Dynamic Performance with Kinematic of Cleaning Unit in Thresher Machine

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Abstract: A machine that separates grains from harvested crops quickly and with little effort is known as a thresher. It is suitable for threshing mustard, jowar, maize, wheat, and millet. There are three main mechanisms, namely feeding, threshing, and cleaning in the machine. The mechanism in the cleaning unit is identified as a simple four-bar mechanism. The performance of the mechanism is analyzed using the Newton-Euler equation of motion in this work. The dynamic performance of this mechanism is validated by ADAMS software.

Keywords: Thresher machine, Kinematic, Dynamic analysis, Adam software

1. INTRODUCTION

Thresher machine used in agriculture was first invented in 1786 by Scottish mechanical engineer Andrew Meikle. This machine is used to separate grains from plants quickly and with little labor. It involves three mechanisms as threshing, feeding, and cleaning. In feeding mechanism, dry crop feeds continuously into feeding hopper using manually or a suitable conveyor system. Threshing is the process of removing grains from panicles and separating them from the bulk of the straw. It is accomplished by the cutter and beaters attached to threshing drum as seen in Figure 1. In cleaning unit, the grains then pass through a concave into a cleaning device. Three sieves move back and forth to clean the grains. A fast-moving air is sent by a blower that blows out husk which is lighter than grains.

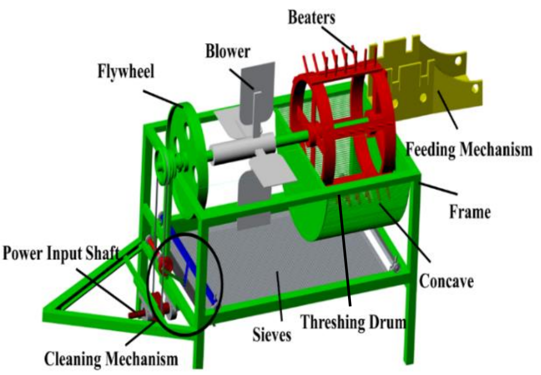

Figure 1. A thresher's working model

The performance of threshing unit can be measured on the basis of efficiency, capacity, damage or losses of grains with respect to threshing parameters such as feed rates, types of drums and their speeds [1]. The cleaning process can be modeled in sorghum thresher unit [2]. Both axial and tangential threshing units can be used to represent the threshing and separation of grains. The percentages of unthreshed grain, free grain, and separated grain along the rotor or concave length are described and calculated using a model [3]. In a developed threshing device, the impact of parameters like feed rate and drum speed is displayed on a closed capsule sesame straw sieve [4]. The design issues in conventional thresher machine such as there is no provision for separation of seeds from the chaffs, more labor and time consuming are improved [5]. A model for threshing of Cereal is designed which in-cooperate friction between the crop surface and threshing cylinder [6]. To evaluate the load application pattern and physiological work load while operating the pedal-operated paddy thresher, four alternative designs of thresher drive-linkages are adopted in place of the four-bar linkage design now in use [7]. A threshing machine for the millet is designed and it tested for the different moisture content percentages and threshing cylinder speeds. As the moisture content drops, the millet thresher operates more effectively [8]. All dimensions are taken from workshop [9]. A CAD model of thresher machine is shown in Fig.1.In this paper, a simple four bar mechanism is identified in the cleaning mechanism. The kinematic and dynamics analysis of the cleaning mechanism is performed. This paper is organized as follows. Sec. 2 and 3 describes the kinematic and dynamic analysis of cleaning mechanism. In section 4, a numerical example is solved, and the outcomes are shown. In section 5, conclusions are provided.

2. KINEMATIC ANALYSIS OF CLEANING MECHANISM

Cleaning mechanism separates the grains from straw when grains move over reciprocate the sieves, a fast-moving air is sent by a blower. Four links in the cleaning mechanism are shown in Fig. 2. Sieves are attached to the link 4. It is a four-bar crank-rocker Grash of Mechanism.

2.1 Position Analysis

Link 2 as input link rotates at 600 rpm in anticlockwise direction and link 4 is the output link at which sieves are attached. The angle θ3 and θ4 with respect to input θ2 is found out using loop closure equations [10].

