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ANALYSIS AND DESIGN OF JACQUARD DRIVE SYSTEM FOR TEXTILE POWERLOOM MACHINE

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ABSTRACT

The Indian textile industry is one the largest and oldest sectors in the country and has a major share in the national economy. Powerloom industry in Maharashtra is more rapidly growing industry than in other states in India. Solapur is the home of Handloom and Power loom industry which provides employment to a large number of workers (approximately 100000). The jacquard drive system in a power loom is obtained by a chain drive system. In the present system, frequent chain failure and jerky power transmission is observed. Field visits are carried out in order to investigate the reasons of failure of the existing chain drive system. The chain drive fails due to long distance between shafts, swaying effect, misalignment between the axis of shaft and inadequate lubrication. Failure issues are responsible for the downtime and probable rejection of product due to interruption in weaving cycle. An alternative for jacquard drive is hence felt necessary in order to avoid/reduce the number of failures.

The chain drive is hence studied in detail for the required speed reduction and types of gear pairs needed to replace the chain drive. Bevel gear drive system is selected from numbers of possible alternatives. The current work represents systematic attempt of redesign the jacquard drive system for textile Powerloom. Radical design procedure is carried out in order to design the gear drive system. The analytical results are validated using numerical simulation. Proposed design of positive gear transmission system is manufactured which has shown no failure over a period of one month in comparison to four failures for a chain drive system for the same period improving the system reliability.

KEYWORDS: Jacquard drive system, chain drive, failure of chain, gear drive

INTRODUCTION

The Indian textile industry consists of three distinct sectors representing broadly three levels of technology and Organization, namely, mills, powerlooms and handloom[1]. The Powerloom industry is the biggest small scale industry of Maharashtra. Solapur is known as city of textiles because of its manufacturing capacity and capabilities especially for towels and napkins [3].The jacquard drive system in a power loom is obtained by a chain drive system. An overview of the chain drive system was done through the visits to the textile industries and it was found that there is frequent chain failure and jerky power transmission.[2]These phenomenons are responsible for the downtime and rejection of product when the weaving cycle is interrupted due to chain failure. It is essential to study the chain system, involved velocity ratios and to prevent the failure of chain drive system or otherwise replace the drive by some suitable alternative. As discussed above the problems of chain failure due to jerky power transfer can be addressed to the long length of chain used for jacquard movement. This problem is dominantly due to longer centre distance of driver and driven shaft and sagging of the chain. Frequent lubrication is also a requirement of this drive system. The yarn particle gets embedded/adhered to the chain (due to lubricant) thereby affecting the performance of the chain drive system. In tune with these issues the objectives of the current study are to study the failure of existing chain drive system and to study other positive drive systems; which can replace chain drive system.To design and develop a new design of positive gear drive transmission system and analyze the proposed gear drive system.

FAILURE OF CHAIN DRIVE SYSTEM

In addition to the communicated literature [2], visits are undertaken in the industries and around Solapur to get the experiential data regarding the failure of chain system.Two types of chains are used in local textile industry:1.Simple chain 2. Roller chain

1. Simple chain:

It is used for 70% Textile industries in Solapur. It is made up of cast iron links hinged together. It is used for conventional old looms for power transmission.

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2. Roller chain:
It is used where recent looms are installed. The links are made of steel blocks and combined together. It gives good performance than simple chain.

Various failures of both chains in textile industry have been observed and are as shown in Figure 2.1.

(a) ***(b)*** ***(c)*** ***(d)***

Figure 2.1- Failures of Chain

The reasons for failure of chain drive are due to long distance between shafts, swaying effect, misalignment between the axis of shaft and inadequate lubrication.In order to solve this critical issue, alternative systems are studied.

LITERATURE RELATED TO PROBABLE ALTERNATIVE

As mentioned above, it became necessary to develop an alternative for the chain drive system in order to solve the problem of breakdown. Visits to nearby textile and allied industry were undertaken in order to acquire the information about similar technology or application which used in the industry**.**

a) Belt transmission system

It was possible to replace the existing chain system by belt drive as the distance was large however in present application, the concept of belt drive kept aside due to following reasons,

- Belt was a flexible drive and application requires a rigid drive.
- The velocity ratio not remains constant.
- Slip can be a critical issue.
- Due to friction there will be considerable loss of power which may result in lower efficiency.
- Belt drives had comparatively short service life

b) Cam and follower system: Belt drive was not suitable for the present application and the option was hence rejected. As an alternative, the cam and follower system was thought of since it used in mat weaving machine. After studying the cam and follower system, following observations were noted.

- It required designing specific type of cam profile.
- Single motor will not fulfill the requirements.
- Speed variation was not possible.
- Considerable amount of vibrations.

