A Review - Design and analysis of let-off mechanism in shuttle loom

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Abstract

Weaving machine (loom) has very wide scope in modern textile. Shuttle and shuttle less weaving machines are widely used in textile industry. Tremendous developments has occurred in the field of shuttle less looms. As per Indian tradition, people have demand of clothes without selvage and low price. Therefore, it is necessary to develop the let-off mechanism of shuttle loom to achieve superior and cheap fabric quality of clothes.

There are five basic mechanisms in shuttle loom, shedding, picking, beat up, let-off and take up. Let off is the secondary motion , it is also known as warp unwinding or warp releasing motion. The main function of the let mechanism is to deliver the warp to the weaving area at required rate and the constant tension by unwinding it from the weaver's beam. Length of the path traveled by catch holder varies for different position of intermediate rod in leverage system and subsequently the cover factor and fabric quality of clothes are changed. Torque requirement at the crank has to be fulfilled by the driving motor. Kinematic and dynamic analysis of the compound mechanism can be performed to obtain the torque required at the crank to run the mechanism flawlessly.

Keywords: Leverage System, Cover Factor, Shuttle loom, shuttle less loom.

Introduction

Weaving is a method of fabric production in which two distinct sets of yarns or threads are interlaced at right angles to form a fabric or cloth.The longitudinal threads are called the warp and the lateral threads are the weft or filling. The method in which these threads are inter woven affects the characteristics of the cloth. Cloth is usually woven on a loom, a device that holds the warp threads and inserts weft threads into it. The warp and filling threads interlace with each other is called the weave.

1.1 Shuttle loom

The shuttle loom is the oldest type of weaving loom which use shuttle that contains a bobbin of filling weft thread that pass through the warp and return back to its original position. The shuttle is batted across the loom and during this process; it leaves a trail of the filling rate of about 110 to 225 picks per minute (ppm). It is very effective and versatile. The shuttle looms are slow and noisy.

1.2 Shuttle less Loom

The shuttle less loom is also used in weaving loom which uses different devices other than the shuttle, which passes weft from one side to another side of loom. There are many type of shuttle less looms are used for weaving such as Projectile Looms, Rapier Looms, Water Jet Looms and Air Jet Looms.

Weaving Operations

1.2.1 Shedding:

In weaving, the shedding is the temporary separation between upper and lower warp yarns or threads through which the weft is passing. The shed is created to make it easy to pass the weft into the warp and thus produce fabric on loom. Many of looms have some sort of device which separates some of the warp threads from others. This is called the shed and allows for a shuttle carrying the weft thread to move through the shed perpendicular to the warp threads.In shedding some of warp threads are raised, some are lowered.

1.2.2 Picking

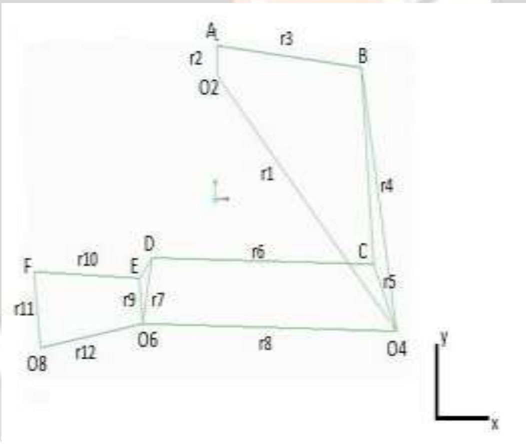
The picking is mechanism which passes weft thread from one side of the fabric to the other side using any one of shuttle, a projectile, a rapier, a needle, an air jet , a water jet. Inserted weft thread is known as pick. The shuttle is normally pointed at one end that pass through the shed. The Filling yarn or weft thread come through a hole in the shuttle as it moves across the loom. A single cross of the shuttle from one side of the loom to the other side is known as a pick. Shuttle is use to insert the weft thread through the warp threads, and this operation is known as a picking operation.

