A REVIEW: DESIGN & MANUFACTURING OF FRONT AXLE (BEAM) FOR AN AUTOMOBILE

[1]Mr. Kolambe Chetan

[1]Assistant Professor
[1]Mechanical Engineering Department
[1]Anantrao Pawar College of Engineering & Research,Pune,India.

Abstract* — An axle is a central shaft for a rotating wheel. On wheeled vehicles, the axle may be fixed to the wheels, rotating with them, or fixed to its surroundings, with the wheels rotating around the axle. The axles serve to transmit driving torque to the wheel, as well as to maintain the position of the wheels relative to each other and to the vehicle body. The axles in a system must also bear the weight of the vehicle plus any shipment. The front axle beam is one of the major parts of vehicle suspension system. It carries about 35 to 40 percent of the total vehicle weight is taken up by the front axle. Hence proper design of the front axle beam is extremely critical. In present paper work design of the front axle for heavy commercial vehicle were done.

***Keywords*— Front Axle Beam, Automobile Component Design, Manufacturing of F.A.Beam.**

I. INTRODUCTION

The auto industry is one of the key sectors of the Indian economy. The Industry comprises of automobile and the auto components sectors and encompasses commercial vehicles, multi-utility vehicles, passenger cars, two wheelers, three wheelers and related auto components. During last few decades due to global economic scenario optimum vehicle design is major concern. To accomplish the need to design a moderate car, the structural engineer will need to use imaginative concepts. The demands on the automobile designer increased and changed rapidly, first to meet new safety requirements and later to reduce weight in order to satisfy fuel economy requirements. Experience could not be extended to new vehicle sizes, and performance data was not available on the new criteria.

To prevent interference due to front engine location & for providing greater stability and safety at high speeds by lowering the center of gravity of the road vehicles; the entire center portion of the axle is dropper. As shown in figure.

Front axles are subjected to both bending and shear stresses. In the static condition, the axle may be considered as beam supported vertically upward at the ends, i.e. at the center of the wheels and loaded vertically downwards at the centers of the spring pads. The vertical bending moment thus caused is zero at point of support and rises linearly to a maximum at the point of loading and then remains constant.Under dynamic conditions, the vertical bending moment is increased due to road roughness.

Thus it is very difficult to find out the crack propagation in short time. So it is necessary to include finite element method. A computer dependent numerical technique has opened up a new approach to vehicle design. During the vehicle operation, road surface irregularity causes cyclic fluctuation of stresses on the axle, which is the main load carrying member. Therefore it is important to make sure whether the axle resists against the fatigue failure for a predicted service life. Axle experiences different loads in different direction, primarily vertical beaming or bending load due to curb weight and payload, torsion. Due to drive torque, cornering load and braking load. In real life scenario all these loads vary with time. Vertical beaming is one of the severe and frequent loads on an axle Due to their higher loading capacity; solid axles are typically used in the heavy commercial vehicles. During the vehicle service life, dynamic forces caused by the road surface roughness produce dynamic stresses and these forces lead to fatigue failure of axle housing, which is the main load carrying part of the assembly. Front axle can experience a 3G load condition when vehicle goes on the bump.

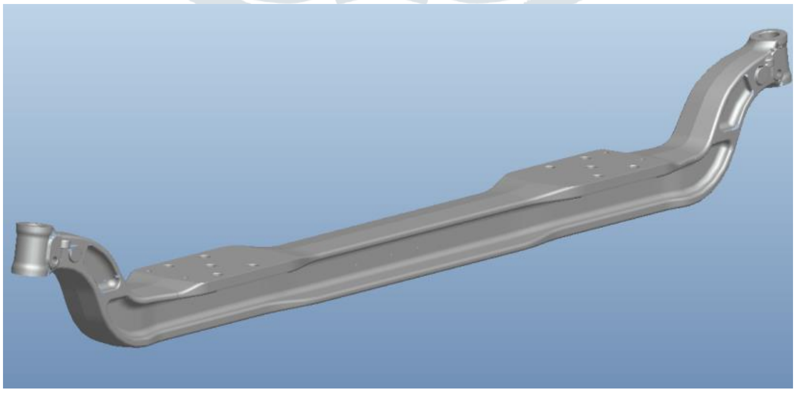

Fig.1 Front axle beam

II. SYSTEM COMPONENT ASSEMBLY

All standard axles have an I cross section in the middle (spring seat to spring seat) and circular or elliptical cross sections at the ends. The front axle beam will have I cross section in the middle and circular cross sections at the ends. An axle is usually a forged component for which a higher strength to weight ratio is desirable. The I cross section has lower section modulus and hence gives better performance with lower weight. This type of construction produces an axle that is lightweight and yet has great strength. The I-beam axle is shaped so that the center part is several inches below the ends. This permits the body of the vehicle to be mounted lower than it could be if the axle were straight. A vehicle body that is closer to the road has a lower center of gravity and holds the road better. On the top of the axle, the springs are mounted on flat, smooth surfaces or pads. The mounting surfaces are called spring seats and usually have five holes. The four holes on the outer edge of the mounting surface are for the U-bolts which hold the spring and axle together. The center hole provides an anchor point for the center bolt of the spring. The head of the center bolt, seated in the center hole in the mounting surface, ensures proper alignment of the axle with the vehicle frame. A hole is located in each end of the I-beam section. It is bored at a slight angle and provides a mounting point for the steering knuckle or kingpin.

