

# Design and Manufacturing of Spike Shaft for Differential Locking System Purpose

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**ABSTRACT:** The differential locking system used in automobiles is defined as a system that provides increased traction as compared to standard or open differential by restricting each of the two wheels on the same rotational speed without regard to available traction or differences in resistance seen at each wheel. The differential locking system (DLS) is the important element in automobile used for traction movement of the 4 wheeler vehicle under ideal condition. This traction movement dominates the wheel motion and speed at the time when wheel(s) are trapped on the pit/slippy road. In this project, engagement will lock the spike shaft thereby the conventional differential actions stops and both the wheel shafts get engaged in drive and thus equal power is given to either wheels.

**KEYWORDS:** Spike Shaft, Dog Ring, Differential Locking

## I. INTRODUCTION

A differential is a gear train with three shafts that has the property that the angular velocity of one shaft is the average of the angular velocities of the others, or a fixed multiple of that average. In automobiles and other wheeled vehicles, the differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve roll farther and faster than the other. The average of the rotational speed of the two driving wheels equals the input rotational speed of the drive shaft. An increase in the speed of one wheel is balanced by a decrease in the speed of the other.

When used in this way, differential couples the input shaft (or prop shaft) to the pinion, which in turn runs on the crown wheel of the differential. This also works as reduction gearing to give the ratio. On rear wheel drive vehicles the differential may connect to half-shafts inside an axle casing or drive shafts that connect to the rear driving wheels. Front wheel drive vehicles tend to have the pinion on the end of the main-shaft of the gearbox and the differential is enclosed in the same casing as the gearbox. They have individual drive-shafts to each wheel. Older 4x4 vehicles and tractors usually have a solid front axle; the modern way can be a separate differential and drive shaft arrangement for the front.

A differential consists of one input, the drive shaft, and two outputs which are the two drive wheels, however the rotation of the drive wheels are coupled by their connection to the roadway. Under normal conditions, with small tire slip, the ratio of the speeds of the two driving wheels is defined by the ratio of the radii of the paths around which the two wheels are rolling, which in turn is determined by the track-width of the vehicle (the distance between the driving wheels) and the radius of the turn.

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## MATERIAL PROCUREMENT

Material is procured as per raw material specification and part quantity. Part process planning is done to decide the process of manufacture and appropriate machine for the same.

General material used:-

EN24 - Alloy Steel

EN9 - Plain Carbon Steel

MS - Mild Steel

STD - Standard Parts Selected From PSG Design; Data/Manufacturer Catalogue

## II.OBJECTIVE

- a. To prevent the unexpected reverse motion of an Automobile under gradients and mountain roads.
- b. To prevent the loss of traction while vehicle driving on the slippery road.
- c. To lock and unlock differential locking system according to driver's will.
- d. To ensure the safety of the driver and vehicle on inclined grounds.

## III.PROBLEM DEFINITION

Loss of Traction

The torque applied to each driving wheel is a result of the engine, transmission and drive axles applying a twisting force against the resistance of the traction at that road wheel. In lower gears and thus at lower speeds, and unless the load is exceptionally high, the drivetrain can supply as much torque as necessary, so the limiting factor becomes the traction under each wheel. It is therefore convenient to define traction as the amount of torque that can be generated between the tire and the road surface, before the wheel starts to slip. If the torque applied to drive wheels does not exceed the threshold of traction, the vehicle will be propelled in the desired direction; if not, then one or more wheels will simply spin.

## IV.WORKING OF SYSTEM

When one of the wheels (e.g. RH wheel) goes in a pit or slippery condition due to loss in traction (friction between road and wheel) wheel shaft stops turning.

- As a result the LH wheel shaft speeds up to twice, transmission speed vehicle tiers cannot generate enough traction to come out of the pit.
- The proximity sensor senses this drop in speed or motion and through the electronic relay operated the DC motor.
- DC motor pinion drives the rack shifter mechanism to the right.
- Shifter mechanism moves the dog ring toward right and the dog teeth engage in the spike shaft slot.
- Engagement will lock the spike shaft thereby the conventional differential actions stops and both the wheel shafts get engaged in drive and thus equal power is given to either wheels.

