DEVELOPMENT OF POST HARVEST FOOD PROCESSING MACHINE

K.S.Zakiuddin , J.P.Modak

Abstract

kadwa is hay cut into small pieces for feeding to livestock. It is a good fodder, and at its best when it is cleanly and evenly cut, free of dust, of good colour and with a fresh aroma. kadwa can be purchased from commercial kadwa cutting mills. Cutting kadwa can be done by manually and electric operated cutting machine, as far as cutting manually is concerned. Traditionally for the operator it is done manually which is physically demanding through it energy and postural requirements and is commonly regarded as source of drudgery. Many farmers associated with this task reported back, shoulder and wrist discomfort. It may also cause clinical or anatomical disorders and may affect worker's health. The machine consists of a human powered flywheel motor using a bicycle-drive mechanism with speed increasing gearing and a flywheel, which drives the process unit through a spiral jaw clutch and torque-increasing gearing.

Manually energized flywheel motor has been adopted for many designs of rural applications in the last two decades, establishing functional feasibility and economic viability of energized process machines. The paper presents experimental work executed for establishing generalized experimental based empirical model for kadwa-cutting operation. Estimation of mathematical model and its simulation. Some third world development projects currently transform used bicycles into pedal powered tools for sustainable development. The articles discuss about the applications for pedal power technology.

Keywords: Flywheel, Spiral Jaw Clutch ,Kadwa Cutter.

1 Need for Manually Energized Fodder Cutter

Developing countries like India are facing problems of Power storage due to rapid industrialization.Non availability of power in Interior areas and large scale unemployment of semi-skilled worker. In the context of the present condition in India of Power shortage and exhaustion of coal reserves and unemployment, it is felt that “Manually Energized Kadwa Cutter machine” for cutting kadwa is very necessary. This machine is environment friendly i.e. non-pollutant. It will bring Innovation & mechanization in agricultural engineering. Unskilled women may also get employment. Development of such an energy source which has tremendous utility in energizing many rural based process machines in places where reliability of availability of electric energy is much low. In the recent past a human-powered process machine has been developed for brick making [1] Wood turning [2], Finger type torsionally flexible clutch [3] and manually energized battery charging unit [4] .

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2 Concept of manually energized Chaff Cutter

The average work rate of a man working continuously is equivalent to 75W [5]. Therefore only continuous manufacturing process requiring less than 75W can be man powered. Any manufacturing process requiring more than 75W and which can be operated intermittently without affecting end product can also be man powered. Such man powered manufacturing process can be based on the following concept.

In this processes a flywheel is used as a source of power. Manpower is used to energize the flywheel at an energy input rate, which is convenient for a man. A rider rides the bicycle, after maximum possible energy is stored in flywheel it is supplied through suitable clutch and gearing system to a shaft, which operates the process unit. The flywheel will decelerate at a rate dependent on load torque. Larger the resisting torque larger will be the deceleration. Manually driven kadwa cutting machine operates on the basis of above principle. If such machine is developed it will be great help to farmers of rural area because it does not need conventional energy. It is environment friendly.

3 OPERATION

Schematics of a System are described in Fig.1, 2 it comprises of a bicycle mechanism, speed rise gear pair having speed amplification ratio and a flywheel. A human being paddles the system and energizes flywheel of the size 1m rim diameter x 10cm rim width x 2cm rim thickness to the speed of 700-800 rpm in a minute’s time. This stores around 3000 kgf m of energy in a flywheel in a minute’s time. Then the paddling is stopped and torsionally flexible clutch is engaged which communicates stored energy in the flywheel to a process unit. Upon engagement of the clutch there is instantaneous momentum transfer. Hence, a complete system is subjected to a severe shock. The input shaft of the process unit suddenly accelerates on load to the maximum possible speed and then subjected to a speed decline as energy is drawn from the flywheel to overcome the process resistance. The exhaustion of the flywheel energy occurs during 15-20 seconds amounting to the extent that the processes needing h p in the range 2 hp to 8 hp can be energized by such a system. The energy stored in flywheel is supplied at the required rate to shaft of the chaff cutter and cutting of fodder , to obtain small pieces of fodder. A free wheel is used between pedals and the flywheel to prevent the back flow of energy from flywheel to pedals. A special jaw clutch is used in this machine in place of conventional friction clutch. A manually driven type fodder cutter machine is being developed in absence of any design data. The functional feasibility and economic viability of this concept is confirmed of manually energized kadwa cutter machine