A small hole is drilled from front to rear at a right angle to the steering knuckle pinhole. It enters the larger kingpin hole very slightly. The kingpin retaining bolt is located in this hole and holds the kingpin in place in the axle. The steering knuckle is made with a yoke at one end and a spindle at the opposite end. Bronze bushings are pressed into the upper and lower arms of the yoke, through which the kingpin passes. These bushings provide replaceable bearing surfaces. A lubrication fitting and a drilled passage provide a method of forcing grease onto the bearing surfaces of the bronze bushings. The spindle is a highly machined, tapered, round shaft that has mounting surfaces for the inner and outer wheel bearings. The outer end of the spindle is threaded. These threads are used for installing a nut to secure the wheel bearings in position.

A flange is located between the spindle and yoke. It has drilled holes around its outer edge. This flange provides a mounting surface for the brake drum backing plate and brake components. The kingpin acts like the pin of a door hinge as it connects the steering knuckles to the ends of the axle I-beam. The kingpin passes through the upper arm of the knuckle yoke, through the end of the I-beam and a thrust bearing, and then through the lower arm of the knuckle yoke. The kingpin retaining bolt locks the pin in position.

The ball-type thrust bearing is installed between the I-beam and lower arm of the knuckle yoke so that the end of the I-beam rests upon the bearing. This provides a ball bearing for the knuckle to pivot on as it supports the vehicle's weight.

When the vehicle is not in motion, the only job that the axle has to do is hold the wheels in proper alignment and support part of the weight.

When the vehicle goes into motion, the axle receives the twisting stresses of driving and braking. When the vehicle operator applies the brakes, the brake shoes are pressed against the moving wheel drum. When the brakes are applied suddenly, the axle twists against the springs and actually twists out of its normal upright position.

In addition to twisting during braking, the front axle also moves up and down as the wheels move over rough surfaces. Steering controls and linkages provide the means of turning the steering knuckles to steer the vehicle. As the vehicle makes a turn while moving, a side thrust is received at the wheels and transferred to the axle and springs. These forces act on the axle from many different directions. Therefore, the axle has to be quite rugged to keep all parts in proper alignment.

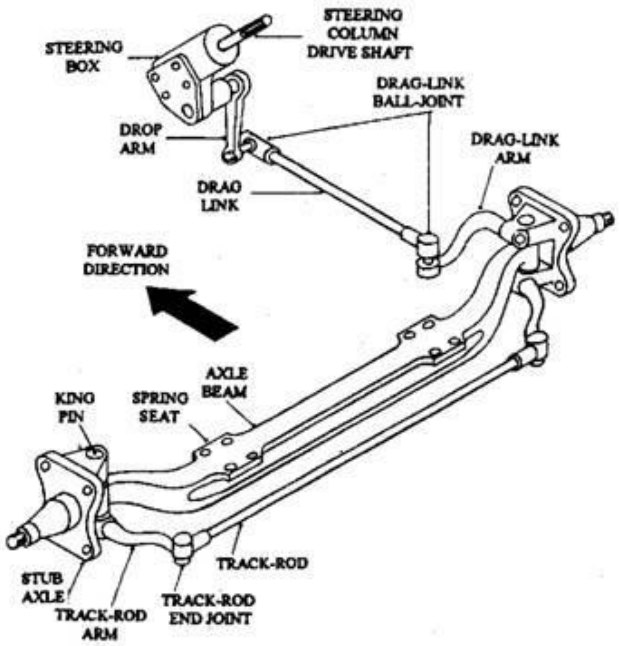

Fig.2 A typical axle beam steering linkage layout.

III. MANUFACTURING METHODOLOGY

Front Axle Beam is made for drop forging method as per below mention 4 Steps

A. Roller Die
B. Bender
C. Trimming
D. Hot coining

A. *Roller Die: -*

Fig.3 Roller Dia for Front axle beam

Two times square block is inserted in roller, first time square block is take spring pad shape on upper roller die & second time it will take second spring pad shape on lower roller die.
After use the roller operation stress is affected on the axle, to remove the stress level, it will be heated on desire temperature.

A. *Bender: -*

Bender is process to which the axle is bending in desire condition.

Fig.4 Bender Dia for Front axle beam

A. *Trimming: -*

After bending, the waste material come out from die but it will stick on raw part of axle, to remove this trimming operation is done

Fig.5 Upper trimmer Die **Fig.6** Lower trimmer Die

D. Hot coining: -

After trimming the stress level is increases to remove the stress level again axle raw part heated up to desire temp.
Hot coning or hot padding is process to make the spring pad portion use upper & lower die with maintaining 0.5 mm parallelism.

III. FRONT AXLE BEAM DESIGN

Front axle beam design required system specifications are shown in Table 1.

