

Advance Differential Gear Backlash Measurement Sensor System

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Abstract: In today's generation everyone loves speed power and torque, especially when it comes to the heavy duty vehicle the power and torque is most important factor which costumer demands. But this power and torque can't be permanent in the heavy duty vehicle, as they are subjected to the heavy load application, the transmission losses starts in the early years, and these transmission losses leads to wear and tear in other mechanical component. So to avoid these failures something has to be done for better interaction between the component and the user. These transmission losses usually start with the removal of material from the gear teeth or the differential gear. So keep the record of removal of material from transmission something has to be done, and we come up with the solution for this problem. We have made the sensor attached along with the gear and the differential gear that keep the record on the removal of material. This system allows the user to understand when to change the transmission system or the differential gear box by giving the signals in form of light on the dashboard.

Keywords: Differential Wear Measurement, Wearing Measurement Sensor, Gear Tooth Backlash Sensor, Differential Bevel Gear Tooth Wear.

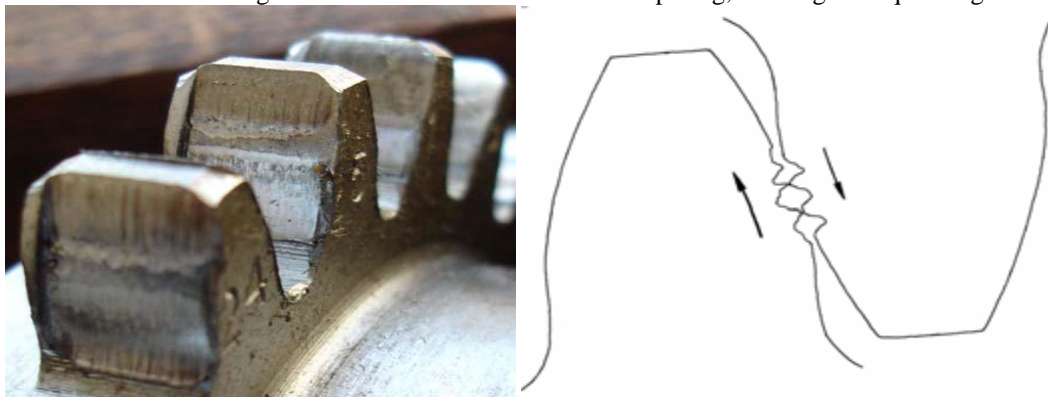
Date of Submission: 11-03-2019

Date of acceptance: 27-03-2019

I. Introduction.

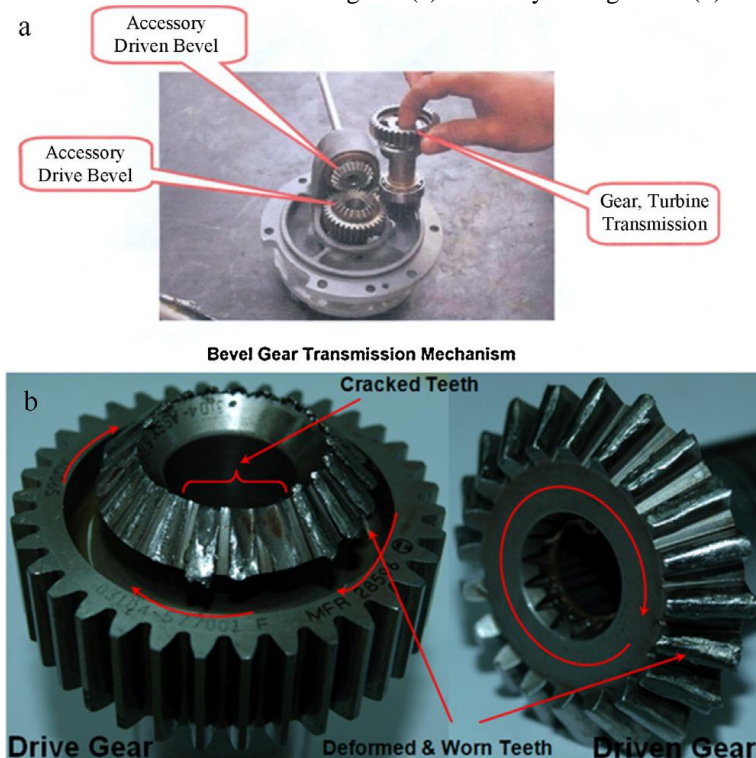
In today's world there is very less number of population which takes very good care of their vehicle, their harsh driving and the thrilling skills give them the amazing experience but the impact on the gears and the transmission system is beyond the imagination of the normal user. The transmission system, differential and the gears faces the wear and tear due to the thrilling experience demanded by user. The heavy duty vehicles runs on the rough surfaces, loose gravel roads, mostly constructional and the deconstruction sites, on these surfaces they require the lot of traction and this leaves the huge impact on the transmission system and its failure. This transmission failure is directly related to the type of usage of the vehicle. As we know that the differential has many advantages, those few gears inside the differential box makes run the vehicle stable during the traction. Let's take an example for better understanding, there is the truck which is subjected to heavy loads in everyday use, the differential gear box and other gear components can't be regularly opened and checked, so due to the heavy load and the rough usage on uneven tracks or snowy roads there are issues faced by the gears and other equipment. In recent days the maintenance has become a big problem as no one takes their vehicle for maintenance on the allotted time and date, so these issues should be delivered with the solution. This system helps the driver by indicating him with the removal of material and wear and tear in the gear and differential by indicating the signal in form of light on the dashboard. The working of this system very simple, this doesn't include lots of components. The best part is this device doesn't have any disadvantages. A combination of different kinds of teeth wear, with very intensive metal losing (weight reduction), is progressive teeth wear. Intensive teeth scoring at the beginning of the work eliminates flank surface roughness and makes a very smooth flank. At the same time, this process eliminates micro pitting between the roughnesses. The pitting process is disturbed and the fatigue stress cycles number for high stresses is higher in comparison with clean pitting (compare diagrams in Figure 5). For the lower stress levels, the fatigue process needs higher stress cycle's numbers. By pitting relished surface particles, makes damage process more intensive (scuffing) in comparison with pitting. This is a combination of pitting and scuffing which wears more material from gear flanks. A hardened layer can be partly or completely eliminated. The soft teeth inside the material and roughness made by pitting and scuffing are liable to squeezing, especially in the area of high stresses. [1]

