

Design and Fabrication of Spur Gear Differential

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ABSTRACT:Differentials play a vital role in automobiles. With the development of manufacturing technology, the potential of a light weight spur gear differential system can be rediscovered. Since the trend today is to GO-GREEN by removing the weight of automobile components. Among many types of differential systems, spur gear differential system is easy to manufacture and simple in operation, when compared to other conventional differential systems. Spur gear differential system refers to a transmission system, which receives input from a prime mover (motor, I.C engine, etc) and distributes it among two outputs, allowing suitable adjustments in their speed according to the needs of the machine, utilizing a gear train mechanism which consists only of spur gears. This paper deals with the design and manufacturing process involved in the components of spur gear differential, the assembly of components and working of the spur gear differential system are also discussed. In addition to this, its applications, advantages and scope for improvement in the future are also discussed.

I. INTRODUCTION

Differential System

Differential is a power transmission device, which distributed power from a prime mover to two or more outputs. These outputs are called **PTOs (Power Take Offs)**. Here transmission usually implies shafts transmitting rotary motion, torque and power. A differential kinematic ally constrains the input speed (N_i) and the output speed ($N_1, N_2, N_3 \dots$ etc.) to satisfy an equation of the form

$$N_i = aN_1 + bN_2 + cN_3 + \dots$$

where a, b, c ...etc. are constants. This governing equation defines the behaviour of the differential and is use for determining it's suitability for any particular application.

The differential serves three purposes in automobiles:

1. To aim the engine power at the wheels
2. To act as the final gear reduction in the vehicle, slowing the rotational speed of the transmission one final time before it hits the wheels
3. To transmit the power to the wheels while allowing them to rotate at different speeds.

II. MECHANISM USED IN SPUR GEAR DIFFERENTIAL

A spur-gear differential has two equal-sized spur gears, one for each half-shaft, with a space between them. Instead of the Bevel gear, also known as a miter gear, assembly (the "spider") at the centre of the differential, there is a rotating carrier on the same axis as the two shafts. Torque from a prime mover or transmission, such as the drive shaft of a car, rotates this carrier. Mounted in this carrier are one or more pairs of identical pinions, generally longer than their diameters, and typically smaller than the spur gears on the individual half-shafts. Each pinion pair rotates freely on pins supported by the carrier. Furthermore, the pinion pairs are displaced axially, such that they mesh only for the part of their length between the two spur gears, and rotate in opposite directions. The remaining length of a given pinion meshes with the nearer spur gear on its axle. Therefore, each pinion couples that spur gear to the other pinion, and in turn, the other spur gear, so that when the drive shaft rotates the carrier, its relationship to the gears for the individual wheel axles is the same as that in a bevel-gear differential.

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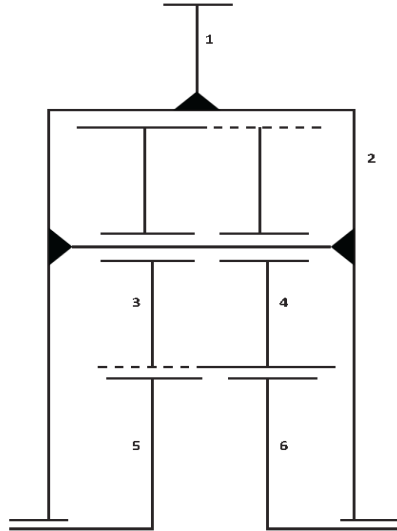
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Components Of A Spur Gear Differential

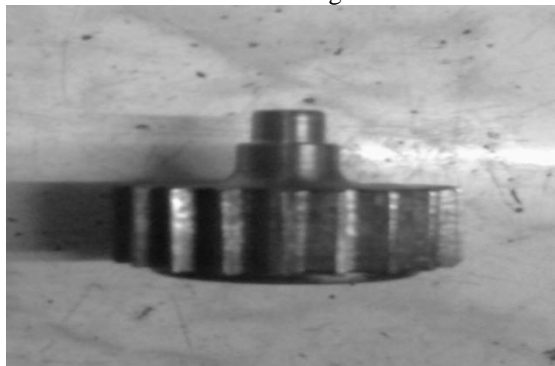
- Output Gears
- Idler Gears
- Idler Shafts
- Casing
- Output Shafts
- Ring
- Frame

