Faults Diagnosis and Design of the Sprockets for Dispenser in Ginning Industries

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Abstract

An Improvement in the roller chain and sprockets also design sprockets for the particular application can reduce the faults related to the sprockets failure, By design a new sprockets and selecting proper chain drive it's possible to reduce faults related to sprockets failure. In this study faults diagnosis and new tooth generating and modeling approach of the sprockets are used which is effectively eliminate the faults related to the sprockets failure. As well as a method or system for designing such a sprockets tooth profile, related suggestion and results are discussed.

Keywords: Wear, Vibration, Noise

I. INTRODUCTION

Fault diagnosis is investigating one or more root causes of problems to the point where corrective action can be taken. Kurt Josef Ferreira [1] In This it is also referred to as "fault isolation", especially when need to show the distinction from fault detection. This study Conducted on the most important drive that is chain drive of the ginning industrial equipment called as dispenser. Dispenser is equipment which is used to dispense the cotton. There are various accessories used in this ginning process to improve the quality and the efficiency of the process. One of these is a dispenser. It has a basic feature with a constant ratio because of no slippage or creep. So, it is widely used as a positive drive mechanism in various machines. Sprockets and chain is two main important elements in the chain drive. It is found that the sprockets failure in this system play an important role to reduce production and the efficiency of the system. Using the root cause analysis find the various causes of the sprockets failure in the research related [3] same authors have already discussed on the faults related to the sprockets failures, So that the catastrophic failure get reduce.

Following are the various faults which have found using root cause analysis and the brainstorming session [3]

1) Wear in sprockets
2) Noise in the drive
3) Excessive chain tension
4) Chain climbs sprockets
5) Vibration in the sprockets.
6) Polygonal action
7) Misalignment of the chain and sprockets

II. DETAILS STUDY OF THE FAULTS

While running the sprockets these faults are analyzed by using the various techniques of the faults detection [3] these techniques have discussed by the various researched are as follows.

A. Wear:

Present work mainly deals with investigation of wear, which causes decrease the life of the sprockets also failure of the sprockets and chain. Due to improper design of the sprockets and the manufacturing process, the forces acting on the sprockets are increases due to this sprockets wear occurs. There are several methods for measuring wear volume rate. For instance, the change in the weight of a specimen before and after a wear test can be measured by electronic balance; (Cho et al). This is the main fault of the sprockets failure which reduces the efficiency of the drive. It is found that the main resign for this wear is the backlash in between the chain and roller due to this the impact force acted upon it and causes wear in the sprockets.

From various researches it is found that by design sprockets teeth with its appropriate curve and profile, it gets reduce backlash in between the sprockets and chain due to this the wear and tear of the sprockets and chain reduces. For this fault used the appropriate design procedure for the sprockets and manufacture sprockets.

B. Vibration:

A body is said to vibrate when it describes an oscillating motion about a reference position. The number of times a complete motion cycle takes place during the period of one second is called the Frequency and is measured in hertz (Hz). The main resign of this cause is the undercut in the sprockets due to this Impact force occurs when the roller chain engages with the sprocket especially at constant speed. The transient peaks of the impact force are present during chain starts to mesh into the sprocket. The impact force is one of the main sources of vibration and noise existed in the timing chain drive mechanism. It may also result in the stretch and fatigue of chain drives. This vibration in the sprockets is found out with the help of the finite elements method [6] and this shows the various frequencies with respective deformation.

C. Noise:

Noise reduction has emerged as a paramount criterion in the design of roller chain drive systems in recent years. It is generally recognized that in roller chain systems, the two most significant noise sources are from the polygonal action and intensive impacts due to relative velocity between the chain rollers and sprocket teeth during their meshing process. Polygonal action is the effect of the fluctuation of the position in which the chain and sprockets engage due to the wrapping of the chain in a polygonal manner, causing both longitudinal and transverse chain span vibrations. The vibrations result in unsteady chain speeds which affect the engagement process as well as the impact levels..

