Experimental Analysis of Bucket Elevator Chain Breakdown

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Abstract: A Bucket Elevator is a material handling equipment. It can elevate variety of bulk material from light to heavy and from fine to large lumps .It consist of rubber belt and on which metallic and plastic bucket are fixed. In this study we are finding the various faults related to the sprocket and chain failure and diagnosis this fault using the various methods of the failure causes. The present work is aimed at designing and analysis required to decide the capacity of a chain drive that should be used to drive a bucket elevator of particular specification. In this study we minimize the break-down of bucket elevator by replacing simplex roller chain and sprocket by duplex roller chain. Duplex chain have more breaking load capacity than the Simplex chain In duplex chain power rating and tension in chain are less than the simplex chain.

Keywords:Bucket Elevator, Simplex chain, Duplex chain.

1. INTRODUCTION

1.1 BUCKET ELEVATOR

1.1 Introduction: - A Bucket Elevator can elevate a variety of bulk material from light to heavy and from fine to large lumps .A Centrifugal discharge elevator may be vertical orinclined. Vertical elevator depends entirely on the action of centrifugal force to get the material into the discharge chute and must be run at speeds relatively high.

It consists of:

1) Bucket to contain the material.

2) A belt to carry the bucket and transmit the pull

3) Means to drive the belt

4) Accessories for loading the buckets or picking up the material for receiving the discharged material for maintaining the belt tension and for enclosing and protecting the elevator.

The Bucket Elevator are used in:

a) Foundry (Casting) industries

b) Cement industries

c) Fertilizer industries

d) Paper mill

e) Powder industries

f) Coal mines

g) Pharmaceutical industries

1.2 Part of Bucket Elevator:-

I) Casing - Elevator will consist of boot section, intermediate casing and head section .Elevator boot,Intermediate casings and head casing will be of welded or bolted connection .Fabricated from rolled steel, Mild

Fig 1.1 Bucket Elevator Assembly

Steel, Angle section and sheets. The sheet thickness for the intermediate casings and head casing will be 3mm whereas for the boot section and the receiving chute sheet thickness will be 5mm .The intermediate casing will not exceed 1.8 to 2.5m.Boot section will be provided with inspection door on both side for cleaning and replacement of buckets.

II) Head section: It will be provided with a crowned head pulley of Mild steel of Mild steel plate welded construction. The pulley face will be straight approximately for 1/3 $^{rd.}$ face length in the center. For the balance portion both side straight length, the pulley have crown.

III) Boot section: It will be provided with bottom pulley of M S construction mounted in externally lubricated pillow block bearing.

Figure No. 1.2 Tail pulley of Elevator

IV) Take up device: It is provided at bottom section or top section elevator for elongation of belt

V) Drive unit: Elevator will be head driven .The drive motor will be totally enclosed fan cooled squirrel cage induction motor suitable for operation 3 phase 3.7 kW AC supply system at 1440 rpm.

VI) Belt: The belt will be Nylon fabric 350mm, 5 ply Grade M-24 or heat resisting quality with 3mm bottom.

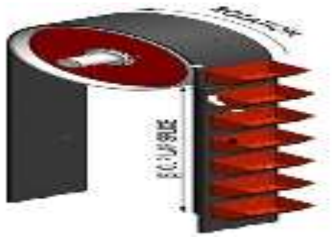

Fig. No-1.3 Belt with Buckets

1.6 Chain drive

A Chain drive consists of an endless chain wrapped around two sprockets. A Chain can be defined as a series of link connected by pin joints. The Sprocket is a toothedwheel with a special profile for the teeth. The chain drive is intermediate between belt and gear drives.

1.6.1 There are three types of chains:

a) Load lifting chains

b) Hauling chains

c) Power transmission chains

1.6.2 Load lifting chains are used for suspending raising or lowering loads in materials handling equipment. The popular example of this chain is a link. Link chain areused in low capacity hoists, winches and hand operated cranes.

1.6.3 Hauling chains are used for carrying materials continuously by sliding, pulling orcarrying inconveyors. The example of this is a Block chain. It consist of sideplates ofsimple shapes andpins.

1.6.4 Power transmission chains are used for transmitting power from ones haft to another.

1.7Roller Chain:

A Roller chain consists offollowing fiveparts:

a) Pin

b) Bushing

c) Roller

d) Inner link plate

e) Outer link plate

The pin is press fitted to two outer link plates , While the bush is press fitted to inner link plates the bush and the pin form a swivel joint and the outer link is free to swivel with respect to the inner link . The roller are freely fitted on bushes and during engagement turn with the teeth of the sprocket wheels . This results in rolling friction instead of sliding friction between roller and sprocket teeth . The rolling friction reduces wear and frictional power loss and improves theefficiency of the chain drive.