Output Gears

Our project uses two output gears of different dimensions. These two gears get coupled together by means of SKF 6000 bearing. Each output gear is machined for one quantity. The images of the two gears is shown below

Output Gear 1

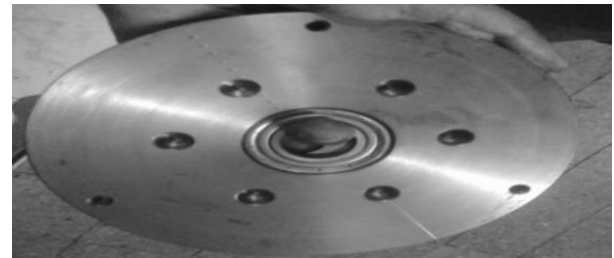
This gear has small projection that has a diameter equal to the inner diameter of the SKF 6000 Bearing. The outer diameter of the gear flange is machined for the SKF 6000 bearing Fit.



Output Gear 1

Output Gear 2

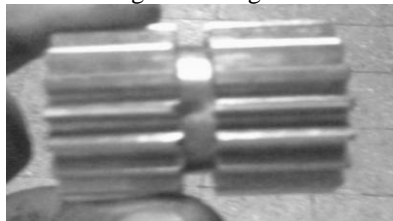
This gear has a step-bore that has the diameter equal to the outer diameter of the SKF 6000 Bearing. The inner Step-Bore diameter is machined for the SKF 6000 Bearing Fit.



Output Gear 2

Idler Gear

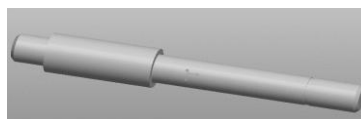
This part is an integral of two gears machined as a single part. This gear will be mounted on idler shaft by means of two SKF 6000 Bearing. The Step-Bore on the both sides are machined to the outer diameter of the SKF 6000 Bearing. The Step-Bore Surface is machined For SKF 6000 Bearing Fit. This gear is machined for 6 quantity.



Idler Gear

Idler Shaft

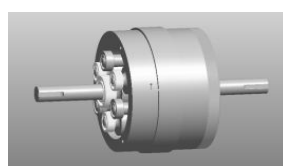
This shaft is where the idler gear is mounted using SKF 6000 Bearings. The long part after the step is where the idler gear is mounted. The outer diameter of the shaft is machined for the SKF 6000 Bearing Fit.



Idler Shaft

Casing

This part is the very integral part of the part. This part has 6 holes of 10mm diameter for 10mm depth on one side. These six holes have a different angular displacement between each other. This part has a central hole throughout the thickness. The central hole has a Step-Bore made of the outer diameter of the SKF 6004 Bearing. The Step-Bore is machined for SKF 6004 Bearing Fit. This part is machined for two quantities.



Casing

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Output Shafts

This shaft is the output of the differential. Spur Gear Differential has two output shaft of equal dimensions. The output gears, after coupling together by SKF 6000 Bearing is keyed to the two output shafts by means of 8*7 key. This part is machined for two quantities.



Output Shaft

Ring

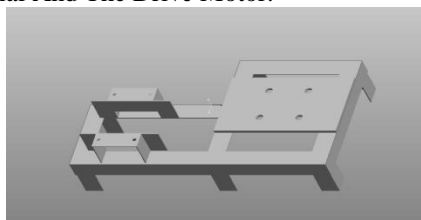
This part is the cover for the six idler shaft and output gear set this part is held between the two casings and is bolted. The holes on either sides are ensured to have same axis line for the alignment of the holes in the casing. This part is machined for one quantity.



