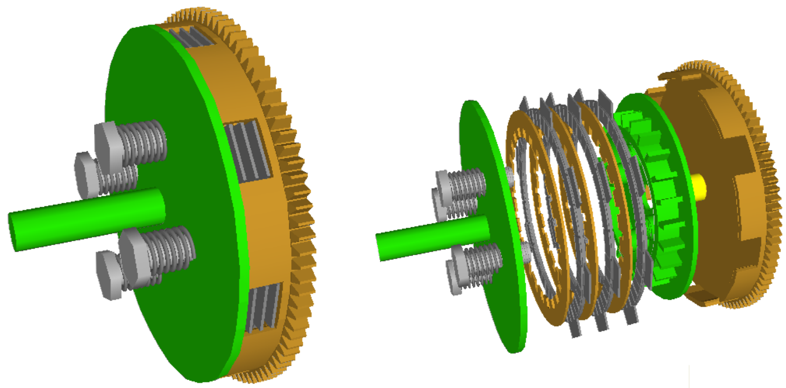

Figure 2.9 multi-plate clutch

D.) Diaphragm clutch:

This clutch is similar to the single plate clutch except diaphragm spring is used instead of coil springs for exert pressure on the pressure plate . In the coil springs, one big problem occur that these springs do not distribute the spring force uniformly. To eliminate this problem, diaphragm springs are used into clutches. This clutch is known as diaphragm clutch.

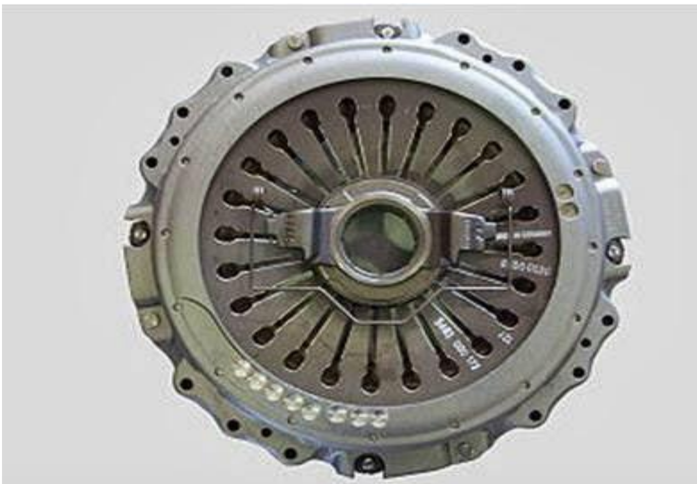

Figure 2.10 diaphragm clutch

3. Hydraulic clutch

This clutch uses hydraulic fluid to transmit the torque. According to their design, this clutch is subdivided into two types.

A.) Fluid coupling:

It is a hydraulic unit that replaces a clutch in a semi or fully automatic clutch. In this type of clutch there is no mechanical connection between driving member and driven member. A pump impeller is blotted on a driving member and a turbine runner is bolted on the driven member. Both the above unit is enclosed into single housing filled with a liquid. This liquid serve as the torque transmitter form the impeller to the turbine. When the driving member starts rotating then the impeller also rotates and through the liquid outward by centrifugal action. This liquid then enters the turbine runner and exerts a force on the runner blade. This make the runner as well as the driven member rotate. The liquid from the runner then flows back into the pump impeller, thus complete the circuit. It is not possible to disconnect to the driving member to the driven member when the engine is running. So the fluid coupling is not suitable for ordinary gear box.

Figure 2.11 Fluid coupling

B.) Hydraulic torque converter:

Hydraulic torque converter is same as the electric transformer. The main purpose of the torque converter is to engage the driving member to driven member and increase the torque of driven member. In the torque converter, an impeller is bolted on the driving member, a turbine is bolted on the driven member and a stationary guide vanes are placed between these two members. This all parts are enclosed into single housing which filled with hydraulic liquid. The impeller rotates with the driven member and it through the liquid outward by centrifugal action. This liquid flowing from the impeller to turbine runner exerts a torque on the stationary guide vanes which change the direction of liquid, thereby making possible the transformation of torque and speed. The difference of torque between impeller and turbine depends upon these stationary guide vanes. The hydraulic torque converter is serve the function of clutch as well as the automatic gear box.