The inner and outer link plates are made of medium carbon steels. These link plates are blanked from cold rolled sheets and hardened to 50 HRC .The pins , bushes and roller are made of case carburizing alloy steels and hardened to 50 HRC.The pitch (p) of the chain is the linear distance between the axes of adjacent rollers. Roller chain are standardized and manufactured on the basis of the pitch.

These chains areavailable in single strand or multi strand constructions suchas simple,duplex or triplex chains.

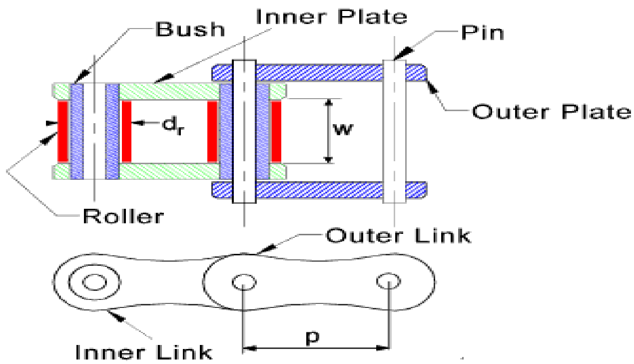

Figure No 1.7 Duplex Roller Chain

1.8 Sprocket Wheels:-

Figure No.1.8 Duplex Sprocket

1.8.1Duplex Sprocket: There are different construction for sprocket wheel as shown in fig. Small sprockets up to 100 mm in diameter are usually made of a disk or a solid disk with a hub on one side. They are machined from low carbon steel bars. Large sprocket with more than 100 mm diameter are either welded to a steel hub or bolted to a cast iron hub .In general sprocket are made of low carbon or medium carbon steels . In certain application stainless steel is used for sprockets .When the chain velocity is less used for sprockets . When the chain velocity is less than 180 m/min, the teeth ofthe sprocketwheel are heat treated to obtain a hardness of 180BHN. For high steel speed application therecommended surface hardness is 300 to500 BHN. The teeth are hardened either by carburizing in case of low Carbon steel or by quenching and tempering in case of high carbon steel .

1.8.2 Identification of Faults:

a) Wear of Sprocket. b) Noise in the drive.

c) Vibration in the sprocket. d) Excessive chain tension.

e) Jerk due to the belt. f) Misalignment of the chain and sprocket.

1.9Problem Area for the Project:

The Company is facing the problem of the breakdown of Bucket Elevator .They have to keep bucket elevator working continuously to achieve mass production .The failure of working of bucket elevator causes loss of production which create impact on the customer commitment and quality .

2.0 Objective:

1) To study the existing layout and working of company.

2) To eliminate chain drive breakdown of elevator by introducing new arrangement.

3) To reduces the breakdown time.

2.1Design of Simplex chain &Duplex chain

2.1.1. Given data:

Power of driving sprocket = 3.7 KW

Speed of Driving sprocket = 1440 rpm.

Multistrandfactor (K_1) = 1 (For simplex Chain)

Tooth correction factor (K_2) = 1

Service factor (Ks) = 1.3

2.1.1.2 KW rating of the chain

$=\frac{(Powertobetransmittedbymotor)\ X\ K}{K1\ XK\ 2}$

$= \frac{3.7\ X\ 1.3}{1\ X\ 1} = 4.81$ KW

The power rating of the chain at actual speed 1440 rpm =

Given value of speed not available in table

At1400rpm = 5.28 KW (power

At1800 rpm = 6.98 KW (Power)

By using LinearInterpolation method,

$PowerP\ = 5.28 + \frac{6.98-5.28}{1800-1400} X\ (1440\text{-}1400)$

P = 5.45 KW

From Table Chain 08A is suitable for the application.

2.1.1.3. Number of Links:

We know that Pitch (p) = 12.7 mm d_1 = 2.51mm b_1 = 7.75 mm

$\frac{N2}{N1} = \frac{Z1}{Z2}$

$N_2 = \frac{17}{24} X\ 1440 =$ **1024 rpm**

The center distance between the ages of the driving and driven sprocket should be between 30 to 50 times of pitch of the chain.

2.1.1.4. Centre distance (a) =

$$= 2\ X\ \frac{a}{p} + \frac{(Z1+\ Z2)}{2} + \frac{p}{a}\ X\ \frac{(Z2-Z1)^2}{2\pi}$$

=

$$2\ X\ \frac{635}{12.7} + \frac{(17+24)}{2} + \frac{12.7}{635} + \frac{(24-17)^2}{2\pi}$$

= 121.76 = 122 links

2.1.1.5. Correct center distance

$$==\frac{p}{4}\left[L_n - \frac{Z_2+Z_1}{2}\right] + \sqrt[2]{\left(L_n - \frac{z_1+z_2}{2}\right)^2 - 8\left[\frac{Z_2-Z_1}{2\pi}\right]^2}$$

$$= \frac{12.7}{4}\left[102 + \sqrt[2]{102^2 - 8\left[\frac{24-17}{2\pi}\right]^2}\right]$$

= 646.52 mm

Correct center distance (a) = 646.52 mm

The center distance calculated by the formula does not provide any sag. In practice a small amount of sag is essential for the link to take the best position on the sprocket wheel.