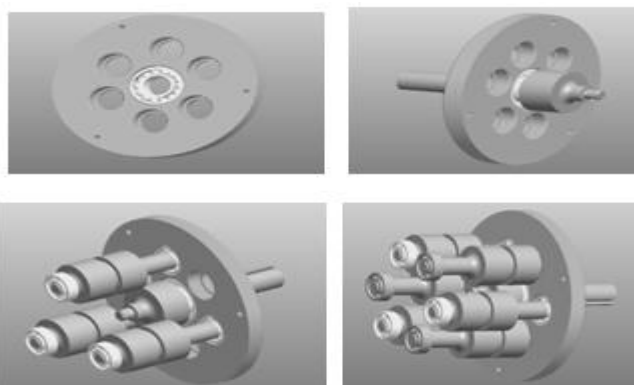
Ring

Frame

The Frame For The Mounting The Spur Gear Differential And The Drive Motor Is Welded Using Arc Welding Process. The Angle Section Used Here Are ISA 5050 Of Thickness 3mm. The Figure Above Represents The Frame Along With Spur Gear Differential And The Drive Motor.



III. ASSEMBLY OF COMPONENTS



Casing

This picture shows one of the casings used in spur gear differential with six holes made for idler shafts to hold and there is a centre hole for the outer shaft. Casing With SKF 6004 Bearing Fixed At Centre To Hold One Of The Output Shaft. Then Casing With SKF 6004 Bearing Holding One Of The Outer Shafts, Casing With One Of The Pair Of Idler Shaft Held At One Of The Hole. Casing With One Full Set Of Idler Gear Along With An Output Shaft, Casing With Full Set Of Idler Shaft Fixed With Bearing SKF6000. Casing With Idler Gear Fixed In Their Respective Positions And With Another Output Shaft Fixed To Another Output Shaft With Bearing SKF 6000. With Inner All Parts Assembled So Ring Part Is Set At Center And Open End Shown Will Be Closed By Another Casing.

Assembled View Of Spur Gear Differential



IV. WORKING

In spur gear differential, the input is given to the casing ring. Two outputs are obtained from two shafts on either side. The input and output shafts are parallel to each other and output shaft along the same axis. Under equilibrium conditions the sum of output torque is equal to the applied input torque.

Let,

T_i is the applied input torque.

T_1 and T_2 are the torque transmitted by the shafts.

Then, under equilibrium condition,

$$T_i = T_1 + T_2$$

The idler shaft maintains the torque balance.

When $N_1 = N_2$, the idler gears are stationary with respect to casing.

Advantages and disadvantages of a spur gear differential

Advantages

- Light weight
- Compact
- Low inertia
- Lower bearing reactions, and hence casing is less bulky.

Disadvantages

- **Noisier:** This can be improved by using helical gears.
- **Number of components:** The number of gears in a SGD is more than that in any usual differential.

V. SCOPE FOR FUTURE DEVELOPMENT

A slim design of spur gear differential for passenger cars, which it claims is 30% lighter than its predecessors, Compared with the original bevel spur gear differential, it saves up to 30 per cent in weight and creates up to 70 per cent free axial space because of its slim design. Certain qualities must be evaluated on an individual basis in order to ensure continued, effective and safe gear differential operation.

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In absolute terms, this means up to three kilograms mass reduction for each differential and up to 90mm of extra space in the gearbox. With certain design modifications, this type of differential can also be used for heavy duty vehicles. A slim design of gears facilitates weight reduction as well as increases its efficiency.

VI. CONCLUSION

Therefore all the parts were designed using conventional design procedure and their part diagrams were developed using AUTOCAD and PROE software. The fabrications of parts were done in lathe, gear cutting machines. Therefore spur gear differential system can be even more optimized for weight thereby increasing the efficiency and reducing the cost when compared to other conventional differentials used. This type of differential system can be used for light duty and commercial vehicles.

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