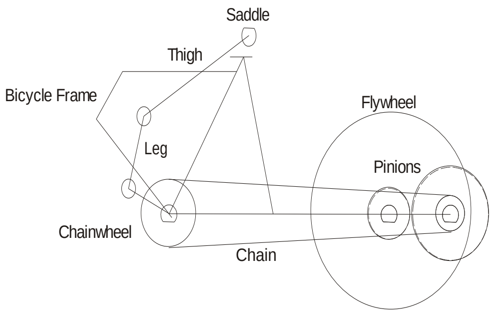

Figure 1: Energy unit and the transmission system.

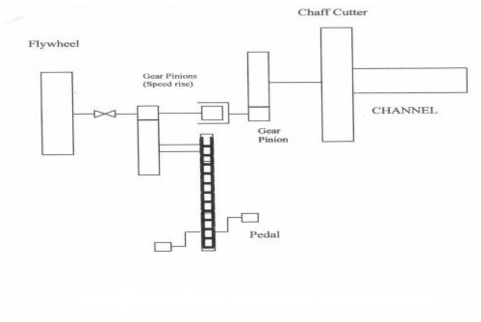

Figure. 2. Schematics of Kadwa Machine

4 Design of Experimentation

Generalized experimental models for Resistive Torque, Number of Cuts, and Process time are established adopting methodology of experimentation [6]. It is planned to generate design data by performing extensive experimentation by varying physical quantities encountered in the process of cutting over the widest range. The planning of experimentation is carried out by using the classical plan of experimentation [7]. The response data is collected based on this entire generalized models are formed.

The Methodology of Experimentation is briefly stated as under:

(1) Identification of all independent, dependent and extraneous variables.
(2) Reduction of variables through dimensional analysis.
(3) Determination of Test Envelopes, Test points and Test sequence.
(4) Design of an Experimental Setup.
(5) Execution of experimentation to generate the experimental data.
(6) Purification of an experimental data.
(7) Formulation of the mathematical model of the dimensional Equation.
(8) Artificial Neural Network Simulation.

5 Dimensional Analysis

The process variables for manually energized kadwa cutter were identified and are as tabulated in Table 1. Dimensional analysis was carried out to established dimensional equations, exhibiting relationships between dependent π terms and independent π terms using Buckingham π theorem.

Table 1 - The process variables, their symbols and dimensions are listed

Sr. No.	*Description*	*Types of variable*	*Symbol*	*Dimensions*
1	Tip diameter of blade	Independent	D	L
2	Hub diameter	Independent	d	L
3	Acceleration due to gravity	Independent	g	LT^{-2}
4	No. of blades	Independent	n	-
5	Young modulus of elasticity of cutting blade	Independent	E	$ML^{-2}L^{-1}$
6	Width of cutting blade	Independent	W_b	L
7	Thickness of cutting blade	Independent	t_b	L
8	Cutting blade angle	Independent	α	-
9	Equivalent moment of inertia of flywheel	Independent	I	ML^2
10	Angular velocity of flywheel	Independent	ω	T^{-1}
11	Gear ratio	Independent	G	-
12	Sp time instant during cutting operation	Independent	t_c	T
13	Kinetic Energy of flywheel	Independent	e	ML^2T^{-2}
14	Instantaneous torque on cutting blade	Dependent	Tc	ML^2T^{-2}
15	No. of cuts during cutting	Dependent	Cp	-
16	Process time for cutting chaff	Dependent	t_p	T

M, L and T are the symbols for mass, length and time respectively.Dimensional analysis can be used primarily as experimental tool to combine many experimental variables into one. The main purpose of this technique of is making experimentation shorter without the loss of control.

