International Journal of Scientific Research in Computer Science and Engineering

Research Paper
Volume-1, Issue-2, March- April-2013
Available online at www.isroset.org

ISSN No. 2320-7639

Cost Analysis of Differential Bevel Gear

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***Abstract*-In this paper we have selected the best cost saving manufacturing process to produce straight bevel gears without any compromise with quality parameters, and then validate the samples taken from vendor as per our design requirement. and to increase Durability & Productivity of Straight Bevel Gears. Precision forging process is select to produce differential straight bevel gears because it reduces the cost/gear approx. 30% on existing machined gears and also improves strength or increase the gears life by approx. two times. To validated we have used tractor as a testing equipment and validate the gears to our design specification.**

Key words*- *Straight Bevel Gear, Spiral Bevel Gear Circular Pitch, Pressure Angle, Pitch Diameter, Tooth Parts.

INTRODUCTION

*Bevel Gear:*Bevel gears are primarily used to transfer power between intersecting shafts. The teeth of these gears are formed on a conical surface. Standard bevel gears have teeth which are cut straight and are all parallel to the line pointing the apex of the cone on which the teeth are based. Spiral bevel gears are also available which have teeth that form arcs. Hypocycloid bevel gears are a special type of spiral gear that will allow nonintersecting, non-parallel shafts to mesh. Straight tool bevel gears are generally considered the best choice for systems with speeds lower than 1000 feet per minute: they commonly become noisy above this point. One of the most common applications of bevel gears is the bevel gear differential,

*Functional Description of differential:*Power is supplied from the engine, via the gearbox, to a driveshaft, which runs to the drive axle. A pinion gear at the end of the propeller shaft is encased within the differential itself, and it engages with the large *crown wheel*. The crown wheel is attached to a *carrie*r, which holds a set of three-four small planetary straight bevel gears. The three planetary gears are set up in such a way that the two outer gears (the side gears) can rotate in opposite directions relative to each other. The pair of side gears drive the axle shafts to each of the wheels. The entire carrier rotates in the same direction as the crown wheel, but *within* that motion, the side gears can counter-rotate relative to each other. Thus, for example, if the car is making a turn to the right, the main crown wheel may make 10 full revolutions, and during that time, the left wheel will travel more revolutions because it has further to travel, and the right wheel will travel fewer revolutions correspondingly, as it has less distance to travel. The side gears will turn in opposite directions relative to each other by, say, 2 full turns each (4 full turns with regard to each other), resulting in the left wheel making 12 revolutions, and the right wheel making 8 revolutions. When the vehicle is traveling in a straight line, there will be no differential movement of the planetary system of gears other than the minute movements necessary to compensate for slight differences in wheel diameter, undulations in the road (which make for a longer or shorter wheel path), etc.Input torque is applied to the Crown wheel, which turns the entire carrier (all Blue), providing torque to both side bevel gears (red and yellow), which in turn may drive the left and right wheels, if the resistance at both wheels is equal, the planet gear (green) does not rotate, and both wheels turn at the same speed.

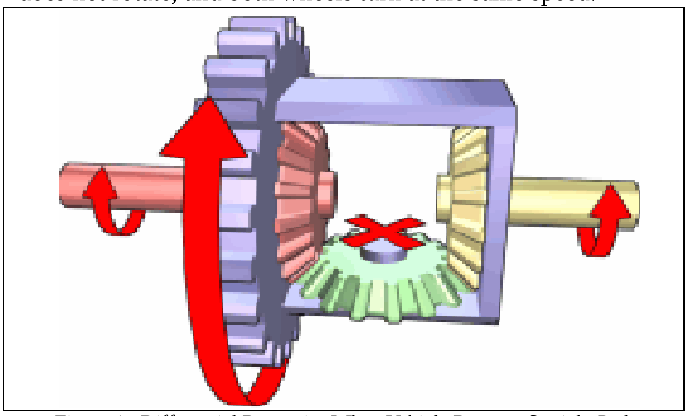

Figure 1 : Differential Dynamics When Vehicle Runs on Straight Path.

If the left side gear (red) encounters resistance, the planet gear (Green) rotates about the left side gear, in turn applying extra rotation to the right side gear (yellow).

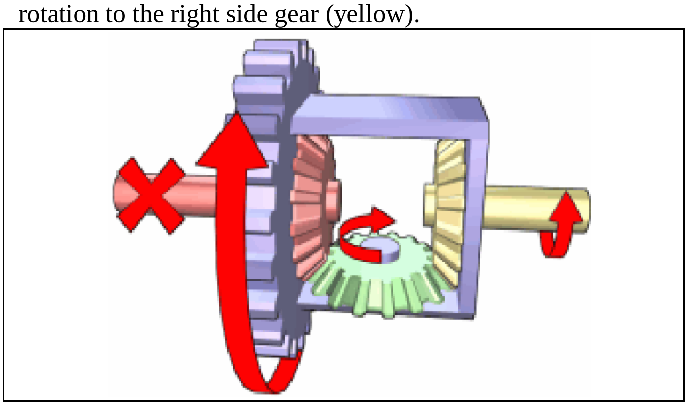

Figure 2 : Differential Dynamics When Vehicle Takes Turn.