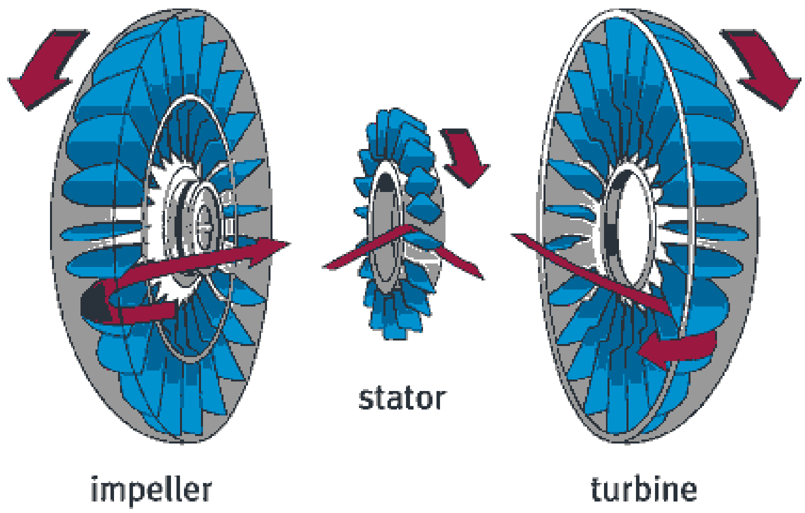

Figure 2.12 Hydraulic torque converter

According to the method of engaging force:

1. Spring types clutch:

In this type of clutches, helical or diaphragm springs are used to exert a pressure force on the pressure plate to engage the clutch. These springs are situated between pressure plate and the cover. These springs are inserted into compact position into the clutch. So when it is free to move between these two members, it tends to expand. So it exert a pressure force on the pressure plate thus it brings the clutch in engage position.

2. Centrifugal clutch:

As the name in the centrifugal clutch, centrifugal force is used to engage the clutch. This type of clutch does not require any clutch pedal for operating the clutch. The clutch is operated automatically depending upon engine speed. It consist a weight pivoted on the fix member of clutch. When the engine speed increase the weight fly of due to the centrifugal force, operating the bell crank lever, which press the pressure plate. This makes the clutch engage[5].

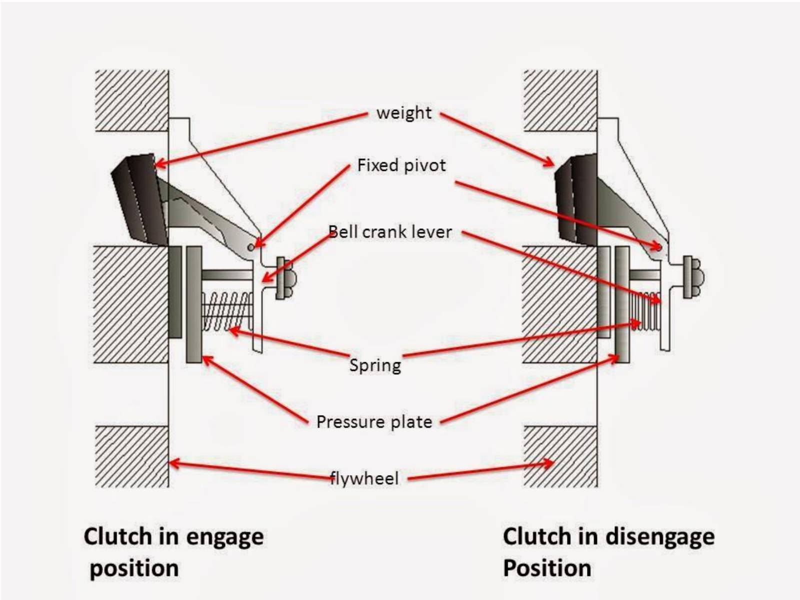

Figure 2.13 Centrifugal clutch

3. Semi-centrifugal clutch:

One big problem occur in centrifugal clutch is that they work sufficient enough at higher speeds but at lower speed they don’t do their work sufficiently. So the need of another type of clutch occurs, which can work at higher speed as well as at lower speed. This type of clutch is known as semi-centrifugal clutch. This type of clutch uses centrifugal force as well as spring force for keeping it in engaged position. The springs are designed to transmit the torque at normal speed, while the centrifugal force assists in torque transmission at higher speeds[7].

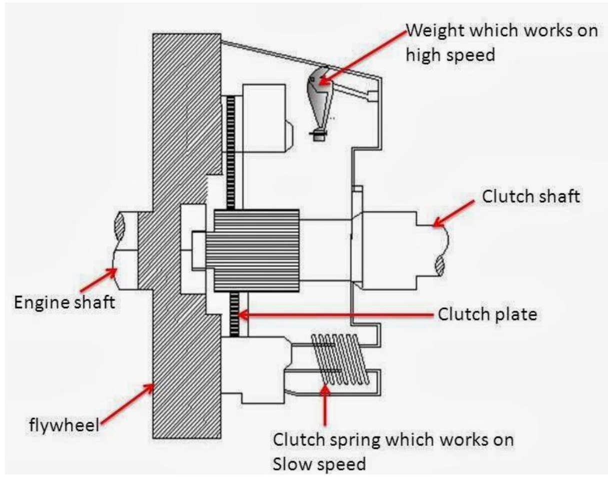

Figure 2.14 Semi-centrifugal clutch[7].