The center distance is therefore reduced by a margin of 0.002a to 0.004a to account for the sag.

2.1.1.6.Distance for sag =0.002a to 0.004a

= 0.002 x 646.52 to 0.004 x 646.52

= 1.3 mm to 2.58 mm

2.1.1.7. Length of the chain L = Number of link X pitch

= 122 X 12.7

= 1549.4 mm

2.1.1.8. Pitch Circle Diameter of drivingsprocket:

D_1 = p X Cosec (180/Z_1)

= 12.7 X cosec (180/17) = 69.11mm 0.06911m

For the driven sprocket:

$Z_2 = Z_1 \frac{N1}{N2}$

$= 17 \frac{1440}{1020}$ =1020 rpm

2.1.1.9. Pitch circle diameter of driven sprocket (D_2):

D_2 = 12.7Cosec (180/24)

= 97.30 mm

= 0.09730 m

2.1.2.0. Pitch line velocity of driving sprocket:

$$v = \frac{Z1\ X\ p\ X\ N1}{60000}$$

$= \frac{17\ x\ 12.7\ x\ 1440}{60000=}$ = 5.18 m/s

2.1.2.1. Tension in the chain (P_1)

$= \frac{1000\ x\ Power\ rating\ of\ motor}{v}$

$= \frac{1000\ X\ 3.7}{5.18}$ = 714.285 N

2.1.2.2 Factor of safety $= \frac{Breaking\ load}{Chain\ tension}$

$= \frac{13800}{714.285}$ = 19.32

2.1.2.3. Dimension of the driving sprocket wheel:

Pitch p= 12.7mm, d_1 = 8.51 mm, b_1= 7.75 mm

a) Outer diameter:

1) $(D_a)_{max} = D+1.25p - d_1$

= 69.11 +1.25(12.7) – 8.5

= 76.475 mm

2) $(D_a)_{min} = D+p(1- -\frac{1.6}{17}) - d_1$

$= 69.11 + 12.7\ (1 - \frac{1.6}{17}) - 8.51$

= 72.1 mm

b) Root diameter and roller seating radius:

$(r_i)_{max} = 0.505\ d_1 + 0.069\sqrt{d_1}$

= 0.505 x8.51 +0.069 (√8.51)

= 4.437 mm

$(r_i)_{min} = 0.505\ d_1$

= 0.505 x 8.51 = 4.297 mm

C) Root diameter (Df):

$D_f = D-2r_i$

= 69.11- (2 x4.29) = 60.53 mm

3.1. Design of Duplex chain

We know the power = 3.7 kW, speed N_1 = 1440 rpm

Number on of teeth on driving sprocket = Z_1 = 17

Multistrand factor K_1 =1.7 (From Table 4.6)

Tooth correction factor K2 = 1.00

Service factor K_s = 1.3

1) KW rating of chain $= \frac{Power\ to\ be\ transmitted\ by\ motor}{K1\ X\ K2}$ X

$= \frac{3.7\ x\ 1.3}{1.7\ x\ 1}$ = 2.82 KW

By using interpolation method we find the value of power rating at1440 rpm,

P= 2.73 + (3.44-2.73) /1800-1400 X (1440-1400)

= 2.80 kW

Referring to table the power rating of the chain 06 B is 2.73 kw and 3.44 kw at1400rpm and 1800 rpm respectively .Therefore the chain number 06B is selected.

The duplex chain 06 B is selected which have less pitch than present simplex chain (12.7mm)

So we select duplex chain of 10A from Table 4.5 with pitch of 15.875 mm.

The dimension of Chain 10 A are pitch = 15.875 mm, d_1 = 10.16 mm, b1= 9.4 mm, p_1= 18.11 mm and breaking load 43600 N.