D. Polygonal Action:

The polygonal action means that the pitch line of the chain is a tangent or secant line of the pitch circle of the sprocket alternately. The pitch line of the chain keeps moving up and down. The instantaneous transmission ratio between driving and driven sprockets is variable. Those features are able to cause an uneven chain velocity, transversal and longitudinal vibration, noise and meshing impact, and damage the synchronization and evenness of the transmission, so that the application of the roller chain drive is used to be limited in a lower speed. Polygonal action plays an important role in the transition of the power in the chain drive. The chain passes around the sprockets as a series of chordal links. This action is similar to that of non slipping belt wrapped around a rotating polygon

E. Misalignment of the Chain and Sprockets:

Accurately installation of the sprockets is very important to the life of machines. That is, sprocket alignments can maximum drive life also gives the efficient to the system. Chain and sprockets misalignment is directly affected to the drive system performance. Proper alignment increases the life of the drive also. It is observed that the sprockets alignment of the drive does not follow any standard procedure to align the sprockets and the misalignment in between two sprockets is up to 15mm. which is affected the drive performance. Form the standard alignment procedure it is found that alignment of the sprockets in this dispenser system is not correct, there is an offset between the two shaft and the sprockets due to this the chain force not be distributed continuously to the each teeth of the sprockets so that the tension of the chain increase continuously this is the reason to damage the teeth of the sprockets and the chain also decrease the life of the chain drive.

F. Excessive Chain Tension:

The tension force of the chain reflects the stress state of the chain. The excessive chain tension may result in insecurity. And damage the drive system. This chain tension can be calculated analytically and by using various simulations in software. Chain tension is important aspects in the chain drive to avoid any damage related to the chain drive. In Design of the drive shows the tension of the chain with its tight and slack side. Design calculation shows the appropriate values of the drive with its calculation. For that particular values selecting the chain and sprockets with using standard catalogs.

III. DIAGNOSIS OF THE FAULTS

A. Wear:

For these faults various studies have been done, this is important to find the wear rate and its causes for the system. For various study the material is responsible for the cause of the various wear and its heat treatment process are also responsible for these cause. But in this study material is keeping same and goes through the sprockets design consideration for reducing the wear in the sprockets. For this to avoid the backlash in between the sprockets and chain, According to the Hiroshi Makino and Hidetsugu Terada [17] in this paper the modeling procedure of the sprockets is given to reduce the backlash according to this The inventors discovered that this defect can be eliminated by so designing the tooth profile that the roller pitch line of the chain may be offset

a certain distance above the contact pitch line, thereby permitting the center of the rotating roller to follow a generic involutes curve .By using this technique design, drafting the sprocket and the developed with the same material as C45 (medium carbon steel)

B. Vibration:

It is found that the main resign of the excessive vibration in the sprockets is the undercut in sprockets. Due to this the impact force is acted on the sprockets this may cause the vibration and noise in the drive. By eliminating this undercut and the excessive tension this cause get reduces according to the related study the design of the sprockets for the particular method can eliminate this cause.

C. Polygonal Action:

The polygonal action means that the pitch line of the chain is a tangent or secant line of the pitch circle of the sprocket alternately. The pitch line of the chain keeps moving up and down. The instantaneous transmission ratio between driving and driven sprockets is variable. Those features are able to cause an uneven chain velocity, transversal and longitudinal vibration, noise and meshing impact, and damage the synchronization and evenness of the transmission, so that the application of the roller chain drive is used to be limited in a lower speed. Polygonal action plays an important role in the transition of the power in the chain drive.

The chain passes around the sprockets as a series of chordal links. This action is similar to that of non slipping belt wrapped around a rotating polygon. The chordal action is illustrated in the fig. where the sprocket has only four teeth. It is assumed that the sprockets are rotating at constant speed of "n" rpm. in fig A, the chain link AB is at a distance of D/2 from the center of the sprockets wheel and its linear velocity is given by, $V_{max} = \pi DN/60000$ m/s, as the sprockets rotated through an angle $\theta/2$ the position of the chain link AB is shown in the fig B, in this case, the link is at a distance of $D/2 \cos(\theta/2)$ from the center of the sprocket and its linear velocity is given by,

$V_{min} = \pi DN \cos(\theta/2)/60000$ m/s.

It is evident that the linear speed of the chain is not constant or uniform but varies from Vmax to Vmin during every cycle of the tooth engagement. This result a pulsating and the jerky motion. The variation in the velocity is given by,

$(V_{max} - V_{min}) < (1-\cos(\theta/2))$

As the $\theta = 180$,

$(V_{max} - V_{min}) < (1-\cos(180/z))$,

As the number of teeth increases to φ, cos (180/z) will approach unity and (Vmax – Vmin) will become zero. Therefore, the variation will be zero. In order to reduce the variation in the chain speed, the no of the teeth on sprockets should be increase.