4. Electro-magnetic clutch:

In the electromagnetic clutch electro-magnate is used to exert a pressure force on pressure plate to make the clutch engage. In this type of clutch, the driving plate or the driven plate is attached to the electric coil. When the electricity is provide into these coils then the plate work as the magnate and it attract another plate. So both plates join when the electricity provides and the clutch is in engage position. When the driver cut the electricity, this attraction force disappear, and the clutch is in disengage position[7].

Figure 2.15 Electro-magnetic clutch[7].

According to the method of control:

1. Manual clutch:

In this type, clutch is operate manually by the driven when he need or when shifting the gear. This types of clutch uses some mechanical, hydraulical or electrical mechanism to operate the clutch. All friction clutches are include in it.

2. Automatic clutch:

This type of clutch used in modern vehicle. This clutch has self operated mechanism which control the clutch when the vehicle need. Centrifugal clutch, hydraulic torque converter and fluid coupling includes in it. This type of clutches is always used with the automatic transmission box[7].

CHAPTER THREE

DESIGN MODIFICATION

3.1 Preface

The vehicle under study which shown in figure (3.1) is a four axle's heavy vehicle, which is normally, operated using 2 axles. Axles (3 and 4).In case of muddy or loose land axles 1 and 2 are engaged using a transfer gear box. The correct practice as recommended by the vehicle manufacturer is to stop vehicle completely before engaging the additional axles. But in the practical usage, drivers do not a bide to instructions and use the shifting handle while the vehicle is moving, which results in frequent breakage of the compound gear of the transfer gear box. In this chapter, a proposal modification of the existing design will be presented in order to make it possible for the drivers to engage axle number one and two without causing any damage of the transfer gear box.

3.2 Existing transfer

The vehicle employs a mechanical step – type power train. The power train represents asset of gear units and mechanism which convert the engine torque in value and direction and transmit it to the wheels, hydro jet screw and to the winch gear unit. The power train layout and components are shown in fig (3-1). The clutch disengages the engine from the power train and engages them smoothly. Disengagement is required for stopping and quick braking of the vehicle, for shifting gear in the gearbox and in the transfer, for engaging and disengaging the hydro jet and winch. A smooth engagement of the engine with the power train gear units and engine. The clutch ensure transmission of the engine torque to the power train gear unit during the vehicle motion and protects the power train parts against damage loused by abrupt change in the engine or vehicle motion speed.

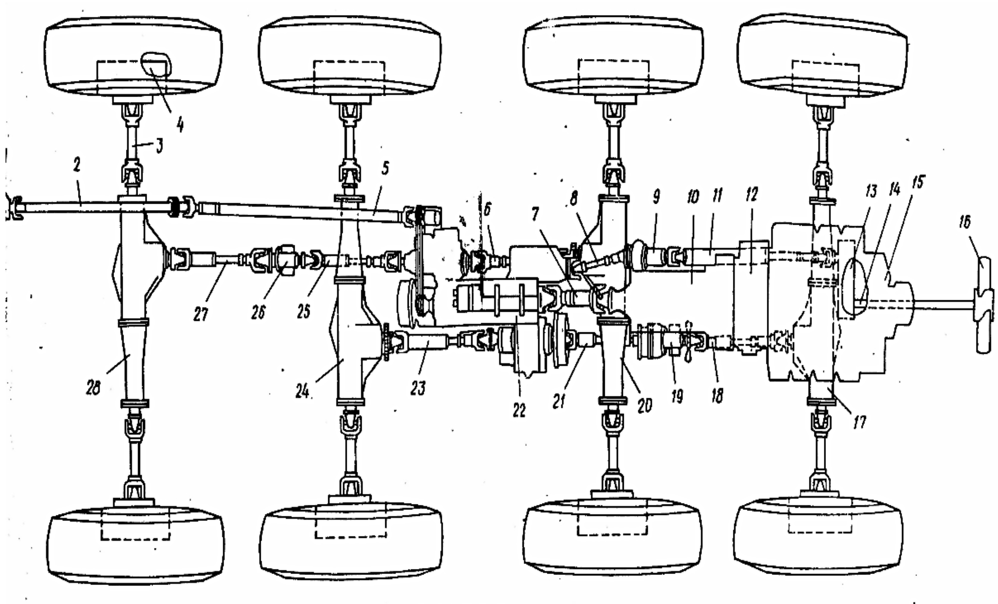

Figure 3.1 power train

(1) Winch reduction gear. (2) Winch drive front universal –joint shaft. (3) Wheel reduction gear unit drive propeller shaft. (4) Wheel reduction gear unit. (5) Winch drive rear universal-joint shaft. (6) Third axle drive propeller shaft. (7) Intermediate propeller shaft. (8) Hydrojet drive front propeller shaft. (9) Hydrojet propeller shaft pillow block (intermediate support). (10) Gear box. (11) Hydrojet drive rear propeller shaft. (12) Clutch. (13) Hydrojet gear unit. (14) Propeller screw shaft. (15) Engine. (16) Propeller screw. (17) Fourth axle. (18) Front axle drive rear propeller shaft. (19) Fourth axle propeller shafts pillow block. (20) Third axle. (21) Fourth axle drive front propeller shaft. (22) Transfer. (23) Second axle drive propeller shaft. (24) Second axle. (25) First axle drive rear propeller shaft. (26) First axle propeller shafts pillow block. (27) First axle drive front propeller shaft. (28) First axle.

