Design and Analysis of Picking Mechanism of Shuttle Loom

Darji Yugalkishor M.[1], Kaushal P. Khamar[2]

[1]Department of Mechanical Engineering, LCIT, Bhandu, Gujarat Technological University, Gujarat, India

[2]Assistant Professor, Department of Mechanical Engineering, LCIT, Bhandu, Gujarat Technological University, Gujarat, India

Abstract: ***Shuttle Loom is one of the oldest machine of weaving for fabrics. To obtain minimum power consumption, detail analysis of other auxiliary mechanism called Picking, Checking, and Take-up, Beat-up, Let-off is required. The function of Picking and Checking Mechanism is to apply brake to shuttle, and prepare the shuttle for next picking cycle. It uses spring loaded swell to retard the shuttle. Due to retardation velocity of the shuttle decreases to zero. If brake do not release at time of picking, then it require more power for picking. Due to this some of the picking parts are under over-stress, so Picking Stick, Picking Shaft Bearing (Bracket), Picking shaft brake-down before its permissible life.***

Keywords: Shuttle; Picking; Checking; Picking Shaft; Picking shaft Bracket; analysis

1. Introduction

Weaving is the method of fabric production in which two district set of yarns are intersect at right angle to form a fabric or cloth. The longitudinal threads called warp, and lateral threads called weft threads. There are two type of looms as per classification: Shuttle loom and Shuttle less loom. In Shuttle less loom there are Rapier loom, Projectile loom, Air-Jet loom, Water-jet loom, Circular loom. There are mainly five operations of weaving namely (Shedding) opens the warp sheet into layers, (picking) causes the shuttle carrying weft to be propelled from one end of the loom to another,(Beat up) motion lays the previously laid weft to the fell of the cloth,(take up and let off)motions. Picking is the 2nd primary weaving motion. The main function of the picking mechanism is to insert the weft through warp [1].

2. Actual problem during Picking

Figure 1: Picking Shaft brackets

During the working of picking mechanism there are large forces are induced on it for hit the shuttle. And due to that stresses developed during running of it. It may causes of failure of picking mechanism parts like as picking shaft, picking shaft brackets, picking stick (wooden), as well as sometimes shuttle drop box may failure during running of machine.

3. Theoretical calculation of picking Mechanism

Present Picking mechanism with motor pulley diameter of 76.2(3”) and RPM of motor is 960. Whereas diameter of driven pulley of machine is 506mm (20”), which runs at 144RPM. Center distance between two adjutancy pulleys is 368.3mm. [3]. Lift of the picking Bowl = 74.05mm. [4] The picking starts at 110 degree from crank shaft zero degree at front position, and thus the relevant time to fly shuttle is 0.13095 second, so that getting velocity of the shuttle is 14.74 m/s and maximum velocity of shuttle is 15.38 m/s, so that acceleration of the shuttle is 427m/s^2.[6] Considering the mass of shuttle is 0.450Kg. , and force require to hit the shuttle is 192.16N. Power require for that is 0.1140kW.
Checking mechanism is used to nullify the velocity of the shuttle, so the forces absorbed by checking mechanism called swell box. The terminal velocity of the shuttle is found 13.4528m/s, and retardation of shuttle is found 500.886m/s$^{2.}$ [5]. Retardation force acting on the shuttle during collision with swell. The force exerted by swell on shuttle during the collision so reduced by approx. 32%. , so that

$$F_s = 2\mu F_s \tag{1}$$
$$F_s = 2 \, x \, 0.25 \, x \, 61.5$$
$$F_s = 30.75 \, N$$

Force exerted by swell on the shuttle during the collision

$$F_c = \frac{1}{2} M_c a_c \tag{2}$$
$$F_b = 61.5\text{N}$$

The force exerted by pickers against shuttle during the collision is given by

$$F_p = F_s \tag{3}$$
$$F_p = 30.75\text{N}$$

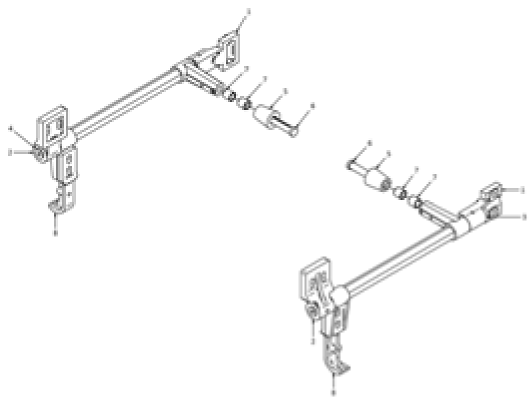

Figure 2: Picking Mechanism Parts [6]

1. Picking Shaft bearing Back (Bracket)
2. Picking Shaft bearing front (Bracket)
3. Picking Shaft
4. Picking bowl (follower)
5. Picking bowl pin
6. Picking pin bush
7. Picking arm.