It observed that the controlling of all the movements using a single cam was difficult; due to these limitatiions a next alternative is discussed.

c) Spur Gear Drive System: It is simplest type of a gear which is easy to manufacture and a rigid drive also.But due to following limitations it is also not selected:

- It can not be transmit power for 900 aligned shafts
- It is noisy in operation
- Inaccurate speed reduction
- It also require more lubrication and less power transmission

d) Bevel Gear Drive System: The final probable option was suggested about the gear drive. According to power transmission direction, speed reduction, the bevel gear is seleceted due to following reasons:

- Power transmission in 90 degrees required, which can be achieved using bevel gears.
- Straight bevel gear can fulfill the need and are easy to design and manufacture and can provide reasonably good service.
- Smooth teeth engagement results in quiet operation.
- This system gives good result even at high speed and high power transmission.
- Vibrations are less as compared to chain drive.
- Less lubrication required as compared to chain drive system and covering the drive was possible.

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DESIGN OF GEAR BASED TRANSMISSION SYSTEM

The design of gear based transmission system was divided into following three main parts and layout is also shown in figure 4.1.

4.1 Design of Bevel Gears at Motor End

4.2 Design of Bevel Gears at Jacquard Drive End

4.3 Design of Intermediate Shaft

For designing the system it was required to measure the speed of driver shaft which is carried out by using Tachometer. It was also enlisted the data required for material selection of various components such as bevel gear and pinion with help of measuring instruments such as vernier caliper, measuring length tape etc.

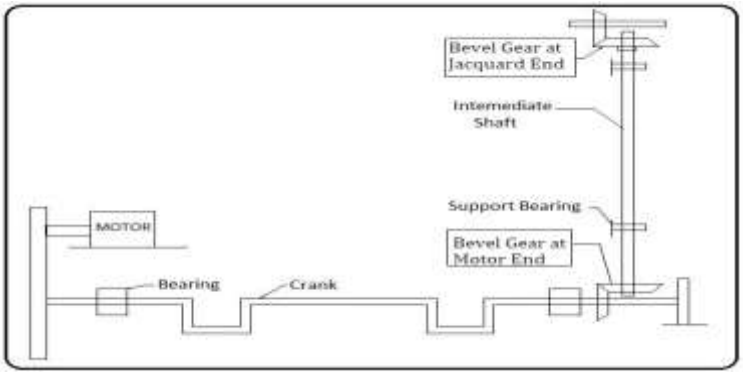

Figure 4.1 Layout of Bevel Gear Transmission System

By using the standard formulaes the analytical design procedure for bevel gear drive system was carried out.[13] The final calculated dimensions of the bevel gear drive system are given in table No. 4.1.

Table No.4.1 Design of beve gear

Sr. No.	***Parameters***	***Design of Bevel Gears at Motor End***		***Design of Bevel Gears at Jacquard Drive End***	
		Gear	**Pinion**	**Gear**	**Pinion**
1	No.of teeth(z)	16 mm	16 mm	20 mm	40 mm
2	Module (m)	5 mm	5 mm	4 mm	4 mm
3	Pitch Diameter (D)	80 mm	80 mm		
4	Cone distance (A)	56.568 mm	56.568 mm		
5	Mean radious (r)	33.33 mm	33.33 mm	66.66 mm	33.33 mm
6	Face width (b)	18.85 mm	18.85 mm		
6	Beam Strength	1391.153 N		1745.39 N	
7	Wear strength	829.432 N		829.43 N	
8	Dynamic Load	7.318 N		22.524 N	
9	Effective Load	680.099 N		695.315 N	

4.3 Design of Intermediate Shaft

An Intermediate shaft is required to have a connection between Motor end and Jacquard end through the bevel gear pairs. The forces acting on shaft are investigated through the force analysis on both ends. Considering intermediate shaft as a simply supported beam the moment were taken ; respectively shear force and bending moment diagram are drawn. Finally diameter of shaft is found out as 25 mm.

MODELING AND ANALYSIS OF BEVEL GEAR DRIVE SYSTEM

According to the finalized dimensions modeling of the system was be done by using CATIA-V5 R19, which is as shown in Figure 5.1.

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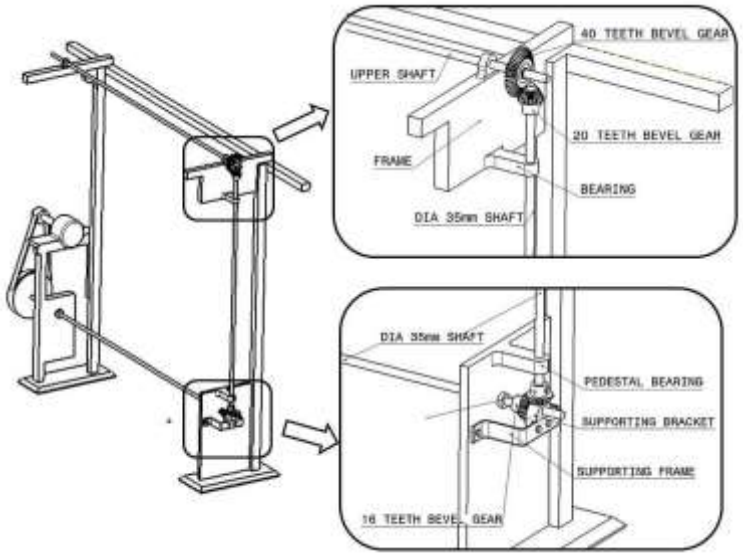

Figure 5.1- Assembly of Bevel gear drive system with Powerloom Frame

The gear drive is designed according the load conditions and the induced bending stress is validated using the ANSYS ; which is as shown in Figure 5.2.