The transfer designed to distribute the engine torque between the driving axels, hydro jet and winch and to change tractive force on the driving wheels. The transfer is an inter axle, mechanical, two-step mechanism installed under the the landing party seals and secured on the brackets and longitudinal beam of the vehicle hull through rubber pads. The transfer case consists of upper case and lower case (Fig.3.2).

An inter axle gear – type differential installed on bearings serves to decrease power circulation in the vehicle power train between the third and fourth axles. Driven step - up gear and step-down gear are installed on the differential housing on keys,

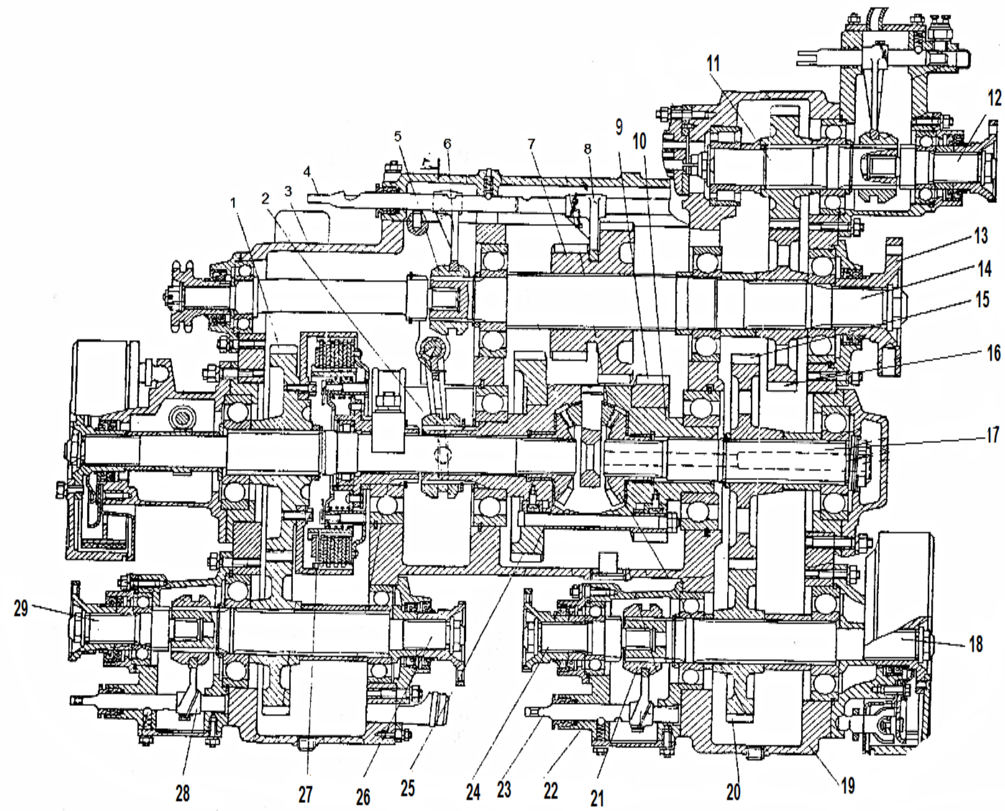

Figure 3.2 transfer gearbox

(1)Front Drive Gears (2)Differential Inter Locking Engagement Coupling (3)Upper Case (4)Gear Shift Fork Rod (5)Winch Drive Coupling (6)Winch Drive Engagement Fork (7)Cluster Gear (8)Gear Shift Rod Fork (9)Step-Up Gear (10)right-hand planet gear box (11)Hydrojet power take-off Shaft (12)hydro jet drive shaft(13)Propeller Shift Attachment Flange (14)Primary Shaft (15)Rear driven gear (16)driven gear Intermediate Shaft (17)rear intermediate shaft(18)2nd ,4th Axles Drive Secondary Shaft (19)Lower Case (20) Driven Gear (21)2nd Axle Engagement Coupling (22)2nd Axle Engagement Mechanism Case (23)2nd Axle Engagement Fork Rod (24)2nd Axle Drive Shaft (25) Step-Down Gear (26)1st& 3rd Axles Drive Secondary Shaft (27)Friction Clutch Driving Drum (28)1st Axle Engagement Fork (29)1st Axle drive Shaft.

differential interlocking engagement coupling is installed on the splines. The coupling motion is limited in the direction of disengagement by the retaining ring. The differential output shafts are front intermediate shaft and rear intermediate shaft bearing upon the inner splines of differential axle shaft gears and bearings in the case walls. The axle shaft gears bear upon the differential boxes through bronze bushings with thread providing oil circulation. Driving gears of axle drives are installed on the splines of intermediate shafts. Speedometer drive driving gear installed on the front end of intermediate shaft. The driving gear is engaged with driven gear located in the speedometer drive cover. The shaft front end also serves for support of the rear parking brake drum.

