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A Review on Design and Development of Modified Differential Gearbox

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Abstract:- *The present study addresses the issues of the differential at the time of different conditions and solutions of every problem by changing its material, design and using another system is done. In this paper the view of every researcher is to improve efficiency by increasing its strength decreasing its weight and by changing its structure either chain differential or spur gear differential. This development of differential improves its efficiency from cracking expired it load acting on it*

Key Words: design, development, chain differential, efficiency, spur gear differential

1. INTRODUCTION

When the vehicle is moving on a road and when it takes a turn both the outside and inside wheel need to travel different distance so here the differential gearbox comes into role. The transmission system used in the vehicle contain a component which is used to transfer power from propeller shaft to both the wheels is called as differential. It is an assembly of gear in an epicyclic train which permit the rotation of two shaft at two different speed, used at the rear side of the vehicle to rotate the wheel faster than the other. The differential is used in two ways, one is that it receives an input and creates two outputs whereas other is that It receives two inputs combined it and gives one output. The differential is located in between the two-rear wheel of the vehicle to rotate one wheel faster than the other. When the vehicle takes a turn, the inner wheel covers less distance than the outer wheel, so it means the speed of inner wheel has to be less than the outer wheel. But when the vehicle goes straight both the wheel rotate at the same speed. To provide both the condition differential gearbox is used.

When the vehicles one wheel is in mud, snow, slippery, potholes or stucked to the obstacle the two problem is that the wheel which is stucked rotates twice the normal speed while the other wheel is stationary. This is due to the wheel which is stucked does have enough traction force acting to the road surface. To avoid this problem the development in the gearbox is to be done and the solution to have differential locking system which provide engagement or disengagement. The design of the differential effect on the failure of the differential. As it makes with the assembly of the bevel gear it is good for taking load of the vehicle. So, the enhance the overall differential and to avoid failure due to loading. The design of such differential gear is given to this paper. Some development of differential is to decrease a weight of the differential by replacing bevel gear with spur gear. So overall design and development to reduce the limitations and to increase the efficiency of differential gear is carried out in this paper.

1.1 LITERATURE REVIEW

Author Utkarsh Patil et al. [1] discussed in this paper the transmission system of the vehicle but they mainly focused on the different type of the differential gearboxes. As the vehicle gets stucked in the potholes, mud, slippery road, snow or the obstacle etc. the torque provided to the stucked wheel is more and the vehicles tyre rotate on the same place and does not move forward so to minimize this limitation the authors discussed various modification in the differential gearboxes such as helical gear driven differential, limited slip differential, clutch pack differential, cykro gear differential, electronic controlled differential, belt driven differential, locking differential by centrifugal force etc. this many differentials are designed for special purposes operations and these are unable to eliminate all the limitations so, we can use the combination of it and eliminate the limitation and use in the vehicle for our required operation.

The Author Harsha Bhandaru et al. [2] discussed about the differential gearbox and gearbox to reduce the transmission system using differential gear and he also discussed about various transmission system such as gear array, toroidal CVT, CVT, Lock differential instead of differential.

This all type of differential gears are shown in below figuress. He also discussed about the problems related to the parking faced by the people in the metropolitan areas to solve this he discussed the design in which the wheel directly turns in 90° or we can say in longitudinal axis so that the parking problem in the compact spaces is solved. He also discussed the alternative transmission system components and smart parking system is fabricated friction losses in the transmission components can be reduced by using oil which is used in CVT. The transmission component can be used in the passenger car. The smart parking can be easily implemented in cars.