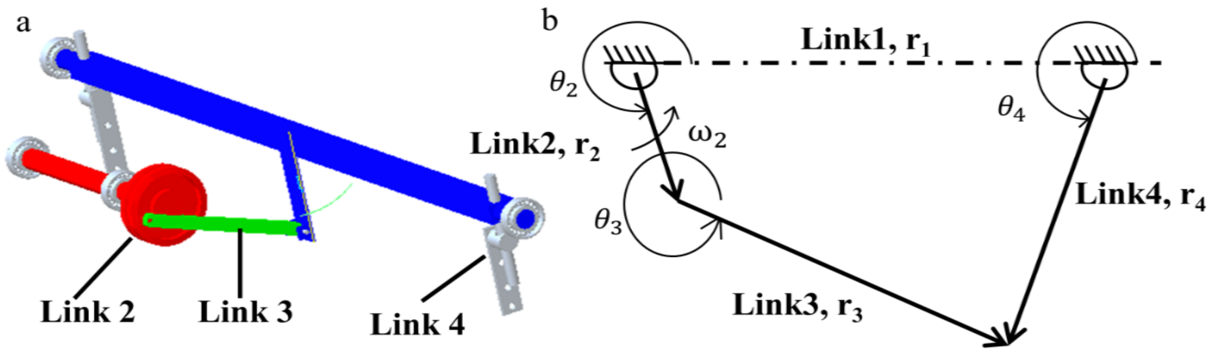

Figure 2. (a) Cleaning Mechanism in Thresher Machine (b) Four Bar Mechanism

If r_1, r_2, r_3 and r_4 are vectors of length of links respectively, then the vector loop closure equation gives the vector sum of lengths as

$$\vec{r_3} + \vec{r_2} = \vec{r_4} + \vec{r_1} \qquad (1)$$

Link 3 and link 4's angular velocities and accelerations are calculated by differentiating equation (1) with respect to time.

3. DYNAMIC ANALYSIS OF CLEANING MECHANISM

The Newton-Euler equation of motion is used to resolve the dynamics analysis of this mechanism. The Newton-Euler equation in vector form is used to determine the reaction forces in joints and driving torque as

$$\left.\begin{aligned} \sum \boldsymbol{F} &= m\boldsymbol{a_G} \\ \sum \boldsymbol{T} &= \boldsymbol{I_G}\,\boldsymbol{\alpha} \end{aligned}\right\} \qquad (2)$$

Where F represents total force on each link, m represents the link's mass, $\boldsymbol{a_G}$ represents the acceleration of the link's center of gravity, T is sum of all moments, $\boldsymbol{I_G}$ is link's moment of inertia about its center of gravity, the link's angular acceleration is indicated by $\boldsymbol{\alpha}$.

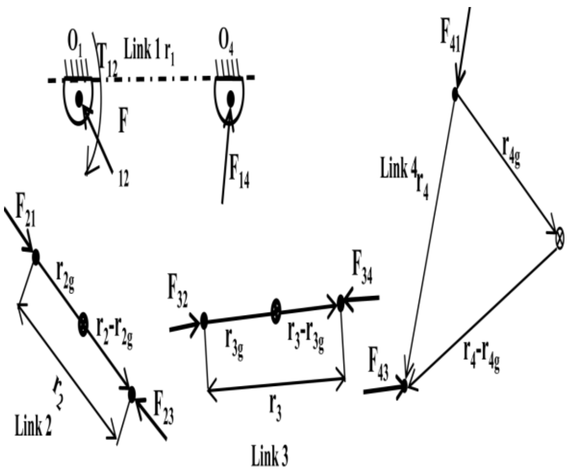

Figure 3. Free body diagram of links in cleaning mechanism

Three dynamic equilibrium equations can be developed for each link based on the free body diagrams (Fig. 3) in terms of forces in the X and Y directions and moments about the center of gravity of the link. Hence there are a total of nine equations for this mechanism. These equations make 9×9 matrix given by Equation (3). Equation (3) is used to determine the forces acting on each link of cleaning mechanism and driving torque (T_{12}) developed by Tractor Power Take Off (PTO).

$$\begin{bmatrix} 1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ \mathrm{r}_{2gy} & -\mathrm{r}_{2gx} & (\mathrm{r}_{2y}-\mathrm{r}_{2gy}) & -(\mathrm{r}_{2x}-\mathrm{r}_{2gx}) & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & \mathrm{r}_{3gy} & -\mathrm{r}_{3gx} & (\mathrm{r}_{3y}-\mathrm{r}_{3gy}) & -(\mathrm{r}_{3x}-\mathrm{r}_{3gx}) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & -(\mathrm{r}_{4y}-\mathrm{r}_{4gy}) & (\mathrm{r}_{4x}-\mathrm{r}_{4gx}) & \mathrm{r}_{4gy} & -\mathrm{r}_{4gx} & 0 \end{bmatrix} \begin{bmatrix} F_{12x} \\ F_{12y} \\ F_{23x} \\ F_{23y} \\ F_{34x} \\ F_{34y} \\ F_{14x} \\ F_{14y} \\ T_{12} \end{bmatrix} = \begin{bmatrix} m_2 \times a_{2gx} \\ m_2 \times a_{2gy} \\ I_{g2} \times \alpha_2 \\ m_3 \times a_{3gx} \\ m_3 \times a_{3gy} \\ I_{g3} \times \alpha_3 \\ m_4 \times a_{4gx} \\ m_4 \times a_{4gy} \\ I_{g4} \times \alpha_4 \end{bmatrix} \quad (3)$$