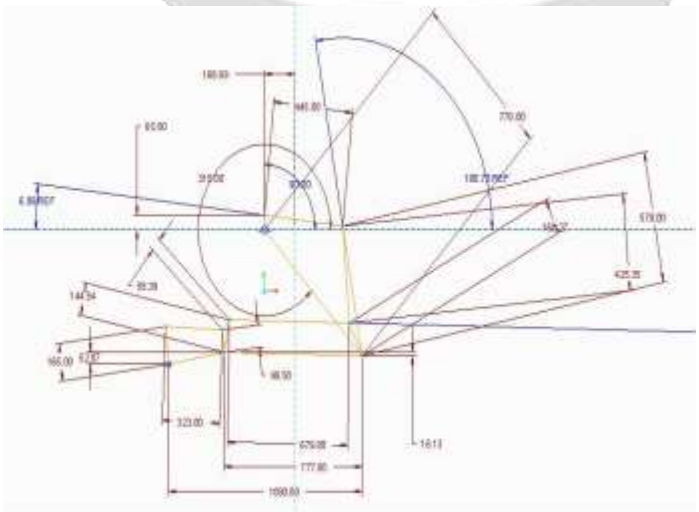
KINEMATIC ANALYSIS OF LET-OFF DRIVE MECHANISM

In this chapter kinematic analysis of let-off drive mechanism has been carried out. Loop closure approach has been used to carry out analysis. The analysis carried out in this chapter which helps in deriving the acceleration and velocity behavior of the compound mechanism.

The advantage of the spreadsheet is that one need to transform the equation in the form of cell address of the data for a particular position. And once the data is generated, simply by dragging down one can have the output of the links for position, velocity and acceleration for each and every input angle of the crank. From the generated data we can have the graph of the performance of the link for particular angle of the input link. These graphs can be helpful to observe how a link will behave throughout its one cycle

1. Position,velocity and acceleration analysis of let-off drive mechanism





Position,velocity and acceleration analysis for crank-rocker

Mechanism

Acceleration of link 3 and link 4 for crank-rocker mechanism (_3 and _4) are solved based on the loop closure equations.

$$A = 2\mathrm{r}_1\mathrm{r}_4\cos\theta_1 - 2\mathrm{r}_2\mathrm{r}_4\cos\theta_2 \qquad (3.1)$$

$$B = 2\mathrm{r}_1\mathrm{r}_2\cos\theta_1 - 2\mathrm{r}_2\mathrm{r}_4\sin\theta_2 \qquad (3.2)$$

$$\mathrm{C} = r_1^2 + r_2^2 + r_4^2 - r_3^2 - 2r_1 r_2(\cos\theta_1 \cos\theta_2 + \sin\theta_1 \sin\theta_2) \quad (3.3)$$

$$\theta_4 = 2arctan\left[\frac{-B+\sigma\sqrt{B^2-C^2+A^2}}{C-A}\right] ; \sigma = \pm 1 \qquad (3.4)$$

$$\theta_3 = \arctan\left[\frac{\mathrm{r}_1\sin\theta_1+\mathrm{r}_4\sin\theta_4-\mathrm{r}_2\sin\theta_2}{\mathrm{r}_1\cos\theta_1+\mathrm{r}_4\cos\theta_4-\mathrm{r}_2\cos\theta_2}\right] ; \sigma = \pm 1 \qquad (3.5)$$

$$r_A = r_2 = r_2(\cos\theta_2\, i + sin\theta_2\, j) \qquad (3.6)$$

Velocity Equations

$$\begin{bmatrix} -r_3\sin\theta_4 & r_4\sin\theta_4 \\ -r_4\cos\theta_3 & r_4\cos\theta_4 \end{bmatrix}\begin{Bmatrix} \ddot{\theta}_3 \\ \ddot{\theta}_4 \end{Bmatrix} = \begin{bmatrix} r_2\ddot{\theta}_2\sin\theta_2 \\ r_2\ddot{\theta}_2\cos\theta_2 \end{bmatrix} \qquad (3.7)$$