The friction clutch driving and driven plates are installed on the toothed rims of friction clutch driving drum and drives drum and are pressed between the thrust and pressure plates by the effort of fourteen springs.

Driving gears are in constant meshing with driven gears and installed on the splines of secondary shafts. The front splinted ends of the secondary shafts carry front axles coupling. The splinted end of the rear secondary shaft serves for a support of parking brake drum.

Upper cover with winch drive rods coupled with the gear shift forks mounted in it is installed on the case upper half two centering locking. The gearshift mechanism locking device retainer lock is installed in the hole over the retainer-ball of the gearshift rod. The front axles engagement mechanisms consist of case and a drive shaft, rod and gearshift fork arranged in it.

The winch power take – off is carried out form primary shaft via winch drive shaft. The splines of the front end of the drive shaft carry the driving sprocket of the winch chain drive.

The hydro jet drive power take –off is carried out from the transfer driving shaft connected with power take –off driven shaft by gears .

The rear end face of the transfer case upper half boss mounts the hydro jet drive engagement mechanism. This mechanism consists of a case, shaft, rod, and fork. The hydro jet drives engagement mechanism has a sending unit of the hydro jet engagement indicator.

The engine torque is transmitted through the gearbox to primary shaft of the transfer (fig 3.2) and further via cluster gear to one of the differential gear. Through axle shaft gears, the torque is transmitted to intermediate front and rear shafts, then to drive and driven front and rear gears and to secondary shafts, from front secondary shaft, the torque is transmitted to the third axle and from rear secondary shaft, to the fourth axle.

The front axles are engaged and disengaged by shifting rods, forks, couplings which engage the toothed rims of front axle's drive shafts. Both axles are engaged and disengaged simultaneously. To increase the cross-country ability and to preclude wheels slipping on rugged terrain, the interaxle differential interlocking is actuated together with engagement of the front axles. With interlocking engage, interlocking rod turns together with fork which moves coupling onto the splines of the friction clutch driving drum hub. In this case, the differential housing is locked with intermediate shafts and the differential does not operate.

The friction clutch is provided in the transfer to preclude overloading of the propeller shafts, driving axles and wheel reduction gear units. When the differential is unlocked friction clutch driving drum rotates together with driven drum secured on the axle drive front driving gear. When the differential is locked the driving is rigidly connected with differential housing by coupling and with driven drum and gear fixed on front intermediate shaft through friction clutch plates. The friction clutch coupling is designed to transmit a certain torque, therefore when one pair of driving axles (first and third or second and fourth) is over loaded the friction clutch plates slip and the interaxle differential operates simultaneously. Shift transfer gears only when the vehicle is motionless and only when the clutch is released. In this case the transfer step-down gear may be selected only when the front axles are engaged. The slots are arranged on bracket rack so that with front axle engagement lever in position corresponding to disengagement of the front axles, the lever latch does not let transfer gear shift lever occupy the position for engagement of the step-down gear.

To engage the step-down gear, proceed as follows:

-engage the front axles;

-release the clutch;

-depress the catch of transfer gearshift lever and withdraw the lever latch from the slot on the bracket rack;
-shift the lever which mentioned above from neutral position forward, release the lever catch and move the lever on until the latch gets fixed on the slot of the bracket rack.

To disengage the step-down gear, proceed as follows:
-release the clutch;
-depress the catch of transfer gearshift lever and withdraw the lever latch from the slot on the bracket rack and shift the lever to this neutral position;
-disengage the front axles.

To engage the step up gear, proceed as follows:
-release the clutch;
-depress the catch of transfer gearshift lever and withdraw the lever catch from the slot on the bracket rack;
- shift the lever to the neutral position backward, release the lever catch and move the lever on until the latch gets fixed in the slot on the bracket rack.[manual of the vehicle]

3.2 Modification of transfer

3.2.1 Cluster gear

The cluster gear of step-up and step-down is mounted on the splines of the driving shaft at the upper half of the transfer case as in Fig (3.3) which shows the section of the cluster gear from fig (3.2)so as to illustrate the position of it. From the existing transfer, the engagement of the cluster gear must be done when the vehicle is motionless and only when the clutch is released. Under certain circumstances the users need to shift the transfer while the vehicle in motion to complete their missions which sometimes lead to damage the cluster gear.