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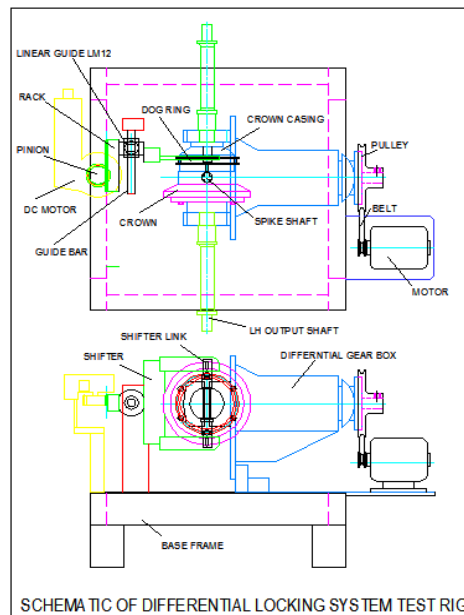
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- Wheels after receiving the power will pull/push the vehicle out of pit. Operator moves the reversing switch to bring the dog ring back out of engagement thus conventional differential action is restored.

## V.MECHANICS OF DIFFERENTIAL LOCKING SYSTEM

The differential is shown in the rear axle housing. The rear axle housing includes a flange supporting the bearing retainer. The bearing retainer supports the differential bearing assembly and a rear axle bearing assembly and the differential bearing assembly as shown in figure below.



## VI.DESIGN METHODOLOGY OF SYSTEM

In our attempt to design a special purpose machine we have adopted a very a very careful approach, the total design work has been divided into two parts mainly;

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine no of controls position of these controls ease of maintenance scope of further improvement; height of m/c from ground etc.

In Mechanical design the components are categorized in two parts:-

- Design parts
- Parts to be purchased

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work.

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## VII.DESIGN AND MANUFACTURING PROCESS OF SPIKE SHAFT

Spike shaft is provided with slots on the top of it. Engagement will lock the spike shaft thereby the conventional differential actions stops and both the wheel shafts get engaged in drive and thus equal power is given to either wheels.



In the above figure, Spike Shaft is shown after completing design in CATIA software.

### MATERIAL SELECTION

Ref: - PSG (1.10, 1.12 & 1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm <sup>2</sup>	YEILD STRENGTHN/mm <sup>2</sup>
EN 24	800	680

### ASME CODE FOR DESIGN OF SHAFT

Since the loads on most shafts in connected machinery are not constant, it is necessary to make proper allowance for the harmful effects of load fluctuations.

### CALCULATIONS

According to ASME code permissible values of shear stress may be calculated form various relations.

$$\begin{aligned}
 f_{s \max} &= 0.18 * \sigma_{ult} \\
 &= 0.18 * 800 \\
 &= 144 \text{ N/mm}^2
 \end{aligned}$$

OR

$$f_{s \max} = 0.3 * \sigma_{yt}$$

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$$= 0.3 \times 680$$

$$= 204 \text{ N/mm}$$

Considering minimum of the above values;

$$\Rightarrow fs_{\max} = 144 \text{ N/mm}^2$$

Shaft is provided with key way; this will reduce its strength. Hence reducing above value of allowable stress by 25%

$$\Rightarrow fs_{\max} = 108 \text{ N/mm}^2$$

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

To Calculate Input Torque

$$\text{POWER} = \frac{2\pi NT}{60}$$

$$\Rightarrow T = \frac{60 \cdot P}{2\pi N}$$

$$T = \frac{60 \cdot 50}{2\pi N}$$

Assuming operation speed = 800 rpm

$$T = \frac{60 \cdot 50}{2\pi \cdot 800}$$

$$\Rightarrow T = 0.5968 \text{ N.m}$$

Assuming 100% overload,

$$\Rightarrow T_{\text{design}} = 2 \cdot T$$

$$= 2 \times 0.5968 \times 10^3$$

$$= 1.19 \times 10^3 \text{ N.mm}$$

Check For Torsional Shear Failure Of Shaft:-

Assuming minimum section diameter on input shaft = 16 mm

$$\Rightarrow d = 16 \text{ mm}$$

$$Td = \pi / 16 \times fs_{\text{act}} \times d^3$$

$$fs_{\text{act}} = \frac{16 \times Td}{\pi \times d^3}$$

$$fs_{\text{ac}} = \frac{16 \times 1.19 \times 10^3}{\pi \times (16)^3}$$

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$$f_{s_{act}} = 1.47 \text{ N/mm}^2$$

As  $f_{s_{act}} < f_{s_{all}}$

⇒ Spike shaft is safe under torsional load.