4. NUMERICAL EXAMPLE

Parameters of links for cleaning mechanism are shown in Table1 and link2 (crank) rotates with constant speed of 600 rpm.

Fig.4 a, b and c represent the variations of reaction forces of link 2 and link4 on link1 and driving torque respectively, with respect to time which are validated using MSC ADAMS Student Edition.

Table 1 Parameters of links for Cleaning Mechanism

Link	**Length , r_i (m)**	**Length , $r_i g$ (m)**	**Mass, m_i (kg)**	**Moment of inertia about CM, I_i^c (kg-m^2)**
1(Frame of thresher)	0.21698	Reference link	Reference link	Reference link
2 (Driving pulley)	0.040	0.0	7.0549488	6.402897e-02
3 (Connecter)	0.243	0.1215	0.6026193	36.36078e-6
4 (Sieve assembly)	0.141	0.808933	81.079	2.9726102e+01

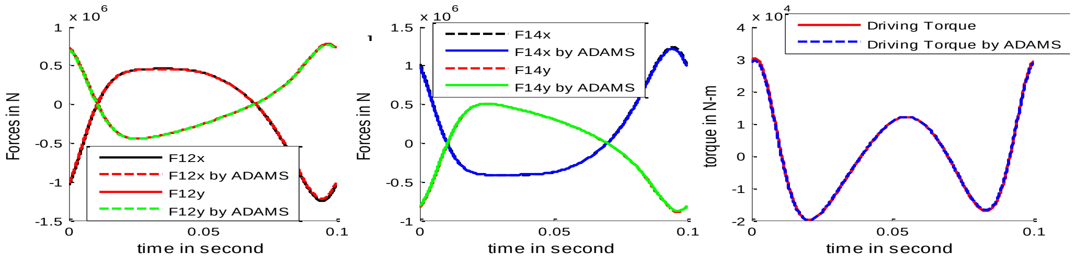

Figure 4. (a,b) reaction forces (c) driving torque

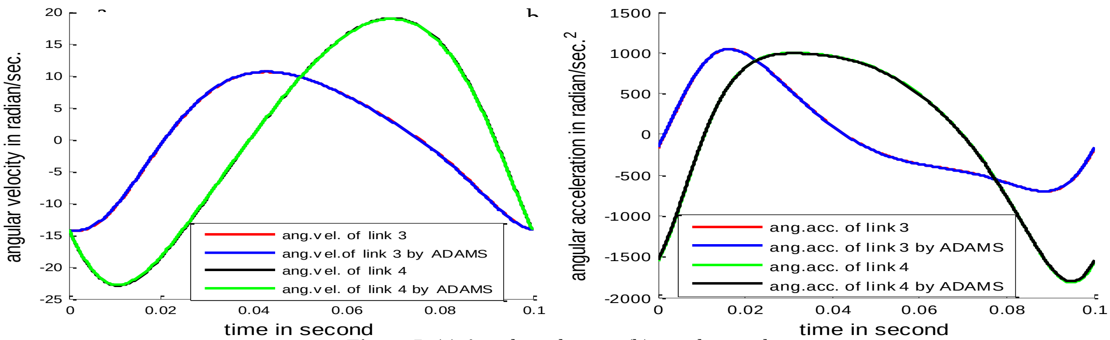

Figure 5. (a) Angular velocities (b) angular accelerations

The variations of the angular velocities and angular accelerations of links 3 and 4 with respect to time are shown in Figures 5 (a) and 5 (b), respectively. Same results are obtained using MSC ADAMS Student Edition 2014.

5. CONCLUSIONS

Lesser research on the kinematic and dynamic analyses of the cleaning mechanism of the thresher machine is reported in the literature. The four-bar mechanism is identified in the cleaning mechanism of the thresher machine. In order to improve the dynamic performance of the mechanism, kinematic and dynamic analyses of the mechanism are performed in this research. MSC ADAMS Student Edition 2014 is used for validation.

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