As shown in figure, Picking Shaft Bracket front and back are made from Cast Iron 25 grade, Picking Shaft , and Picking arm is made from SG Iron with commercial grade, whereas Picking bowl, Picking Bowl Pin and Picking pin Bush is made from Mild steel.

3.1 Proposed Design of Shaft for smooth picking

Picking operation should smooth and jerk free in running condition. Picking is classified as smooth picking and harsh picking according to its performance while running. When the fabrics is very much thin then picking must be smooth. Smooth picking is achieved by designing the component under high factor of safety to that it can sustain extra force. This extra force is generated when shuttle is placed exactly at its prescribed starting position then it disturbed the static equilibrium force in shaft. Picking shaft is under twisting moment so it's better to design circular shaft earlier, its cross section was hexagonal.

Material properties for Grey cast iron of grade 25.
Ultimate tensile strength S_u = 170 to 180 MPa.
Ultimate yield strength S_{yt} = 110 Mpa.

According to ASME code of shaft design the permissible stress for shaft is taken 30% of yield strength or 18% of the ultimate tensile strength of the material, whichever is minimum.

$$T = 0.30S_{yt} = (0.30)(80) = 24\text{Mpa} \tag{4}$$

$$\tau = 0.18s_{yt} = (0.18)(80) = 14.4\text{Mpa} \tag{5}$$

Take minimum value of τ which is 14.4 MPa

For suddenly applied load, the value for combined shock and fatigue factor for bending moment (K_b) and combined shock and fatigue factor for torsion moment and combined shock and fatigue factor for torsion moment (K_t) are 2.5 and 2.2 respectively.

For shaft support with bearing at both ends having length 562mm. bending moment (M_b) for this shaft 13783 N-mm, and torsion moment is 22625 N-mm.To design shaft under torsion moment subjected to fluctuating load using ASME code for shaft design.

$$\tau = \frac{16}{\pi d^3}\sqrt{(k_b M_b)^2 + (K_t M_t)^2} \tag{6}$$

$$d^3 = \frac{16}{\pi(14.4)}\sqrt{(2.5 \times 13783)^2 + (2.2 \times 22625)^2}$$

$$\frac{16}{3.1415 \times 14.4}\sqrt{1187319306.25 + (2477550625)}$$

$$d = 27.76mm$$

$$d \cong 30mm$$

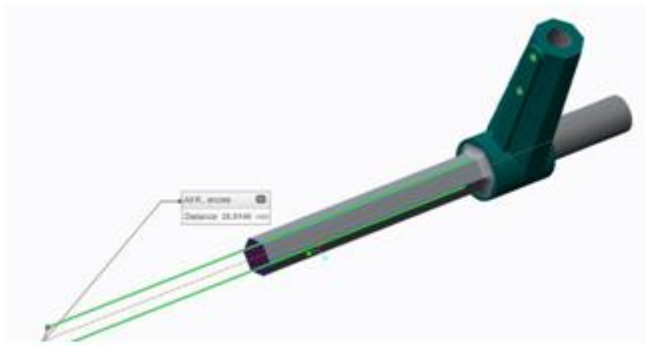

Figure 3: Proposed Shaft forSmooth Picking.

3.2 Simulated Analysis of Picking Mechanism

Here is the simulated result of the existing picking mechanism with the force of 192.16N as calculated in theoretical calculation of picking mechanism, which is exerted on the Picking bowl through the picking cam due to rotating of the bottom shaft of the machine. This simulation did using the Creo Simulate 2.0 with the mesh elements of 8037 tetrahedrons, and 11469 edges, 17411 faces with maximum aspect ratio of 10.83.

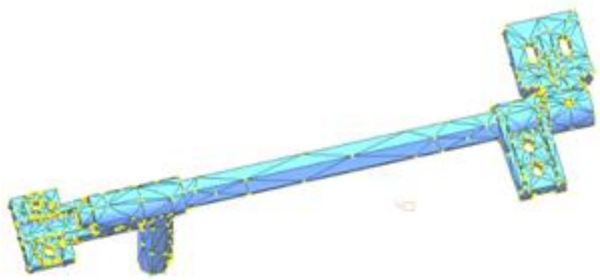

Figure 4: Mashed Result of Picking Mechanism.

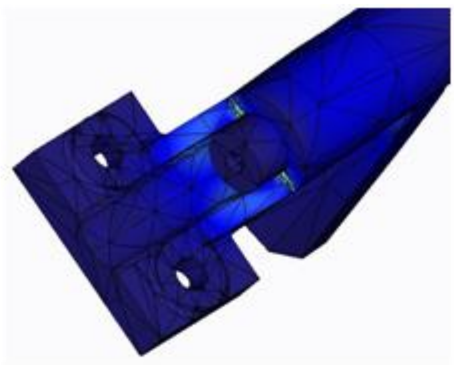

Figure 5: Simulated result of Picking Shaft bracket

Here as shown in Figure 4, the maximum stress concentration is at the portion of the bracket where corner has no fillet or chamfer, so that to reduce stress concentration, there must be radius of chamfer.