$$\ddot{r_A} = \ddot{r_2} = \left(-r_2\ddot{\theta}_2\sin\theta_2 - r_4\ddot{\theta}_2^2 cos\theta_2\right)i + \left(r_2\dot{\theta}_2^2 cos\theta_2 - r_2\dot{\theta}_2^2 sin\theta_2\right)j$$

$$\ddot{r_B} = \left(-r_4\ddot{\theta}_4\sin\theta_4 - r_4\ddot{\theta}_4^2 cos\theta_4\right)i + \left(r_4\dot{\theta}_4^2 cos\theta_4 - r_4\dot{\theta}_4^2 sin\theta_4\right)j$$

For input values of our interest, Solving above equations.

Input Variables :-

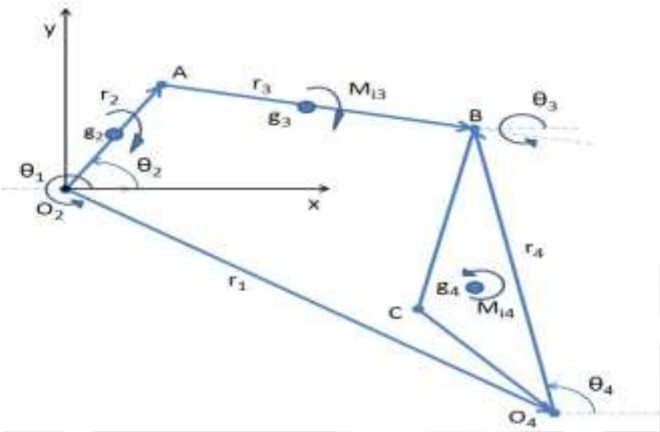
$$\theta_2 = 90\,, \dot{\theta}_2 = 12.56\frac{rad}{s} \;\; \ddot{\theta}_2 = 0\, rad/s^2$$

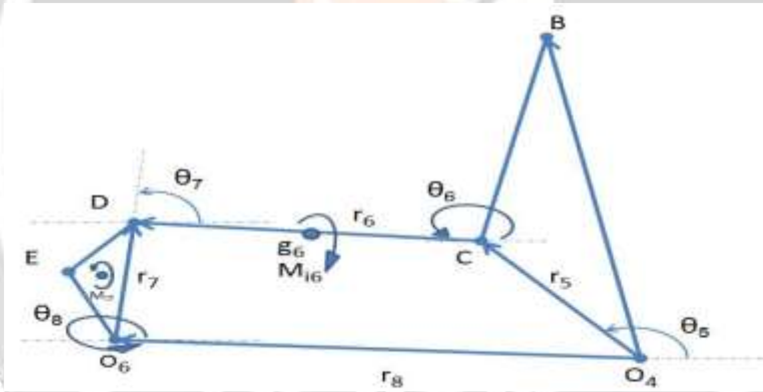
DYNAMIC ANALYSIS OF LET-OFF DRIVE MECHANISM

In this chapter dynamic analysis of let-off drive mechanism has been carried out. Dynamic equilibrium equations has been used to calculate force values. The analysis carried out in this chapter which helps in deriving the force and moments acting on link members. Arc length of the catch holder is a critical design parameter. For various possible combinations of joint rod will be calculated.

Dynamic analysis is carried out to obtain the torque required at the crank to run the mechanism at the constant given rpm. The Kinematic analysis results are useful for calculating the dynamic properties of the link members. The link masses are considered at the center of gravity of the link. It is to be considered that the mechanism as a planner mechanism to simplify our problem. Also the link shapes are simplified to obtain the solution.

