Numerical Analysis of Picking Mechanism of Power Loom with use of Lagranges’s Method

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Abstract. The vibration analysis of Picking mechanism of Power loom carried numerically employing Lagranges’s Equation with treating forced vibration with multi-degree of freedom. From Lagranges’s Equation provides equation motion. The equation of motion is used to determine the natural frequency of system.

Keywords. Natural frequency, Lagranges’s Equation, Forced vibration, Multi-degree of freedom.

1. Introduction

In textile machine, Power loom used to manufacture cloths. During operation creates vibration and noise due to unbalanced forces, impact forces, friction and moving parts. In order to avoid failure of parts finding of natural frequencies essential to avoid resonance condition. The researcher developed mathematical model of metamaterial beam, transfer matrix and significant reduction of vibration[1]. Vibration characteristics and Governing equation is investigated for circular guided saw [2]. Vibration response of bridge is investigated under vehicle load and structural FE model developed[3]. Numerical and experimental analysis is carried on planetary gear system and estimated the natural frequency[4]. Numerical simulation carried on symmetric rotor with presence of crack for vibration response[5].Ritz method is employed to determine the free vibration for curvilinear shallow shell and strain, stiffener and kinetic energies are quantified[6]. Characteristic equation is developed to evaluate vibration frequencies for tapered cantilever with tip mass[7]. Numerical analysis investigated for thin rectangular plate and at bottom filled with liquid, two methods are used to calculate vibration characteristics[8]. Dynamic model for pre-twisted blade system studied, stretching, bending and torsion effects evaluated for model[9]. The vertical, lateral and roll vibration studied for seated human body with multi-body dynamic model. Model used for analysis with following parameters ride vibration, weights, heights and comfort of passengers with multiple excitation[10].Solar panel with satellite’s hinge stiffness support frequency analysis carried, hinge stiffness simulator developed, frequency and stiffness changes based on length and diameter[11]. The equation of motion developed for rotating structure, static and dynamic behavior studied using Finite element model[12]. Three dimensional flexible ring model developed for tire to evaluate vibration analysis of tire, equation of motion developed for different direction of vibration such as lateral, radial and longitudinal[13]. The cantilever beam modeled for frequency analysis with nonlinear vibration and Kelvin–Voigt damping model is used for damping[14]. Studied free vibration for Magnetorheological elastomers embedded sandwich plate. The Lagrange method and finite element method used and governing equation is derived[15]. Estimated nonlinear frequencies for high-speed rotor bearing with unbalanced mass. The equation of motion developed using energy method considering kinetic energy and potential energy [16]. Dynamic analysis carried for drum type washing
machine. The mathematical model developed with considering 6 degree of freedom and dynamic analysis performed using METLAB[17]. Mathematical model developed for rotor bearing system with damping rings subjected base excitation, the influence of following parameters are considered rolling bearing stiffness, rubber damping rings, analysis of unbalanced response and foundation excitation[18]. Number of researcher worked on different systems for vibration analysis using numerical methods. The aim research paper to deriving the equation of the motion and natural frequency using Lagranges’s method for the Picking mechanism of the Power Loom

2. Methods

Lagranges’s method
Lagranges’s equation used to write equation of motion of the vibration system. Using concept of conservative system, sum of kinetic energies and potential energies is constant.

The generalized coordinate Lagranges’s equation

\[
\frac{d}{dt} \frac{\partial (K.E)}{\partial \dot{x}_j} - \frac{\partial (K.E)}{\partial x_j} + \frac{\partial (P.E)}{\partial x} = F_j
\]  

(1)

K. E=Total Kinetic Energy
P. E= Potential Energy
F=External Force
J=1,2,3,4............n;

Energy Method
The sum of kinetic energy and Potential Energy is constant according to conservative energy system.
K.E + P. E=constant