FIGURE 1. Progressive teeth wear – combination of pitting, scuffing and squeezing



The motor rotor transmits power to the tool through the bevel gear installed on the accessory case; in the initial state, the starter transmits power to the rotor motor. The bevel gear on the opposite path. bevel gears, due to the manufacturing and installation errors, impact of movement, sliding friction, alternating circulation bending stresses and other factors, bevel gears can produce metal fatigue on the teeth surface and cause superficial tooth wear, pitting, sticking, peeling and other superficial tooth damage, the precision of the bevel gear movement and the stability of the work generate vibrations and noise, reduce the service life of the bevel gear. Bevel gear, the tooth of the broken bevel gear transmits the problem, stopping work of the motor [2, 3]. Therefore, study and analyze the mechanism of breaking surface damage of bevel gear teeth, develop the process of improvement measurements, it is very important to avoid the transmission error of the gearbox. The deformation of the teeth from the ground is due to the sliding action of the driven pinion. It was also the gear tooth severely worn and deformed in the opposite direction of rotation, but no fracture of the tooth has been observed. The extension of the damage to the fracture was greater in the driving gear than in the driven gear where the teeth were worn and deformed due to constraints applied by the generator to the rear. The efficiency of the transmission mechanism to transmit power will decrease when his teeth break and this will facilitate the loosening of the engaged gears which eventually will result in wear of the driven gear teeth rather than total loss.[4]

FIGURE 2. Drive and Driven bevel gears (a) assembly arrangement (b) damage.



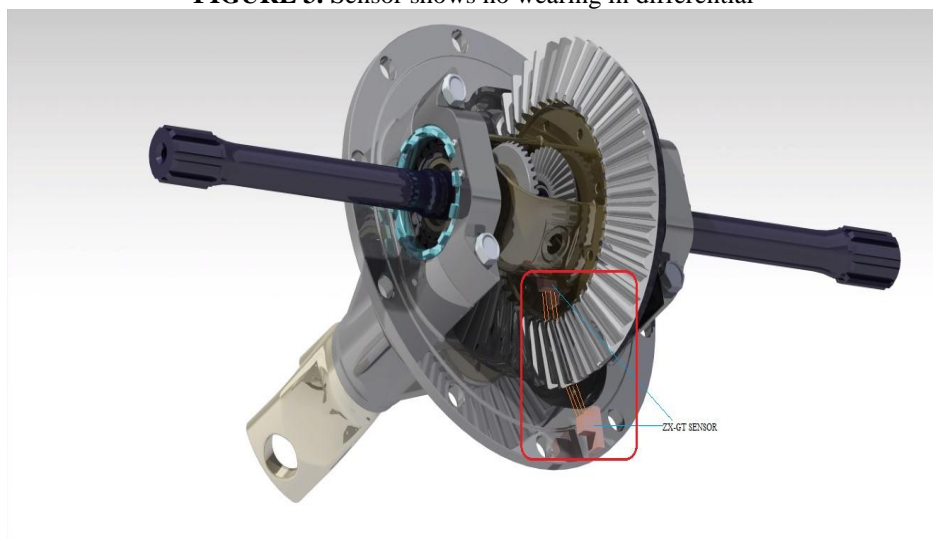
M. Fonte et al [5], a survey on chess analysis of two helical gears of a piped azimuth the helix is executed in this document. The determining the root causes of the damage of the material includes examining the fracture carried out during this research work. In the beginning failure analysis two broken teeth of two helical the gears were kept under observation. At micro-level analysis, electronic scanning microscope (SEM) was used. It is concluded that the failure was caused by the surtax located on the surface of the tooth. With the observation, it is concluded that the beginning of the fatigue crack started at the root of side of the tooth side of the gear, followed by the Growth and final fracture. Failure mode for both gears, it's clearly the same. In assistance with poor lubricating oil performance in a change, a continuum Thrust overload is also the main root cause of this failure. Inappropriate lubrication has caused strong contact constraints the gear teeth were clearly analyzed at the SEM. The premature failure also gives evidence of a possibility of misalignment between the gables and the gears.

