Design & Analysis of Straight Bevel Gear

Mehul A. Raval
Department of Mechanical Engineering
K. J. Institute of engineering & Technology, Savli, Vadodara, (G.J.), India

Abstract— This research gives a detailed approach to straight bevel gear design and analysis. Important design limits are investigated in accord with industrial standards and suggested practices for use in Concrete or cement mixers. The concrete mixer machine contains of the major parts like mixer drum, yoke, prime mover and bevel assembly. Here the drum is functioned by the prime mover through the bevel assembly. So all the mass of the drum is operated by bevel assembly. Due to this reason bevel gear crushed and failed. So the project development with the new design of bevel gear for increasing the life.

Key words: Bevel Gear, Concrete, Cement Mixture, Machine, Analysis

I. INTRODUCTION

Concrete mixer machine combine the elements that make concrete to prepare a well-mixed blend that cures and hardens properly. Movable concrete mixers are small enough to arrange on a construction site; larger cement mixer trucks keep the materials mixing in the drum-shaped barrel at the back of the truck during transport. While there are several different types of concrete mixers, they all function based on the same basic principles. The concrete mixer machine contains of the major parts like mixer drum, yoke, prime mover and bevel assembly. Here the drum is functioned by the prime mover complete the bevel assembly. So all the weight of the drum is operated by bevel assembly.

A. Detail Descriptions of Parts

1) Bag Drum

Bag drum is the main part of the hand concrete mixer machine. It contains of conical shaped construction as shown in figure 1. The ring having 52 teeth are attached outer most exteriors on the drum. It contains of 57 mm hole at the inner surface. It contains of 876 mm and 756 mm outer and inner surface diameter correspondingly.

Fig. 1: ¾ Bag Drum

2) Bag Yoke

Yoke is the secondary component of the bag drum. It is Y shaped element having length of 1287 mm. It consists of three bush bearings. Two bush bearing is situated at the end of the yoke & one is positioned at the center as shown in figure 2.

Fig. 2: ¾ Bag Yoke

3) Bag Ring

Bag Ring is the ring having 58 teeth. It is tightly fitted with the outer surface of the bag drum. The ring having 60 mm thickness. It is prepared by cast iron. These rings contain of 770 mm diameter as shown in figure 3.

Fig. 3: Bag Ring

4) Yoke Pedestal Single

Yoke Pedestal Single is a supportive component of the yoke which is situated on the main frame of the mixer machine. It consists of gun metal bush at the inner surface having 70 mm diameter as shown in figure 2.3.4.

Fig. 4: Yoke Pedestal Single

5) 12 T Bevel with Shaft

It is the key part of bevel assembly. The bevel has 12 teeth. It consist of 51mm thickness and 134 mm outer most diameter. Its weight is around 4.5 kg.

It contains of 25.5 mm inner hole with 8/10 mm key as shown in figure 5.

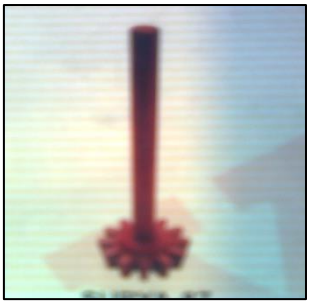


Fig. 5: 12 T Bevel with Shaft

6) Prime mover

It is the power transmission component of the machine. Generally 2 Hp electric motor is used with this machine.

All rights reserved by *www.ijsrd.com*

Fig. 6: Prime Mover

II. PROBLEM EXPLANATION

A. Problem Summary

- The problem is to decrease the loading & centrifugal forces acting on the drum.
- The failing of bevel is now a main problem while the concrete mixture machine is running. Because the drum and bevel is the main part of the mixer machine as shown in figure.
- The drum is run with the help of bevel. So some adjustment in design of bevel is desired to reducing the irregular effect of centrifugal force and hence loading.

B. Detail Description of the Problem

- The failing of bevel is occurred due to rough forces acting on it.
- With the unexpected start of the machine the jerks are produce. So, there is a chance of misalignment of the teeth of bevel and drum ring.
- With the longtime of running due to the friction between bevel teeth and drum ring teeth cleaning will take place.
- While running the machine there should be good mashing between pcd of bevel and addendum of teeth of drum ring.
- So, modification of design of bevel is required.