Fig -1 Planetary Gear System

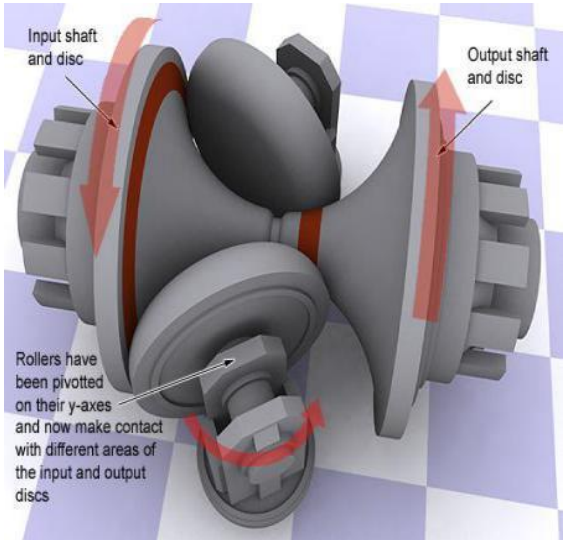

Fig -2 Toroidal Transmission

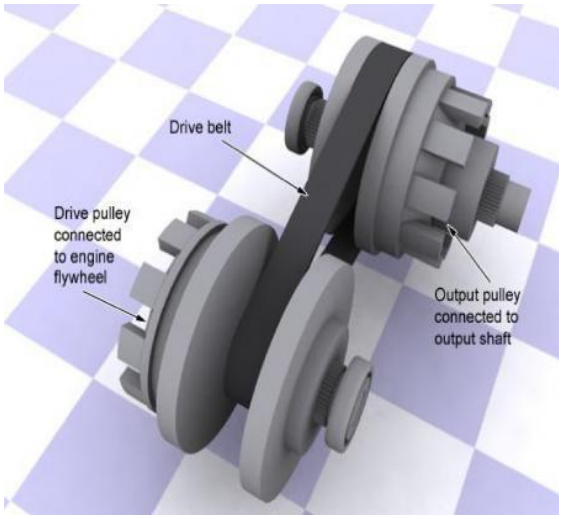

Fig -3 CVT Transmission

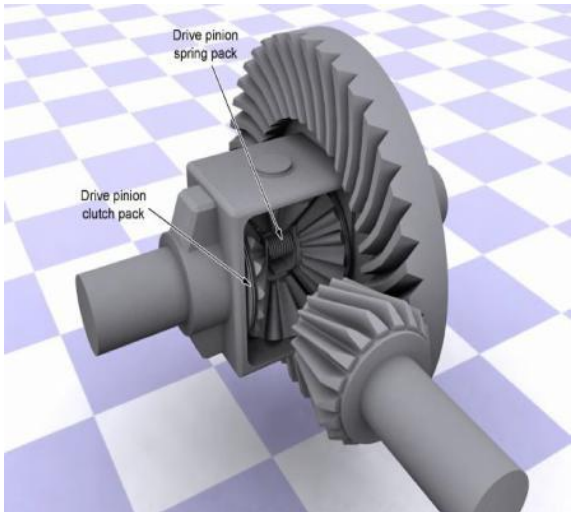

Fig -4 Lock Differential

Bridjesh P et al. [3] proposed that the design, modelling and the structural analysis of chain differential. They found the results using solidworks on the different materials. He analysed the differential stub axle, sprocket and involute bevel gear by aluminium alloy, plain carbon steel and grey cast iron. They observe the stress, strain and displacement value and concluded that the aluminium alloy is safe for differential body, grey cast iron for sprocket and for the gear steel is the safe material.

Chandrakant Singh et al. [4] gives the information about vehicle differential system. When one wheel of the vehicle is stucked in the snow or mud and does not have enough traction i.e. stationary then the other wheel rotates twice its normal speed, so he studied and gave the solution of it by introducing differential locking system which is sensor based. Sensor senses the difference in speed of the vehicles wheels and locks the differential so that the wheels have same traction. This mechanism produces a stabilization force acting though the rear axle, that resist a vehicle rotation. In this paper the differential is going to locked and the shifter mechanism used to move dog ring engage both wheel shaft with drive and equal power is given to the both.