3.3 Comparison of Existing and New Picking Bracket

Figure 6: Existing Bracket

Figure 7: New Bracket

Here, as per existing and new design of Picking shaft bracket there are changes of add chamfer of 5.3mm at where maximum stress are concentration occurs, as well as there is add support at bottom portion of bracket where it fit with frame. So there is increased weight of bracket approx. 70grams, but at customer level problem of failure of picking bracket will reduce. Given table below shows the comparison of two different design of picking bracket, and gives the result of Von-meshes stress reduces from 61.81N/mm^{2}to 54.4413N/mm^2.

Table 1: Comparison of Existing and New Picking Bracket using Creo-Simulated Report

	Existing Bracket	*New Designed Bracket*
Parameters		
max_disp_mag	0.0767686 mm	0.0809646 mm
max_disp_x	-0.0126717 mm	-0.0150417 mm
max_disp_y	0.0281241 mm	0.0301457 mm
max_disp_z	0.0728314 mm	0.0769162 mm
max_stress_vm	61.8167 N/mm^2	54.4413 N/mm^2
max_stress_xx	22.0598 N/mm^2	22.9736 N/mm^2
max_stress_xy	25.2776 N/mm^2	26.1391 N/mm^2
max_stress_xz	11.5682 N/mm^2	-11.7548 N/mm^2
max_stress_yy	-39.5681 N/mm^2	38.6644 N/mm^2
max_stress_yz	24.6041 N/mm^2	22.1625 N/mm^2
max_stress_zz	-14.8263 N/mm^2	-15.4293 N/mm^2

4. Number of Stress cycle for picking shaft bracket

From the above selection it has been found that the diameter of the hexagonal is minimum about of 30mm, but it is of due importance to find the fatigue life of the picking shaft so it will be calculated from the following data:

Ultimate tensile strength, S_{ut} = 200MPa
Yield Strength, S_{yt} = 190MPa
Theoretical endurance limit

$$S_{e'} = 0.5 \times S_{ut} \tag{7}$$

Endurance limit of the component,

$$S_e = S_{e'} \times k_a \times k_b \times k_d \times k_e \times k_f \tag{8}$$

Where,
k_a= surface finish factor = 0.75, for machined or cold drawn
k_s = size factor = 0.81, for rotating shaft
k_t = Temperature factor = 1, for temperature of T≤ 450℃
k_l = Load factor = 1, for rotating, bending shaft carrying dead weight at the end.
k_f = Notch sensitivity factor = 1, least sensitive to notch
Factor of safety = 2
Now, equation of S-N curves,

$$log s_n = \log a + (b \times \log N')^{[2]} \tag{9}$$

Where,
$S_n = 0.9 S_{ut}$ = 0.9×200 = 180MPa, after calculating the stress cycles using above equation (9)
N’ = 1122.012.

5. Conclusions

1) As the add radius and support in the picking shaft bracket, which is made from cast Iron there is reduced stress concentration from where it’s break down possibilities is maximum and its reduces from 61.81N/mm^2 to 54.44N/mm^2.
2) As well as there is change in shape from round to hexagonal of picking shaft with the dimension of A/S of 30mm, reduce the assembly stress concentration.
3) Also the life cycle of the picking shaft is 1122 cycles during stress concentrations.

References

[1] Thomas W. Fox, ``The mechanism of weaving", Macmillan and Co. London, chap.2, p.3, 1984
[2] Machine Design by R.S. Khurmi, J.K. Gupta, Chap. 27, p.1010, 2005.
[3] Machine Design by R.S. Khurmi, J.K. Gupta, Chap. 18, p.688, 2005.
[4] Theory of machine cam and follower
[5] R. Marks, A. T. C. Robinson. ``Principles of weaving”. Chap 4, p.89, The Textile Institute, February 1986
[6] Terminal velocity of shuttle
[7] T. Ishida & K. Chikaoka, Variation of Shuttle-flight Conditions with Loom Speeds, J. Text Inst, Volume 78, Issue 5, p.363, 1987
[8] Sabit Adanur. “Handbook of Weaving” .Chap 7, p.174, CRC press, 200
[9] Prof. Dr. Emel ONDER. “Weaving Technology” Chap 6, p.78, Istanbul Techanical University.
[10] Dynamic Autolooms India Pvt. Ltd., Part Catalougue, Picking parts, p.25, PK-005, PK-006, PK-007, (PK-Indicate Picking Parts).