3.2 For the driving sprocket Pitch Circle Diameter:

D_1=pXCosec180/ ((z1) $=15.875 Cosec \left(\frac{180}{17}\right)$

= 86.465 mm

For the driven Sprocket:

$N_2 = \left(\frac{Z1}{Z2}\right) X\ N1$

$= \frac{(17)}{24}$ X 1440

= 1020 rpm

3.3. Pitch circle diameter of driven sprocket D2 = p X Cosec $\left(\frac{15.875}{7.5}\right)$

=121.62 mm

To make compact construction the center distance is taken as 30 p to 50 p

a = 30 x pitch

= 30 X 15.875 = 476.25 mm

We know that Z_1 = 17, Z_2 = 24 N1 = 1440 rpm, p = 15.875 mm

$L_n = 2\left(\frac{a}{p}\right) + \frac{Z1+z2}{2} + \left(\frac{Z2-Z1}{2\pi}\right)^2 X \left(\frac{p}{a}\right)$

$= 2\,X \left(\frac{476.25}{15.875}\right) + \left(\frac{17+24}{2}\right) + \left(\frac{24-17}{2\pi}\right)^2 = 80.5$

L_n =80 links

Correct centerdistance: For simplification

$\left[Ln - \left(\frac{z1+z2}{2}\right)\right] = \left[80 - \left(\frac{17+24}{2}\right)\right]$ = 59.5 mm

3.4. So **Correct Centre distance**:

$= \frac{p}{4}\left[Ln - \left(\frac{z1+z2}{2}\right)\right] + \sqrt{\left[Ln - \left(\frac{z1+z2}{2}\right)\right]} - 8\left(\frac{z2-z1}{2\pi}\right)^2$

$= \frac{15.875}{4} X \left[(59.5) + \sqrt{59.5^2} - 8\left(\frac{24-17}{2\pi}\right)^2\right]$

= 471.86 mm

3.5 Pitch line velocity $= \frac{\boldsymbol{Z1\,X\,P\,XN1}}{\boldsymbol{60000}}$

$= \frac{\boldsymbol{17X15.875\,X\,1440}}{\boldsymbol{60000}}$ **= 6.47 m/s**

3.6. Tension in chain $P1 = \frac{1000\,X\,3.7}{6.47}$

= 571.870 N

3.7. Factor of Safety:

$= \frac{Breaking\ load}{Chain\ tension} = \frac{43600}{571.87} = 76.24$

3.8. Dimension of the driving sprocket wheel:

i) Outer (Top) diameter

$(D_a)_{max} = D_1 + 1.25p - d_1$

= 86.465 +1.25 X 15.875 -10.16

= 96.145 mm

ii) $(Da)_{min} = D_1 + p\left(1 - \frac{1.6}{z1}\right) - d_1$

$= 86.465 + 15.875\left(1 - \frac{1.6}{17}\right) - 10.16$

= 90.68 mm

iii) Root Diameter and Roller seating radius:

$(r_i)_{max} = 0.505\, d_1 + 0.069\sqrt[3]{d1}$

$= 0.505\,X\,10.16 + 0.069\sqrt[3]{10.16}$

= 5.28 mm

$(r_i)_{min}$ = 0.505 d_1

= $_{0.505}$ X 10.16

= 5.13 mm

iv) Root diameter = $D_f = D_1 - 2r_i$

= 86.465 – 2 X 5.28

= 75.90 mm

Fig 3.1 Paper on Bucket Elevator Duplex chain Drive

Results:

Difference between Simple chain and duplex on the basis of following point:

S.NO	Point to be considered	Simplex chain	Duplex chain
1	Strength	Less	More
2	Power rating	4.81 kw	2.85 kw
3	Length of chain	1549.4 mm	1524 mm
4	Pitch line velocity of driving sprocket	5.18 m/se	6.47 m/s
5	Breaking load	13800 N	43600 N
6	Multistrand factor	1	1.7
7	Tension in chain	714.285 N	571.870 N
8	Number of link required	122	80

Conclusion

The chain drive should be horizontal. The driving side should be on the top .To avoid the breakdown Chain drive adequate tension in the chain is the most important requirement of chain drive. Chain life is reduced if the chain is too tight or to loose. Too tight a chain results in an unnecessary load in the chain and increased bearing reaction. From above Experimental Analysis we concluded that

1) Duplex chain has more strength than Simplex roller chain.

2) The Duplex chains havemore breaking load value than simplex chain.

3) The power rating and tension in chain in duplex chain less than simplexchain.

ACKNOWLEDGEMENT

The project "Experimental Analysis of Bucket Elevator Chain Breakdown" was not an individual task. It was a combined team effort. First of all, I would like to thank my project guide, Prof. M. C. Swami, MSBEC, Laturfor his valuable guidance and incessant encouragement and co-operation extended to me during this work. I would like to express thanks to Mr. Shinde Vikas Vasantrao,Sai InfoTechLatur. Whose moral support and suggestion gave me confidence to complete this work.It is my pleasure to acknowledge sense of gratitude to our Head of mechanical department Prof. S.G. Mantri. And our Principal Prof. N.B. Khatod and for their great support and encouragement in work.

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BIOGRAPHIES

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