It has been observed from various researches that speed variation is 4 % for the sprockets with 11 teeth, 1.6% for the sprockets of 17 teeth, and less than 1% for the sprockets teeth of 24 teeth. According to design calculation and selection procedure, selected the no of teeth as 26 teeth. So that the polygonal action of the chain and sprockets get fulfill.

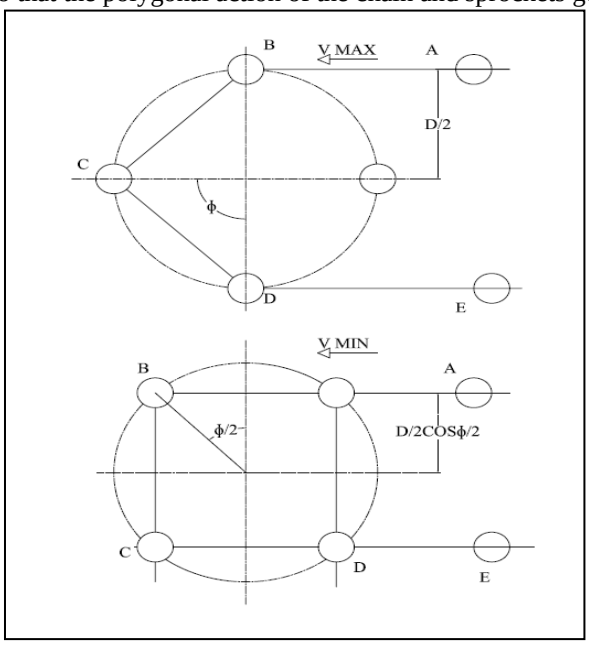

Fig. 1: Polygonal Action of the Chain and Sprockets (A&B)

D. Misalignment of Chain and Sprockets:

Accurate alignment of shafts and sprocket tooth faces provides a uniform distribution of load across the entire chain width and contributes substantially to maximum drive life also reduce the wear and the damage of the sprockets and chain.[12] The following procedures give same basic idea about the sprockets alignment.

By using the dial indicator measured the alignment of the sprockets also Use a straightedge across the machined faces of the sprockets in several different positions, if possible, as a check against wobble. A nylon or similar line is a good substitute for a straightedge, particularly on longer center distances. Should endwise "float" of shafts be present, check the contact of the sprockets for the straightedge. Make due allowance so that sprocket alignment is correct at the mid position of "float." When alignment is correct within closest practical limits, drive the keys home and take a final check on sprocket. Fig shows the basic alignment procedure of the sprockets.

1) Design Calculation:

a) Power calculation:

Tension required to move the empty belt = T_C = F_1 X L X CW = 314.88 lbs = 1396.74 N

Tension required to move the load =

T_L = f_2 x L x mw = 4723.2 lbs = 21009.84 N

Tension required to lift the load = 0

Total tension required to move the load (TE)

= TC+TL+TH = 5038.08 lbs

Break HP = TE X (FPM/33000) = 0.79

Motor HP = BREAK HP/ ήmotor x ήgearbox x ήchain =1.37 = 1.37 x service factor (1.4)

= 1.92 hp = 2 Hp

Torque transmitted by sprocket (T) = 60P ÷ 2πn

Force required for sprocket (F) = torque × radial distance.

b) Drive Calculation:

From ANSI data considering chain No-60 -1

Considering sprocket of pitch ¾" (19.05mm)

Forsprocket 60 (A) FOR CHAIN 60 -1 (ANSI)

Rollerdiameter=11.91mm

Width of the sprocket=12.57

Transverse pitch = 22.78mm

Power given to the drive = 2 HP (1.49 KW)

Number of revolution per minute – 03

Geared motor N1 = 3 rpm

Approximate Center distance between the two sprocket (a) = 510mm

Considering no of teeth = 26 as per standard

Pitch circle diameter (D = P ÷ sin (180/Z_1)