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Comparison betweenMachining Processv/s Precision Forging Process

In Precision forging process Blank forging and tooth cutting operation is not required and it saves time as well as costaprrox 30% to existing cost which is shown in Figure below.

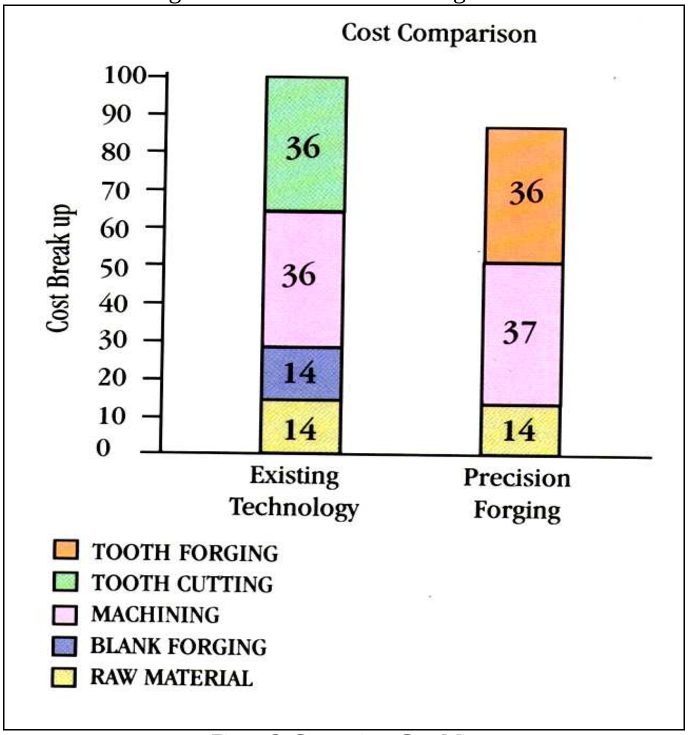

Figure.3: Comparison Cost Wise

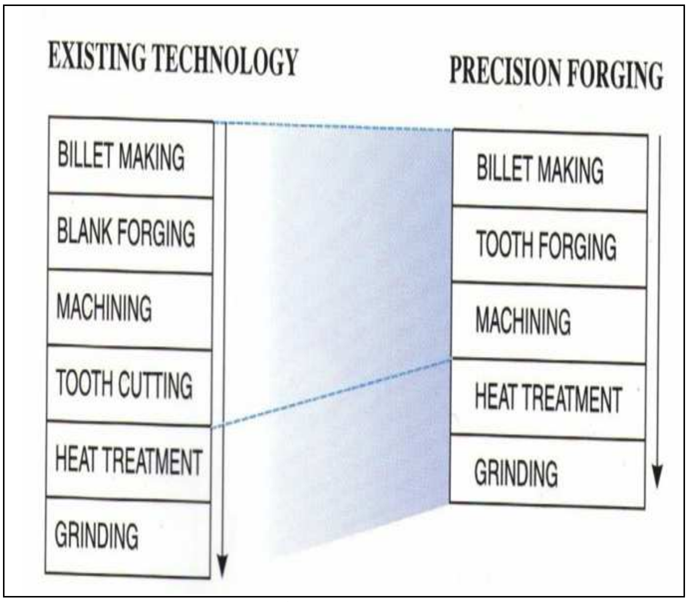

Figure.4: Comparison Process Wise

Advantages by Adopting Precision Forging Process In Place ofMachining Process

Less Material Precision forging conserves gear materials because tooth spaces need not be machined away. Moreover, tighter forging tolerances on all other gear surfaces minimize or eliminate the need for finish machining.

For instance, consider a finished straight bevel gear that weighs 0.82 kg. In a conventional tooth cutting process, such a bevel gear must be machined from a forged blank that typically weighs 1.59 kg. A significant amount of material, however, can be saved if the gear is precision-forged to near-finished dimensions. A precision-forged gear weighs only 1.08 kg, which amounts to a 32 % material savingswhen compared to the gear blank. It follows that less material must be removed from the gear with forged teeth to complete the production process.