Free body diagram of the crank rocker mechanism

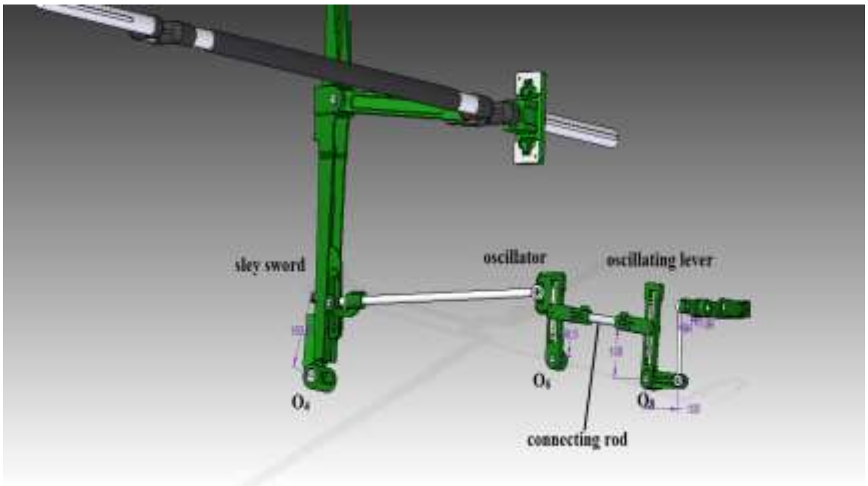




Arc length for different fixed position of joint rod between oscillator and oscillating lever

Assume, this mechanism as line diagram as discussed in chapter 3 (Kinematic analysis of let off mechanism) and take O4, O6, O8 as the fixed points for the leverage system to drive let-off mechanism, The arc length is calculated from following equation :

arc = r x Θ



r_5	arc	∅	r_9	r_{11}	arc_3
160	36.36	13	98.5	108	37.99

Arc calculation for varying lenth of oscillating lever

r_5	arc	∅	r_9	r_{11}	arc_3
160	36.36	13	98.5	110	37.30
160	36.36	13	98.5	115	35.68
160	36.36	13	98.5	120	34.19
160	36.36	13	98.5	125	32.82
160	36.36	13	98.5	130	31.56
160	36.36	13	98.5	135	30.39
160	36.36	13	98.5	140	29.30
160	36.36	13	98.5	145	28.29
160	36.36	13	98.5	150	27.35
160	36.36	13	98.5	155	26.47
160	36.36	13	98.5	160	25.64
160	36.36	13	98.5	165	24.86

Specification of loom

Crank radius (r2) = 0.065 m.
Crank arm (Connecting rod) (r3) = 0.445 m.
Rocker arm (Sley sword) (r4) = 0.578 m.
Center distance between two fixed links (r1) = 0.778m.
distance between fulcrum of slay sword and regulating rod (r5)=0.160m
Regulating rod (r6)=0.679m
Oscillator (r7)=0.144m
Distance between two fixed links (slay sword and oscillator) (r8)=0.777m
Joint rod (r10)=0.323m
Oscillating lever (r11)=0.165m
Distance between two fixed links (oscillator and oscillating lever) (r12)=0.318m
Crank mass (m2) = 32 kg.
Connecting arm mass (m3) = 3 kg
Rocker arm (Total lumped mass) (m4 and m5)= 5 kg
Mass of regulating rod (m6)=1.04 kg

Oscillator mass (m7 and m9)=1.12 kg
Joint rod mass (m10)=1.5 kg
Oscillating lever mass (m11)=2 kg
Crank angle ($\theta 2$) = 0 to 360 degrees
Loom speed (N) = 120 rpm
Rocker angle (Slay angle) ($\emptyset 1$) = 13.5degree

-Conclusion

In this review paper, size specification of shuttle looms Let off mechanism for different combination of joint rod end position, arc length of the last link is calculated. The length of path travel by catch holder is obtained for different position of intermediate rod of leverage system, which improves cover factor and fabric quality of clothes.

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