Table 1. System Parameters

PARAMETERS	DIMENSIONS
FAW	3250 (Kg)
GVW DYNAMIC RADIUS	9500 (Kg) 408 (mm)
FRONT TRACK	1710 (mm)
WHEEL BASE	3220 (mm)
WEIGHT OF FRONT AXLE BEAM (Wa)	40 (Kg)
WEIGHT OF WHEEL RIM+TIRE+TUBE (Wt)	109 (Kg)
BRAKING TORQUE/WHEEL	356592 (Kg-mm)

Cross section of front axle beam is shown in Fig.7, for calculating bending stresses, torsional stress and principle stress value by considering I section dimensions as b1= 68, b2=14, b3= 78, h1= 14, h2= 48, h3=14.

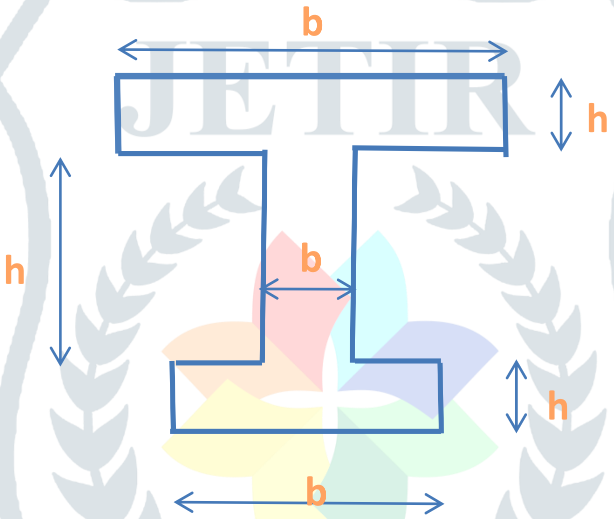

Fig.7 I-section for Front Axle Beam

A. *Material Description: -*

Material: 27C15
Condition: Annealed
Tensile Strength: 78 kg/mm2
Yield limit: 90 Kg/mm2
Elongation: 30%

B. *System Calculations: -*

Table 2. System Calculation Table

MOMENT AT SECTION (M)	918400 (Kg-mm)
MAX. BENDING STRESS (Fb max.)	16.4042 (Kg/mm2)
TOTAL BENDING STRESS (Fb)	21.3902 (Kg/mm2)
TORSIONAL STRESS (Fs)	3.07289 (Kg/mm2)
PRINCIPAL STRESS (Fp)	**34 (Kg/mm2)**

C. *Deflection of Front Axle Beam (X-Direction): -*

Axle beam is considered as a simply supported beam at wheel centers and loaded at the spring pad centers.

Vertical deflection at spring pad

$$Yc= \frac{Wa2\ (3L-4a)}{6EI} \quad \text{(mm)}$$

Deflection at canter of beam (max deflection)

$$Ymax= \frac{Wa(3L2-4a2)}{24EI} \quad \text{(mm)}$$

Table 3. Front Axle Beam Deflection Calculations

TOTAL UNSPRUNG MASS (FAW) (W)	2121 (Kg)
LENGTH (KINGPIN CENTER TO SPRING PAD CENTER HOLE) (a)	420.5 (mm)
FRONT TRACK (L)	1710 (mm)
MOMENT OF INERTIA (I)	2467180 (mm4)
MODULUS OF ELASTICITY (E)	2.1X10^4 N/mm2)
VERTICAL DEFLECTION AT SPRING PAD (Yc)	**34 (mm)**
DEFLECTION AT CENTER OF BEAM (Ymax)	**34 (mm)**

D Design Calculation Result: -

We have design the front axle beam by taking consideration of principle of material 27C15.
The value of principle stress for 27C15 is ~34Kg/mm2.

From above calculation it has observed that 27C15 material stress limit is 90Kg/mm2 and same to be carry forward for design and manufacturing Principle stress calculated for 27C15 is below material Yield limit (i.e. 90 Kg/mm2 ultimate tensile strength 78 kg/mm2). Hence the cross section has been optimizing.

IV ACKNOWLEDGMENT

It gives me great pleasure to present this paper on “Design of Front Axle for an Automobile”. In preparing this paper number of hands helped directly and indirectly. Therefore it becomes my duty to express gratitude towards them.

I am also grateful to Prof. G.E.Kondhalkar (Head, Department of Mechanical Engineering), Dr. K.H. Munde, Department of Mechanical Engineering (ME Coordinator) & Prof. Dr. S.B.Thakare (Principal, Anantrao Pawar College of Engineering & Research) for direct or indirect help in completion of this paper.

REFERENCES

[1] Rainer, Gotthard Ph.: “Computer simulations as Parts of the Development Process”, International Symposium Engineering Center Graz, Austria, 25-26 July 1998.

[2] Petrin, H. Wiesler, B. “Application of FEM-Tools in the Engine Development Process”, 1st Worldwide MSC Automotive Conference, Munich, Germany; September 20-22. 1999.

[3] Papalambros Panos Y., Douglas J. Wilde., Principles of Optimal Design, Modeling and Computation. Cambridge University PRESS. 1988. MSC.Nastran User`s Manual, Version 66, The MacNeal-Schwendler Corporation, Los Angeles, CA, November 1998.