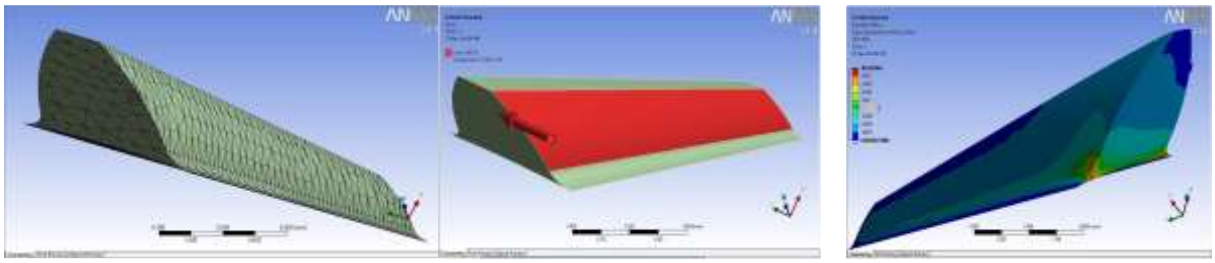

Figure 5.2- Analysis of gear tooth on ANSYS

The bending stress value in the bevel gear found out within the permissible range with the analytical results.

RESULTS AND DISCUSSION

It comprises of the results and discussion related to the gear drive model developed, its validation using through ANSYS software.

- *Results:*

The gear drive is designed according the load conditions and the induced bending stress is validated using the ANSYS software. The results of bending stress according to analytical and ANSYS software are illustrated in Table No. 6.1

Table No. 6.1- Results of Bending Stress of Bevel Gear

Sr.No.	Section	Analytical Results	ANSYS Software Results	Difference in Both Values
1	Motor End Bevel Gear	39.88 MPa	40.433MPa	1.01 %
2	Jacquard Drive End	58.74 MPa	63.695 MPa	7.7 %

- *Discussions*

a) *Based on Prior System Failure Rate:*

The conventional chain drive system was having the problem of swaying which due to long shaft distance i.e. 2m. The swaying effect causes the system vibrations and misalignment which will reduces the transmission efficiency of the system. The frequency of lubrication is also more and also it's a noisy system. The failure of chain drive occurs more frequently which completely shut down the production of Powerloom.The failure data collected from concern maintenance department from the plant; which is as mentioned in below Table no.6.2.

Table No. 6.2 Failure Data of Chain Drive

Powerloom Machine	Frequency of Failure per month	Total Average Shut down time
Powerloom No.1	4	3 hour 10 min
Powerloom No.2	6	4 hour 34 min
Powerloom No.3	5	3 hour 56 min

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As per the collected data the frequency of failure is 4 times per month. The frequency of changing the new chain is also per year for a simple chain per machine. It is also observed that a chain starts to give troubles from six to seven months from its installation period.

b) *Based on Present Gear Drive System:*

The newly designed bevel gear system completely reduces swaying effect. It also reduces the lubrication frequency due to which maintenance time also minimizes. The bevel gear drive system also increases the power transmission efficiency upto 99%. The rigid bevel gear drive system minimizes the frequency of failure which will ultimately increase the working life of the system.The observed failure data as per concern maintenance department from the plant is mentioned as below in table no. 6.3.

Table No. 6.3 Failure Data of Gear Drive System

Powerloom Machine	Frequency of Failure per month	Total Average Shut down time
Powerloom No.1	Nil	Nil

Ultimately the failure rate is drastically reduced by comparing the data obtained from table no. 5.2 and 5.3. Thus, gear drive system can operate without shut down by proper preventive maintenance. It can be said that the reliability of the system is improved.

CONCLUSION

The study of failure of existing chain drive system was carried out by visiting the plant and through various literatures. The specific conclusions are as follows:

- The existing chain drive fails due to long distance between shafts, swaying effect, misalignment between axis of shaft, frequency of lubrication and due to vibrations. The frequency of failure is 4 times per month.
- The bevel gear drive based transmission system is developed and found to be effective. By proper preventive maintenance can operate the system almost without shut down.
- The analytical design, modeling using CATIA-V5 R19 and simulation using ANSYS of bevel gear drive system is successfully carried out.
- In the present work the validation of ANSYS results are in close agreement to the analytical method results.
- Simulation is found to be a vital tool in analysis and also validation of a gear drive system.

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