S.K. Bhaumik et al [6], the survey of the failure analysis performed on a helicopter that caught with an accident. The reason has been found it was the failure of an intermediate change. The examination showed that the driving mechanism was fractured due to the fatigue that finally breaks with leads to a gearbox failure. The teeth of the march have been severely damaged. This type of damage occurs only in hardened material under severe conditions load. His demonstrations show that this is due to chipping. The observation at the micro level reveals that there was more than an initiation of fatigue crack at the tooth level root regions. Incorrect assembly also the misalignment of the shaft of two gears lead to tooth breakage and, finally, to failure of the march. As a result, the shape of the teeth varies continuously due to wear of the teeth over time. This results in the modification of the geometrical parameters of the gear and changes in the level of wear of the teeth [7]. This process is a continuum with a different intensity of time throughout the life of the gear train. Gears use the majority of all types of gear; the process of 3D measurement of cylindrical gears thus becomes a persistent objective [8]. Current methods of measuring gears are long or expensive.

II. Methodology

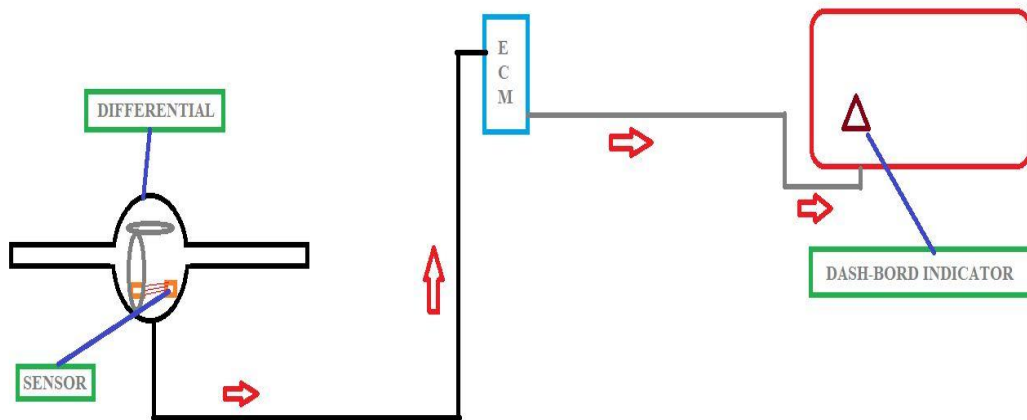
We have designed the system for mainly trucks and heavy duty vehicles as they face more of this problem. As we know the differential gear box comes with few sets of gears which include bevel gears. The power is transmitted to the differential from the propeller shaft; this propeller shaft delivers the power to the bevel gear assembly. In bevel gear assembly the crown gear is rotated with the propeller shaft, now heavy vehicles are subjected to the all road and weather conditions that require lot of traction, this differential distributes the power equally to both the wheels during such conditions and make the vehicle stable. Due to lot of traction there is removal of material from the crown gear, as the crown gear has most of the load acting on it. This leads to the wear and tear to the differential assembly resulting to the gear failure.