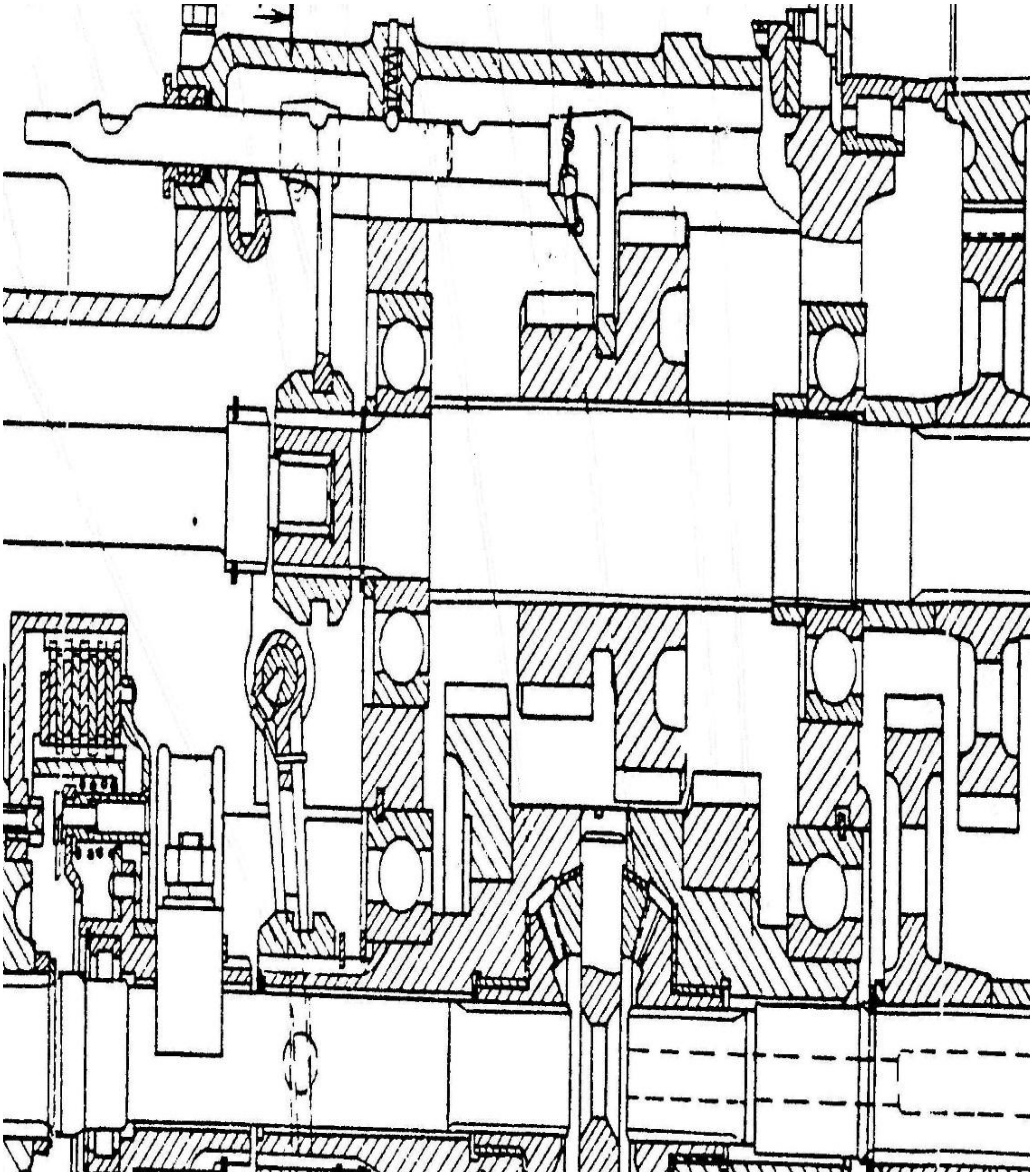

Figure 3.3 study area (section)

3.2.2 Clutch design

Since the shifting the transfer step-down gear may be selected only when the front axles are engaged. To engage the front axle of the vehicle at halt and in motion smoothly we need to modify the way of engagement by adding two clutches between the transfer and the propeller shafts of the first and second front axles.

3.2.2.1 Calculations of clutch design;

To design the clutch we need to know the torque transmitted through it .first assumption of the front axles be done at speed of 3km/hr = 0.83m/s.