C. Why Redesigning Of Bevel Gear Is Needed?

- The bevel gear is individual way by which the rotary motion can be transmitted to the mixer drum and the mixing is take place.
- Therefore, appropriate mashing of teeth of gear with teeth on drum with proper clearance must need.
- That's why bevel is best significant part of the concrete mixer machine. So, appropriate care should be taken with using of the machine.

D. Structure of Bevel Assembly

Fig. 7: Bevel & Ring Arrangement

III. SOLUTION OF THE PROBLEM

A gear is a mechanical method often used in transmission systems that permits rotational force to be transferred to another gear or device. The gear teeth, or cogs, allow force to be totally transmitted without slippage and depending on their configuration, can transmit forces at different speeds, torques, and even in a different direction. During the mechanical industry, many types of gears exist with each type of gear owning specific benefits for its intentional claims. Bevel gears are widely used because of their suitability towards moving power between nonparallel shafts at nearly any angle or speed.

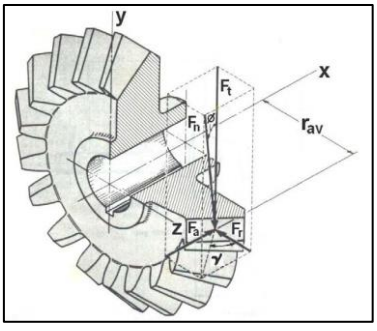
When two bevel gears mesh, their individual pitch cones contact along the common element. The pitch cones when extended, meet at a mutual point called the apex, which is the point of intersection of the shaft axes.

The teeth of straight bevel gears are straight which meet into the apex. The size of bevel tooth (thickness and height) decreases towards the apex of the cone.

Though the bevel gears are typically made for a shaft angle of 90°, they can be produced for almost any shaft angle. The bevel gears are integrally none interchangeable. The straight bevel gear used in concrete mixer machine shown below.

Fig. 8: Straight Bevel Gear

A. Force Analysis of Bevel Gear



Tooth Forces on Gear

All rights reserved by *www.ijsrd.com*

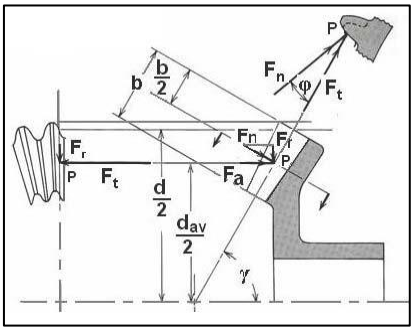


Fig. 9: Bevel Gear - Force Analysis

B. Linear Tooth Force Distribution

In the Fig.10, the resolution of resultant tooth force Fn into its tangential (torque producing), Radial (separating), and axial (thrust) components, is designated Ft, Frand Fa, correspondingly. An auxiliary view is wanted to show the true length of the vector on behalf of resultant force Fn(which is normal to the tooth profile)

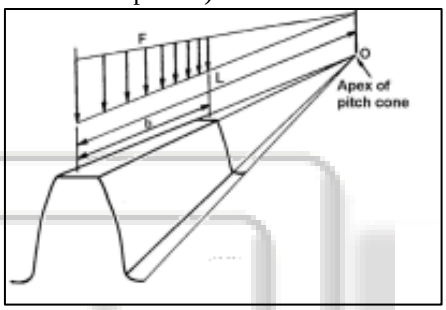


Fig. 10: Apex of Pitch Cone

Resultant force Fn is shown applied to the tooth at the pitch cone surface and midway along tooth width b. It is also expected that load is consistently distributed along tooth width, although the fact that the tooth width is more at the outer end.

$$d_{av} = d\text{-}b\sin\gamma$$

$$V_{av} = \frac{\pi d_{av} n}{6000}$$

$$F_t = \frac{1000\,W}{V_{av}}$$

Where Vavis in meters per second, davis in meters, n is in revolutions per minute, Ft is in Newton's and W is power in kilo Watts.

$$F_n = F_t/\cos\varphi$$

$$F_r = F_n\cos\gamma = F_t\tan\varphi\cos\gamma$$

$$F_a = F_n\sin\gamma = F_t\tan\varphi\sin\gamma$$

C. Analysis of Old Design

- The construction of old design of the bevel gear used in concrete mixer machine is as shown in figure.
- This construction of bevel gear consists of 14 teeth.
- The thickness of each tooth in this construction is 15mm.