The Author Silvia Medvecka-Benova et al. [5] discussed and have done optimization of the differential heavy truck without a wheel reduction. The unique constructions concept solution has a heavy truck because the distribution of the drive torque is placed in the central distribution tube, as shown in Fig. 5 The modified differential gearbox consists of the Axial axle, bevel pinion, Bevel gear, half axle, Drive shaft of the rear axle, Ring gear, Internal ring gear etc as shown in fig. 5 & fig. 6. the modified differential gearbox is cylindrical type. By doing the analysis the author found that the result that the original differential gearbox there was increased stress with the value exceeding the yield strength of the material gearbox in the place of the notch at the head of the gearbox, so by modification of the differential gearbox the value of the stress will be reduced at the notch by 34% and

this is adjusted gearbox is useful for larger load carrying vehicles such as heavy trucks.

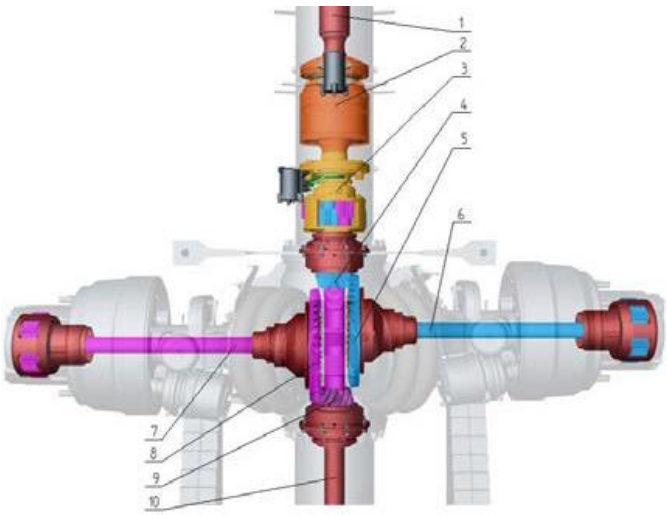

Fig -5 Distribution of the drive torque to the axles

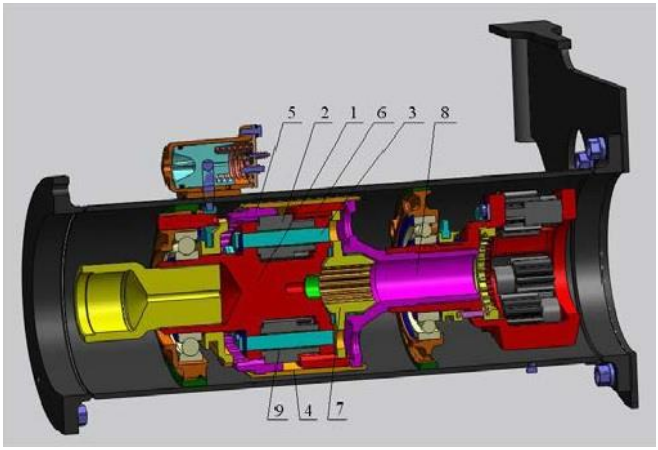

Fig -6 The basic centre differential in the rear-axle tube

Joseph Gerald et al. [6] give the idea about the light weight spur gear differential system by introducing a spur gear at half shaft of the vehicle which transmit the power to the wheel. The carrier is mounted on the propeller shafts which rotates the pinion in opposite direction. This pinion is connected to the half shaft of the vehicle which rotate in the same direction as propeller shaft. These differential claims 30% lighter than the bevel spur differential and 70% free space available because of its slim design for this reason it increases efficiency and reducing the cost compared with others conventional differential. This is used for light duty and commercial vehicles.

Gregory Antoni et al. [7] discussed in thus paper about various mechanical losses in differential gearbox. In differential gearbox friction losses is the major problem it damages the surface of the gear tooth. The friction loss is developed because of the lack of lubrication between mechanical element or by defect in the gear design. He discussed on the friction losses occurred using various relationship graphs. In order to test the influence of these parameters and determine the ability of model to predict any mechanical losses a sensitivity analysis was conducted using numerical approach and experimental study he calculated realistic values for some parameters.