Secondly we assume rolling resistance for loose land and from table(1)below. [4]

Total rolling resistance = 2400N/ton

Table (1)

Rolling resistance varies considerably with the type of road surface

Road surface	Resistance N/1000 kg
Rail road	45
Good asphalt	70
Medium asphalt	95
Poor asphalt	125
Wood paving	130
Granite sets	130
Best macadam	195
Ordinary macadam	210 to 260
Soft macadam	415
Wel - rolled gravel	245
Hard dry clay	430
Sand road	1550
Loose land	2400

The weight of the vehicle is (13.6) Ton [manual book]

So total rolling resistance =2400x13.6=32640 N

Power =force x velocity

=32640x0.83=27091Nm

Propeller shaft speed (differential ratio is 4:1(reduction))

The tire type of the vehicle is 1300x18. So tire speed at 3 km/hr is

$$60V \big/ \pi D = 60 \times \frac{0.83}{\pi} \times 1.3 = 12 rev/min$$

Propeller speed=4x12=48 rev/min=5 rev/min

Torque =27091/5=5418 Nm.

Torque transmitted through the clutch to be designed is 1/3 of the torque which calculated so;

T = (1/3) ×5418=1806 Nm

Uniform Pressure

When uniform pressure can be assumed over the area of the disk, the actuating force F is simply the product of the pressure and the area.

This gives

$\boldsymbol{F = \frac{\pi p_a}{4} (D^2 - d^2)}$…………………(1)

As before, the torque is found by integrating the product of the frictional force and the radius:

$$\boldsymbol{T = 2\pi f p \int_{d/2}^{D/2} r^2 dr = \frac{\pi f p}{12} (D^3 - d^3)}$$

Since $p = p_a , from Eq. (1) we can rewrite Eq. (2) as$

$\boldsymbol{T = \frac{Ff}{3} \frac{D^3 - d^3}{D^2 - d^2}}$……………………(2)

It should be noted for both equations that the torque is for a single pair of mating surfaces. This value must therefore be multiplied by the number of pairs of surfaces in contact.

From table (1) friction material for the clutches [mechanical engineering design-by shigly] material of carbon graphite on steel are selected which have; Friction coefficient (dry) f=0.25

Maximum pressure=2100 KPa

By taking D for outer diameter of the clutch plate d for the inner diameter of the clutch plate by changing the value of diameters of the clutch plate (D&d) to choose the suitable clutch plate for this design.

We try first the actual size of main clutch plate of the vehicle D=345 mm, d=200 mm.

To obtain the value of the torque T and compare it with the torque which calculated.

from eq.(1);

$$F = \pi \times 2100 \times \frac{10^2}{4} \times \left[\left((0.345^2 - 0.2^2)\right)\right] = 130338\,N$$

From eq. (2);

$$T = \frac{(130338 \times 0.25)}{3}\ [(0.345^3 - 0.2^3)]/\ [(0.345^2 - 0.2^2)] = 4544Nm$$

The actual clearance between the propeller shafts of the front axles and the body of the vehicle is less than the actual size of main clutch plate the trial of other dimensions for(D&d) done. Let D=200 mm d=110 mm

By substituting the value of D& d in eq. (1)&(2);

$$F = [(\pi \times 2100 \times 10^3)/4] \times [(0.2^2 - 0.11^2)] = 46016\,N$$

$$T = \frac{(46016 \times 0.25)}{3}\ [(0.2^3 - 0.11^3)]/\ [(0.2^2 - 0.11^2)] = 916Nm$$

Another trial; D=220 mm d=130 mm

$$F = \pi \times 2100 \times \frac{10^3}{4} \times \left[\left((0.22^2 - 0.13^2)\right)\right] = 51954\,N$$

$$T = \frac{(51954 \times 0.25)}{3}\ [(0.22^3 - 0.13^3)]/\ [(0.22^2 - 0.13^2)] = 1161Nm$$

Another trial; D= 260 mm d=160 mm

$$F = \pi \times 2100 \times \frac{10^3}{4} \times \left[\left((0.26^2 - 0.16^2)\right)\right] = 69272\,N$$

$$T = \frac{(69272 \times 0.25)}{3}\ [(0.26^3 - 0.16^3)]/\ [(0.26^2 - 0.16^2)] = 1852Nm$$

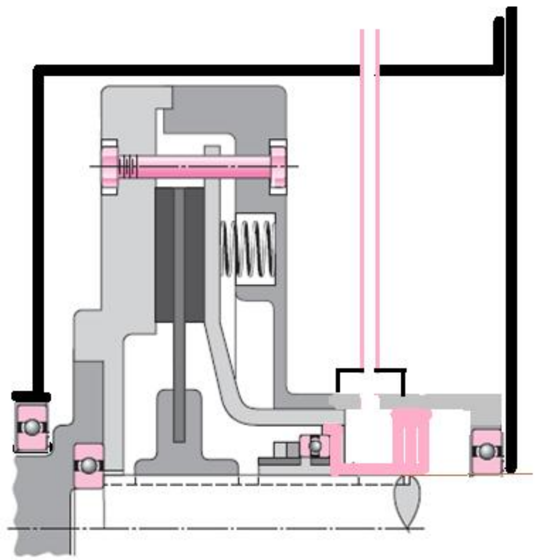

Figure 3.4 clutch design

The design of the clutch done with the diameters (260mm for outer & 160mm for inner) of the clutch plate to transmit the torque of 1852 N for the front axles for the vehicle.