Terms	Value
Module	10mm
Tooth thickness	15mm
Num. of Teeth	14
Pitch circle diameter	119.5mm
Outside diameter	139mm
Inside diameter	121 mm
Bore diameter	24 mm
Base circle diameter	85 mm
Weight	3.2 kg
R.p.m	20 r/min
Pitch cone angle	11°

Table 1: Design Data for 14T Regular Bevel Gear

Terms	Value
t_1	6mm
t_2	12mm
t_3	13mm
Pitch circle diameter	103mm
Teeth height	18.5mm

Table 2: for Front Teeth Profile

Terms	Value
t_a	6mm
t_b	13mm
t_c	15mm
Pitch circle diameter	119.5mm
Teeth height	22mm

Table 3: for Rear Teeth Profile

The 14 T bevel gears are designed by overhead parameter. There are mostly two types of forces acting on bevel gear teeth i.e. Tangential force and radial force, which is shown in fig:5.3

The tangential forces make a bending stress which tends to break the tooth. The radial component makes a compressive stress of comparatively small in magnitude, so effect on the tooth may be neglected.

The detail explanation of such failure is explained in following section.

D. Description of Smooth Running

Drum is connected such a way that one of its sides is connected to bevel and additional side is connected to fly wheel assembly. A Drum is messed with Bevel as Shown in figure .when in working disorder there should be proper messing between pcd of bevel and addendum of teeth of drum ring avoid the failure of bevel.

E. Description of Failing of Bevel

Fig. 11: Regular Bevel

F. Detail Description of Brakeage of Tooth

Every gear tooth act as a cantilever. If the total boring dynamic load acting on the gear tooth is greater than the beam strength of gear tooth than the gear tooth will fail in bending. i.e. gear tooth will break.

All rights reserved by *www.ijsrd.com*

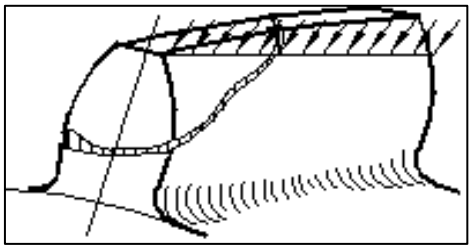


Fig. 12: Breakage of tooth

The other causes of failure of tooth are explained below:-

1) Pitting

It is the surface fatigue failure which happens due to many recurrence of hertz contact stresses. The failure occurs when the surface contact stresses are higher than the endurance limit of the materials. The failure stars with the formation of pits which continue to grow resulting in the rupture of the tooth surface.

2) Scoring

The extreme heat is produced when there is an excessive surface pressure, high speed or supply of lubricant fails. It is a stick-slip phenomenon in which alternate shearing and welding takes place rapidly high spots. This type of failure can be evaded by properly designing the parameters such as speed, pressure and proper flow of the lubricant, so that the temperature at the rubbing faces is within the permitted limits.

3) Abrasive Wear

The foreign particles in the lubricant such as dirt, dust or burr enter between the teeth and damage the form of tooth.

4) Corrosive Wear

The corrosion of the tooth surface is mostly produced due to the presence of corrosive elements such as additive presents in the lubricating oils.

G. Analysis of Drum Ring

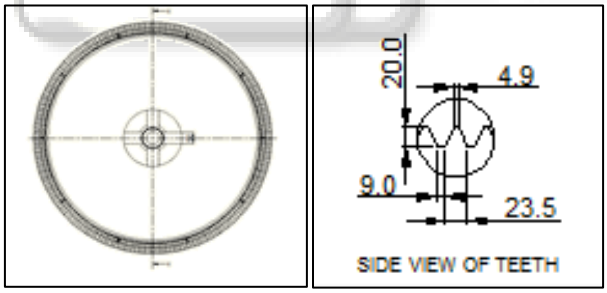


Fig. 13: (A) Drum Ring & (B) Its Section

The drumming consists of 58 teeth. It is rigidly fixed with the outer surface of the bag drum. The ring having 60 mm thickness. It is made by cast iron. These rings consist of 770 mm diameter as shown in figure (a).