Sprocket Top diameter (d_t) = d + 1.25p - d_1

Root circle diameter d_f = d- d_1

Linear speed of the sprockets (v) = $\frac{\pi DN}{60}$

= 5.2 FPM

Angular speed = velocity/radial distance

= 0.309 rad/sec

Torque transmitted (T) = 60P ÷ 2πn

= 4746.1 n-m

Force required (F)= torque × radial distance

= 398.66 N

Average speed (V) = (P × z_1× N_1) ÷ 1000

= 0.026 $m/_{sec}$

Chain tension (tangential force) C_t= 1000×KW ÷ V = 57.36x10^3 N

Tooth frank/profile radius = 0.008 d_1X (z^2 +180) = 81.55 MM

Tooth radius (r_1) = 0.505d_1+0.069 $3\sqrt{d1}$

= 6.11mm

Tooth side radius (r2) = 19.01

Exact Tooth width (w) =0.95Xwidth of sprockets= 11.94 mm

Tooth side relief = 0.10 to 0.15 p = 2.4mm

Tooth height above polygon = 0.5 (p $-d_1$)
= 3.57mm

Factor of safety = $\frac{\text{breaking load}}{\text{rated power}}$
= 10.85

Allowable working load per strand = $\frac{\text{ultimate strenth}}{\text{foctor of safety} \times \text{service factor}}$ = 1065.43 N

Accordingly,

Impact speed (VA) = $\frac{\pi NP}{3000} \sin(\frac{360}{Z1} + \Upsilon)$

Where, Υ- pressure angle = $\frac{180-A-\alpha}{2}$

Where A - pitch angle = 360/Z =

α – roller setting angle = 136.54

VA = 0.002 m/sec

2) Design of the Sprockets Tooth Profile:

It is known that the theoretical contact between a circle and a line makes the involutes curve as a contour of a point on the line. It is seemed, from this theory, that it is better to use an involutes curve as the roller center path for the sprocket tooth. With this invention [7], an adequate amount of offset is given between the roller chain pitch line and contact pitch line as shows in fig. By this a theoretically complete contact between rollers and teeth is made throughout the movement without any back lash. The inventors discovered that this defect can be eliminated by so designing the tooth profile that the roller pitch line of the chain may be offset a certain distance above the contact pitch line, thereby permitting the center of the rotating roller to follow a generic involutes curve (herein called "involute-trochoid "curve). Then, the minimum radius of convex curvature of the involutes trochoid curve cannot be Zero, so that no undercut may appear at the tooth bottom. More specially, the positive amount of offset K is given by: K= y*m

Where "y" stands for the offset coefficient, and "m" stands for the module, which is given by D. The positive amount of displacement is so determined mathematically that the incremental circular arc may be equal to the roller pitch.

The remaining procedure for the sprockets design is same as ANSI standard. [9] Using the 2D software (pro-E)/Auto-cad, design the sprockets. Also using ANSI standard chain no 1040

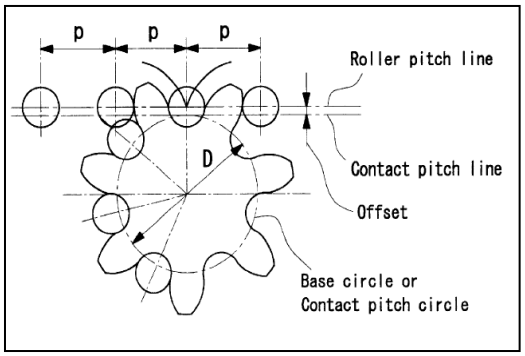

Fig. 2: Offset In Between Roller Pitch Line and Contact Pitch Line

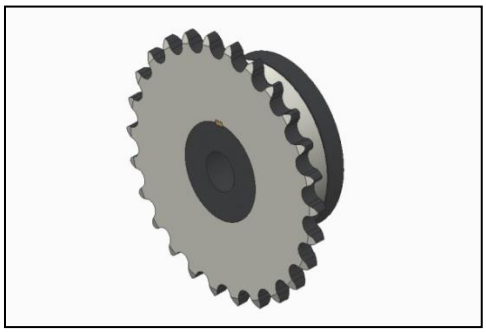

Fig. 3: 3D View of the Designed Sprockets with QD Bush Using Pro-E

IV. CONCLUSION AND DISCUSSION

Discussion covers the detail results and discussions of the experimentation conducted during this dissertation work, and the various method used the various system affecting parameters are analyzed.

By using the design sprockets for the particular causes, it reduces the defects and helps to reduce the following defects.

1) Wear in the sprockets reduce by using the newly design sprockets.
2) Noise in the drive reduced.
3) Vibration in the sprockets using model analysis can be reducing its deflection for the same frequency.
4) For polygonal action the 26 tooth are preferred according to this polygonal action of the sprockets and chain can be maintained.
5) Chain climbs sprockets due to the wear of the sprockets and the excessive chain tension and fluctuation of the chain of the sprockets .by considering design parameter this cause can be eliminate.

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