Figure 3.6 show the position of the additional clutches modification

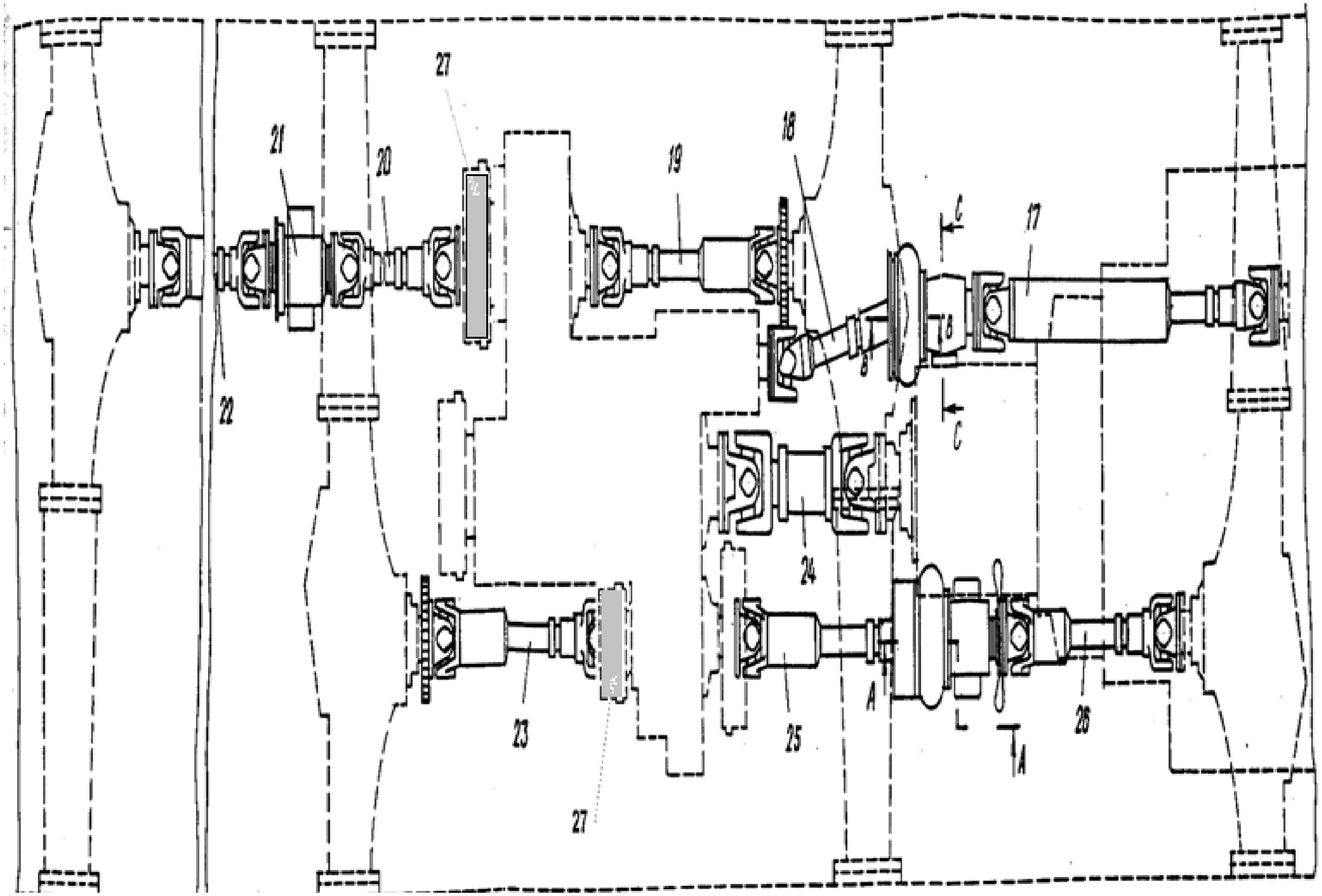

Figure 3.5 additional clutches modification

17-hydrojet rear propeller shaft, 18-hydrojet front propeller shaft, 19-3rd axle drive propeller shaft, 20-1st axle drive rear propeller shaft, 21-first axle propeller shafts pillow block, 22-1st axle drive front propeller shaft, 23-2nd axle drive shafts propeller shaft, 24-intermediate propeller shaft, 25-4th axle drive front propeller shaft, 26-4th axle drive rear propeller shaft,

CHATER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS:

Design of additional clutches fitted to change the way of engagement of the front axles of the vehicle.

4.2 Recommendations:

1. Further work to separate the cluster gear then add a synchronizer to the gears on the drive shaft of the transfer.
2. Modeling this design.

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