The side view of teeth profile on drum is shown in figure (b). The space between two successive teeth is kept 23.5 mm. but the thickness of the old bevel gear tooth is 15 mm, so by modification of old bevel gear by changing its tooth profile does not effect on the performance of the drum ring.

The following section is a modification of the old design.

H. Analysis of Modified Design

- The construction of modified design of the bevel gear used in concrete mixer machine is as shown in figure.
- This construction of bevel gear consists of 13 teeth.
- The thickness of each tooth in this construction is 16.5mm.

Terms	Value
Module	10mm
Tooth thickness	16.5 mm
Num. of Teeth	13
Pitch circle diameter	116 mm
Outside diameter	138 mm
Inside diameter	130 mm
Bore diameter	24 mm
Base circle diameter	90 mm
Weight	3.2 kg
R.p.m	20 r/min
Pitch cone angle	5°

Table 4: Design Data for 13T Bevel Gear

Terms	Value
t_1	9mm
t_2	13mm
t_3	15.5mm
Pitch circle diameter	110mm
Teeth height	18.5mm

Table 5: for Front Teeth Profile

Terms	Value
t_a	10mm
t_b	15mm
t_c	16.5mm
Pitch circle diameter	116mm
Teeth height	22mm

Table 6: for Rear Teeth Profile

- The 13 T bevel gear is designed by above parameter.
- The modify design of 14 t bevel gear is shown in above fig.no. In which we modify the old design parameter as shown in table no.
- In this design we have focused on tooth profile and developed a new modifies design of tooth profile as shown in fig no.
- Our main aim of this project is by changing in the tooth profile, we can reduce the effect of the bending failure, scoring, pitting, abrasive wear, corrosive wear of the tooth. So that the life of bevel gear teeth is increases.
- The comparison of old bevel gear and modify bevel gear is explained in following section.

IV. RESULT & DISCUSSION

Old design	Modify design
The old design of bevel gear consists of 14 teeth.	The new design of bevel gear consists of 13 teeth.
front teeth profile	front teeth profile
a)t_1 = 6 mm	a)t_1 = 9 mm
b)t_2 = 12 mm	b)t_2 = 13 mm
c)t_3 = 13 mm	c)t_3 = 15.5 mm
rear teeth profile	rear teeth profile
a)t_a = 6 mm	a)t_a = 10 mm
b)t_b = 13 mm	b)t_b = 15 mm
c)t_c = 15 mm	c)t_c = 16.5 mm

Table 7: Comparison between Old Design and Modify Design based on Design Parameter

All rights reserved by *www.ijsrd.com*

Old design	Modify design
The effect of Abrasive wear in this bevel is considerably higher than the modify design.	The effect of Abrasive wear in this bevel is considerably lower than old design due to improvement in tooth profile design.
The effect of corrosive wear in this bevel is considerably higher than the modify design.	The effect of corrosive wear in this bevel is considerably lower than old design due to improvement in tooth profile design.
So from above discuss parameter and wear makes the failing of bevel gear is rapidly, so its life is also considerably less than the modify design.	So from above discuss parameter and wear makes the reduction in failing of bevel gear rapidly, so its life is also considerably higher than the old design.

Table 8: Comparison between Old Designs and Modify Design Based on the Causes of Failure Bevel Gear

In this project we developed the new design for the tooth profile of the bevel gear. This modify design does not produce any harmful effect on the teeth profile of the drum ring. This modified design should properly mesh with the teeth of the drum ring. This modified design does not require any additional cost means the manufacturing cost is remain same as earlier

REFERENCE

[1] Bhandari V.B., (2003), Design of Machine Elements, Tata McGraw-Hill Publishing Company Ltd, New Delhi.
[2] Ratnadeepsinh M. Jadeja et al (2013), "Bending Stress Analysis of Bevel Gears", International Journal of Innovative
[3] PSG College of Technology, 2008, Design Data Book, CoimbatoreHill pub. 2001
[4] Shigley, Mechanical Engineering, McGraw−Hill Primis, Eighth Edition, ISBN: 0−390−76487−6
[5] J.Thomson, et, al. "Development of lead-free bearing material for aerospace application ", International journal for metal casting, 2010, ISSN 1939-5981
[6] Bruzhas V.V. et al (2015),"Development of solid-state models for the gears of different geometry", Procedia Engineering 129 (2015) 369 – 373

All rights reserved by *www.ijsrd.com*