## VIII.SIMULATION & RESULTS

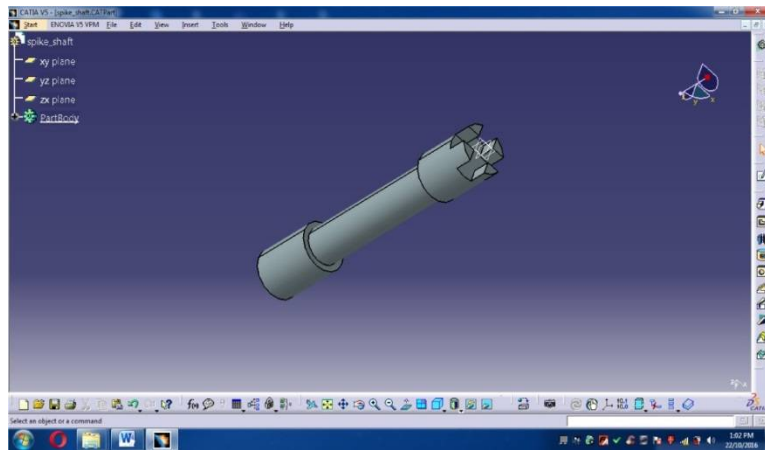


Figure : Design of Spike Shaft in CATIA

The above figure is of design of spike shaft done in CATIA after calculations.

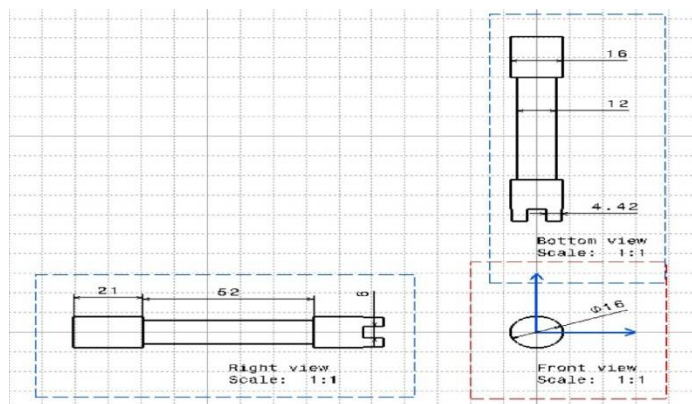


Figure : Drafting Design of Spike Shaft

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In the above figure, drafting of design of spike shaft is shown in CATIA.

### IX.MANUFACTURING PROCESS OF SPIKE SHAFT

PART NAME : INT SHAFT		MATERIAL SPECIFICATION : EN24						
		RAW MATERIAL SIZE: Ø 30X 150						
Sr. No	Description of Operation	Jigs & Fixture	Tools			Time in minutes		
			M/c Tools	Cutting Tools	Measuring Instrument	Setting Time	M/c Time	Total Time
1	Clamp stock	Three jaw chuck	Lathe	-	-	20	-	20
2	Facing Both side to total length 140mm	Three jaw chuck	Lathe	Facing tool	Vernier	-	5	5
3	Turning OD Ø 21 mm through length			Turning tool		5	10	15
4.	StepTurning OD to Ø 17mm through length 134	Centers supports & carrier	Lathe	Turning tool	Vernier	-	20	20
5.	StepTurning OD to Ø 14mm through length124	Centers supports & carrier	Lathe	Turning tool	Vernier	-	20	20
6.	StepTurning OD to Ø 12mm through length10	Centers supports & carrier	Lathe	Turning tool	Vernier	-	20	20

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## X. CONCLUSION

On comparing conventional and our new modified differential locking system, we came to conclusion that locking of wheel shafts with the help of spike shaft and dog ring is found very useful in designing. In concluding the words of our project, since the locking of the differential is very much useful in reducing a considerable amount of loss due the transmission through the differential. Results obtained from the experimentation predict the effective locking which is required by the differential when the vehicle wheel stucked in to any obstacle like mud.

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