The Author Amir Khan et al. [8] discussed about the four-wheel drive. It cannot work without central differential. They studied the phenomenon of windup which is there in small difference in between front and rear wheel produce extra torque applied across the transmission. This case study is for Maruti Suzuki Zypsy. It transfers torque ratio 50:50 for front and rear axle but the torque develop by engine should ratio 60:40 which is ideal ratio for better handling. So, it need to replace gearbox to modified central differential having two different side gears. FEM method is used for analysis and creo-2 is used for calculating design. They concluded that modified central differential is better is better than transfer gearbox.

C Veeranjaneyulu et al. [9] discussed and studied on the on the design and analysis of differential gearbox. They analyse using different material such as cast iron, cast steel and aluminium alloy. The design is done with help of the cosmos software which is used for the finite element method to stimulate the working condition of design of design and it also predict the behaviour of the material. From this paper he concluded that aluminium alloy has the stress value within the permissible limit. So aluminium alloy is safe for differential gearbox. After comparing stress value for speed, they concluded that the value of permissible stress of aluminium alloy is less than the other material. They also observed the frequency analysis of the material. The vibrations are less in the aluminium alloy rather than the other cast iron and cast steel. They concluded that aluminium alloy has three times reduction in weight than other two material which increases the mechanical efficiency of the differential so aluminium alloy is the best material used for it.

Nitin Kapoor et al. [10] design and developed a model of differential gearbox with a material of glass filled polyamide composite material by using CATIA-V5 under the different speed and static loading condition. The stress and strains result of glass filled polyamide composite and metallic materials. glass filled polyamide have the better tensile strength, recyclability, low density, high creep resistance fatigue strength, low von-misses stress, less friction and low cost. by relating composite material different gearbox with conventional it is found to be stress and strains are lower for the composite material which increases mechanical efficiency.

G. Shrikant Reddy et al. [11] designed and analyzed the gear assembly in the differential gearbox. the problem of the failure at the contact regions minimized by modifying gear material in static and dynamic condition. This modification was done by using stresses and displacement at the point the material used by them are Ni-Cr steel and steel and compared it in the ANSYS workbench. So, they got that Ni-Cr steel is the best material in differential gearbox manufacturing as it gives

high strength also the material Ni-Cr has long life compared to steel.

1.2 MATERIALS & METHODS

Design is trailed by researcher by using software's such as CATIA-V5, Solidworks, Creo-2, MATLAB, Ansys. The design and analysis were done on different materials like aluminium alloy, cast iron and cast steel, grey cast iron, glass filled polyamide using these software's and by analytical method they found some final results. Development was done using spur gear in the place of bevel gear, chain and sprocket, different modification in differential gearbox, transmission system, different steering mechanism and sensors instead of ordinary differential gearbox.

2. DISCUSSION

The material used for body of differential gearbox should be aluminium alloy as it reduces the weight and the gear should be made up of steel due to its strength. In the development of modified differential gearbox different system can be used. Till now the differential used to take one input and two outputs but by modifying and adding one extra bevel gear adjustment on crown wheel we can take one input and three outputs. And by analyzing using different materials we can modify differential gearbox having three outputs. Also, there are various special purpose differential gearbox but individually they cannot overcome all the limitations so we can use the combinations of these special purpose differential gearboxes and reduce the limitations to some extent.

3. CONCLUSIONS

i. Use aluminium alloy for body of differential gearbox as it has low weight and high permissible strain, stress values as compared to other materials.
ii. Use spur gear differential instead of bevel gears as it is 30 % lighter than the bevel differential as it reduces the cost and increases the efficiency. It also releases the space upto 70% as it makes the differential slim. Due to this the Go Green concept is implemented.
iii. The use of composite materials like glass filled polyamide having better tensile strength, recyclability, less friction and low cost increases its mechanical efficiency.
iv. Using combination of various special purpose differential gearbox, sensors and different steering mechanism the day to day parking problems can also be solved

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