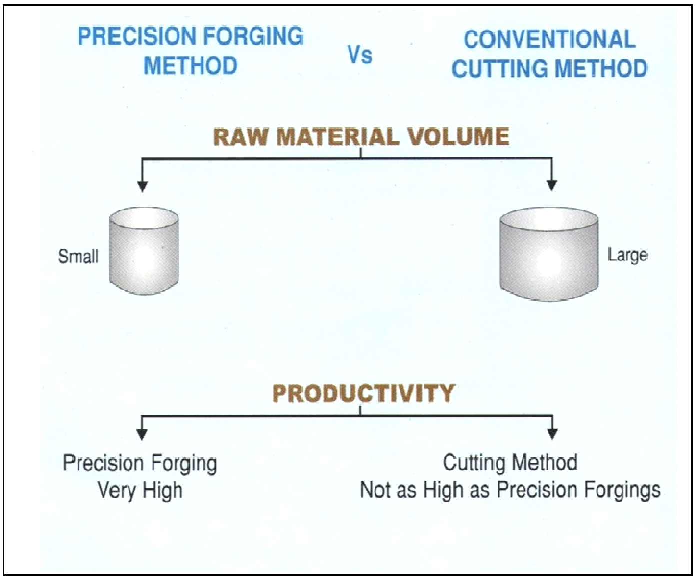

Figure 5: Raw Material & Productivity

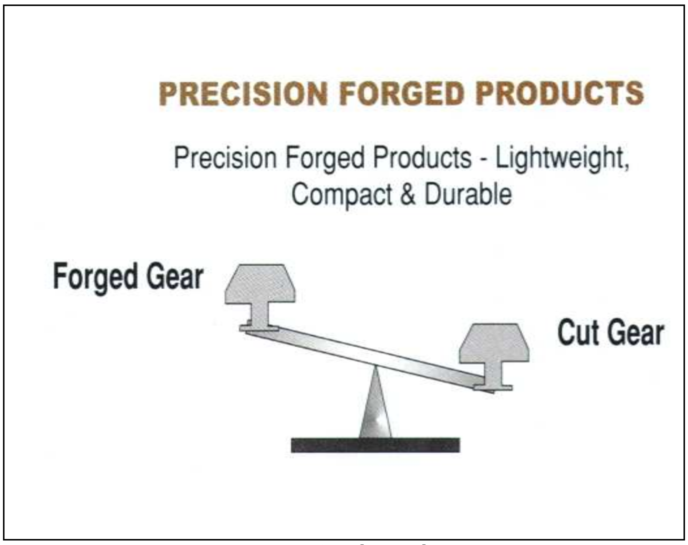

Figure.6 Light weight

More strength The bending strength of forged gears improves to 20 % to 30 % for forged teeth, compared to cut teeth. It is believed that such strength improvements are related to the material grain flow, which is forced parallel to the root surfaces when teeth are forged to shape. Weaker gear teeth typically have a grain flow perpendicular to root surfaces.

Forged gear teeth also show greater resistance to surface pitting. Machined gears had 38.8 % more pits per teeth than precision-forged gears. Such enhanced pitting resistance is thought to be related to the relatively uniform tooth surface produced by precision forging.

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Cost saving achieved by forged bevel gears					
	Description	Qty.	Cost machine Bevel gears	Cost forged Bevel gears	Saving Per tractor
1	Gear rear axle Differential side lh	1	611	470	141
2	Gear rear axle Differential side rh	1	1001	770	231
3	Pinion rear axle Differential	2	416	160	256
Total cost			2028	1400	628

COLLECTED DATA

Quotation given by Vendor

Vendor Quote - Forged Gear			
S.No.	Description	Qty.	CostRs.
1	Gear rear axleDifferential side lh	1	500
2	Gear rear axleDifferential side rh	1	800
3	Pinion rear axle Differential	1	200

Quotation Finalize by Escorts.

Final quote - forged gear			
S.no.	Description	Qty.	CostRs.
1	Gear rear axleDifferential side lh	1	470
2	Gear rear axle Differential side rh	1	770
3	Pinion rear axleDifferential	1	160

CONCLUSION

Cost Saving

Cost of Forged Bevel Gears			
S.No.	Description	Qty.	Cost Rs.
1	Gear rear axle Differential side lh	1	470
2	Gear rear axle Differential side rh	1	770
3	Pinion rear axle Differential	2	160
Total cost			1400

Cost of machined bevel gears			
S.no.	Description	Qty.	Cost rs.
1	Gear rear axle Differential side lh	1	611
2	Gear rear axle Differential side rh	1	1001
3	Pinion rear axle Differential	2	416
Total cost			2028

Substantial Cost Saving Achieved by adopting the Precision Forging manufacturing process for Differential Bevel Gears is 628 Rs. Per Tractor.

Cost Saving Achieved in one Month = No. of Tractor Produced in a month X Saving/Tractor = 3000 X 628=1884000 i.e.
18.8 Lakh Rs. Saved Per Month.
Cost Saving Achieved in one Year = No. of Tractor Produced in a Year X Saving/Tractor = 36000 X 628=22608000 i.e. 2.26 Crores 8 Thousand Rs. Saved PerAnnum.

Therefore we found the following
Enhance Life by 30% In Comparison to Existing Machined Gears.Higher Production Rate and Satisfactory Performance during Testing

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