3. Mathematical Model
The Picking Mechanism mounted up on both side with opposing each other and held against frame by bottom footstep bearing shown in fig.1. The Picking shaft is fixed with Picking Cone, picking cone is held against Picking tappet nose with impact force between them. The Picking stick attached to the Picking shaft formed with wooden. The Shuttle travels to and fro due force imparted by Picking stick and Picker. The shuttle is carried with weft thread (transverse thread). The crank shaft completes one revolution every single pick and is driven by the Motor pulley. The bottom shaft complete one revolution for two picks of shuttle. The crank shaft gear and Bottom shaft gear positioned on the crank shaft and bottom shaft respectively.
Fig. 1 Three dimensional view of Picking mechanism of Power Loom

List of symbols

- $J_1, J_2$ Mass moment of inertia crankshaft gear and Bottom shaft gear respectively.
- $K_1, K_2, K_{ps}$ Stiffness of crankshaft, bottom shaft and Picking stick respectively.
- $m_s, m_{shaft}$ Mass of the shuttle and Mass of the Picking stick respectively.
- $\Theta$ Horizontal oscillation or displacement of Picking Stick.
- $\dot{\Theta}$ Torsional velocity
4. Mathematical Formulation

Refer fig. 2 the mechanical model Picking mechanism with considering multi-degree of freedom. The formulation motion equation carried using energy method and for solution of motion equation evaluated using numerical method Lagranges’s Equation. The Excitation force is provided by the picking tappet nose bit with magnitude of \( mr\omega^2 \)

\[
\frac{1}{2} K_1 \dot{\theta}_1^2 + \frac{1}{2} K_2 \dot{\theta}_2^2 + \frac{1}{2} m_{ps} (l_{ps} \dot{\theta}_3)^2 + \frac{1}{2} m_{shaft} (l_{shaft} \dot{\theta}_4)^2
\]

Considering Single Degree of freedom system with forced vibration

\[
\frac{1}{2} K_1 \dot{\theta}_1^2 + \frac{1}{2} K_2 \dot{\theta}_2^2 + \frac{1}{2} K_{ps} (l_{ps} \dot{\theta}_3)^2 + \frac{1}{2} K_{shaft} \dot{\theta}_4^2
\]

Lagranges’s equation

\[
\frac{d}{dt} \frac{\partial (K.E)}{\partial \dot{x}_j} - \frac{\partial (K.E)}{\partial x_j} + \frac{\partial (P.E)}{\partial x} = F_j
\]

Applying Lagranges’s equation for equation (2) and (3) results into following equation of motion

\[
j_1 \ddot{\theta}_1 + k_1 \dot{\theta}_1 = 0
\]
\[
j_2 \ddot{\theta}_2 + k_2 \dot{\theta}_2 = 0
\]
\[
m_s \ddot{\theta}_3 + k_s \dot{\theta}_3 = 0
\]
\[
m_{shaft} \ddot{\theta}_4 + k_{shaft} \dot{\theta}_4 = mr\omega^2
\]

Solving the above equations using matrix method, provides four frequencies.

\[
\begin{bmatrix}
0 & 0 & 0 & 0 \\
0 & j_2 & 0 & 0 \\
0 & 0 & m_s & 0 \\
0 & 0 & 0 & m_{shaft}
\end{bmatrix}
\begin{bmatrix}
\ddot{\theta}_1 \\
\ddot{\theta}_2 \\
\ddot{\theta}_3 \\
\ddot{\theta}_4
\end{bmatrix}
= \begin{bmatrix}
k_1 & 0 & 0 & 0 \\
0 & k_2 & 0 & 0 \\
0 & 0 & k_{ps} & 0 \\
0 & 0 & 0 & k_{shaft}
\end{bmatrix}
\begin{bmatrix}
\dot{\theta}_1 \\
\dot{\theta}_2 \\
\dot{\theta}_3 \\
\dot{\theta}_4
\end{bmatrix}
\]

5. Conclusion

General numerical solution is obtained for multi-degree of freedom system for Picking mechanism of power loom. Energy method and Lagranges’s equation used to derive governing equation of motion. The Governing equation of motion is solved using matrix method results into multiple frequencies.

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