FIGURE 3. Sensor shows no wearing in differential



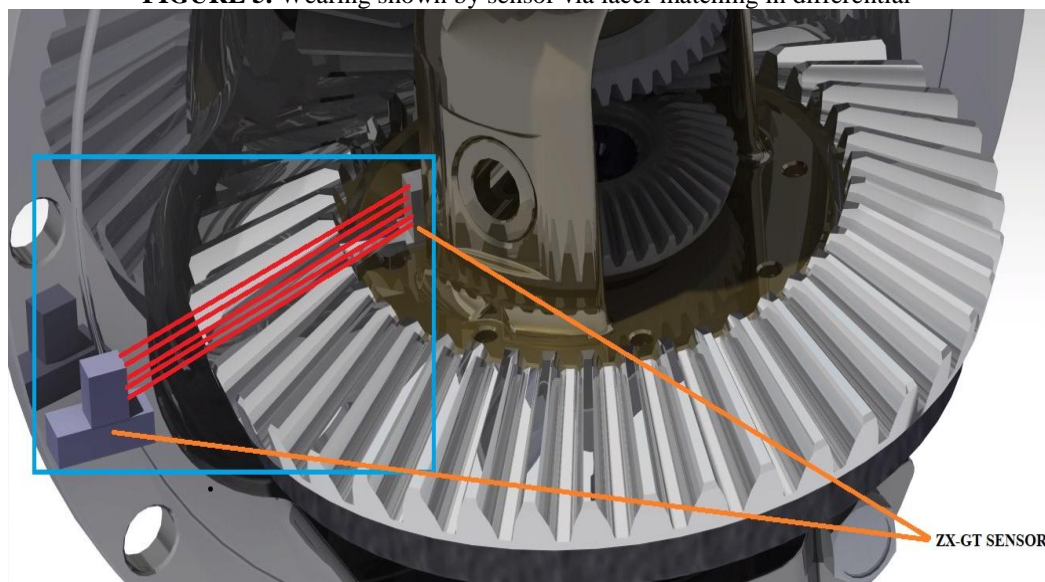
This gear failure can lead to the dangerous situation, so how to keep check on this wear and tear. Here comes our system which is equipped with the laser and sensor to keep the check on the wearing part in the gear, this laser sensor is mounted inside the differential and fixed around the crown gear wheel as shown in the figure below. When there is no wear and tear the laser doesn't match with each other and this makes the signal break and the ECU does not display the signal on the dashboard. These lasers are mounted in front of each other to match and send the signal to the ECU.

FIGURE 4. Circuit of differential gear backlash measurement sensor system





As seen in the first image the laser does not match each other, as there was no wear and tear. After long use the removal of material starts and this removal of material are allowed only up to certain limits, as if it exceeds the limit then the failure will happen. So what this system does is the laser which was not matching with each other now they start to match due to the removal of material. Before there was some material between the lasers which was preventing them to match but as of now after the removal of material will allow the laser to match and the signal will pass to the ECU and the light will display on the dashboard. This is shown in the second image, as you can see the lasers are matching due to the removal of material. Due to this amazing innovation the wearing can be measured and the failure can be prevented by sending the signals to the driver and the precautions can be taken before the damage.

FIGURE 5. Wearing shown by sensor via lacer matching in differential



As per the functioning of the circuit the laser will always be in on condition and the ECU will wait for the signal from laser to display on the dashboard. As the material starts removing the laser will start matching with each other. After matching of laser the circuit gets complete and the signal reaches ECU, now ECU pass the information of the material removal to the dashboard in form of light blinking. The signal is smart to show the amount of wear and tear and also will tell you the acceptable limits for working condition. After those limits the wear and tear will lead to the failure of the gear and also may lead to damaging other components of the assembly.

a. Sensor specification:

Appearance	Optical system	Measuring width	Sensing distance	Resolution	Output Type	Model
Separate type 	Through-beam	28mm	0 to 500mm	10µm	NPN	ZX-GT28S11
					PNP	ZX-GT28S41
Integrated type 			40mm		NPN	ZX-GT2840S11
					PNP	ZX-GT2840S41

III. Conclusion

This concept can be used in the heavy duty vehicles to create the better understanding between the mechanical components and the driver. This can be implemented in the upcoming heavy vehicles to increase the life of the components. This system is very cheap to install in the current running vehicles. As we know the tractors require lot of traction and they face the transmission losses in the earlier years or in few thousand of kilometers. This innovation will play a major role in increasing the life of the transmission system and the differential gearbox without changing its basic design and working concept.

This is the portable system can be attached externally even after the purchasing of vehicle and the major part of this system is that it has no disadvantages and drawbacks. So this system can increase the efficiency and the life of the components and hence will result in increased overall life of the vehicle.

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Y.Lethwala. "Advance Differential Gear Backlash Measurement Sensor System." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 16, no. 2, 2019, pp. 75-79