Resistive torque

$Tc = f[(d/D), n, (D^4/gI)E, (W_b/D), (t_b/D), \alpha, (\sqrt{(D/g)}\ \omega), G]\ \sqrt{(g/D)}\ t_c]$

$(D/gI)\ Te = f\ [\ (dW_b\ t_b/D^3), (D^4/gI)E, \alpha, G, n, (\sqrt{(D/g)}\ \omega)\ \sqrt{(g/D)}\ \ t_c]$ (1)

Number of cuts

$C = f[(dW_b\ t_b/D^3), (D^4/gI)E, \alpha, G, n, (\sqrt{(D/g)}\ \omega)]\ \sqrt{(g/D)}\ t_c]$

$\sqrt{(D/g)}\ Cp= f[(dW_b\ t_b/D^3), (D^4/gI)E, \alpha, G, n, (\sqrt{(D/g)}\ \omega)]\ \sqrt{(g/D)}t_c]$ (2)

Process time for cutting

$t_p = f\ [(dW_b\ t_b/D^3), (D^4/gI)E, (\sqrt{(D/g)}\ \omega), G, \alpha, n]$

$\sqrt{(g/D)}\ t_p = f[(dW_b\ t_b/D^3), (D^4/gI)E, (\sqrt{(D/g)}\ \omega), G, \alpha, n]\ \sqrt{(g/D)}\ t_c]$ (3)

In equations 1,2and 3, f stands for "function of".

6 Formulation of Experimental Data based Models

A probable exact mathematical form for the dimensional equations could be represented by solving this problem by curve fitting technique [8].
An approximate generalized experimental data based models for the manually energized kadwa cutting machine system has been established for responses of the system such as Instantaneous Resistive Torque (π_{D1}), Number of Cuts (π_{D2}) and Process Time (π_{D3}).

7 Model for Dependent pie term Resistive torque, π_{D1}

The models are

$$\frac{D}{gI} TC = 1.645 * 10^3 * \pi_1^{3.8074}\ \pi_2^{0.5141} * \pi_3^{-0.4521} * \pi_4^{1.686} * \pi_5^{2.3237} * \pi_6^{0.8162} * \pi_7^{-0.4189} * \pi_8^{-0.3840}$$

------ (4)

Model for Dependent term Number of Cut . π_{D2}

$$\pi_{D2} = 0.6449 * \pi_1^{-0.0001}\ \pi_2^{-0.0146} * \pi_3^{0.3471} * \pi_4^{-1.0151} * \pi_5^{0.2781} * \pi_6^{0.1233} * \pi_7^{0.9701} * \pi_8^{0.4773}$$

--- (5)

Model for the Dependent term Process time, π_{D3}**:**

$$\pi_{D3} = 43.43 * \pi_1^{0.0001} \pi_2^{-0.1753} * \pi_3^{-0.0012} * \pi_4^{-0.0001} * \pi_5^{-0.0505} * \pi_6^{-0.2508} * \pi_7^{1.0008} * \pi_8^{-0.0004}$$

-- (6)

8 ANN Simulation

For such complex phenomenon involving non-linear phenomena it is also planned to develop artificial neural network (ANN) simulation. The output of this network can be evaluated by comparing it with observed data and the data calculated from the mathematical models & A.N.N model. The values of regression coefficient and the equation of regression lines are represented on the three different graphs plotted, Figure 3(a,b,c) for the three dependent pi terms viz Resistive torque, Number of Cuts, Process time .

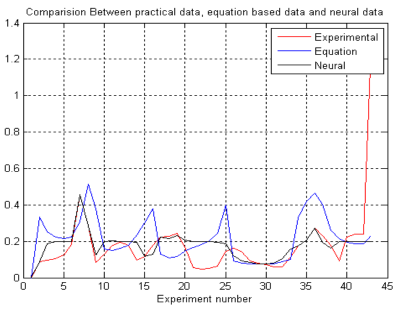

Figure: 3(a)

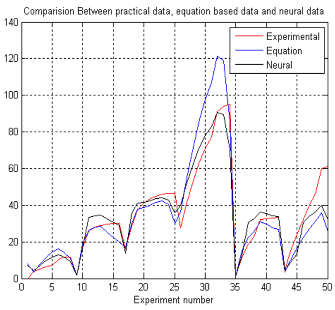

Figure: 3(b)

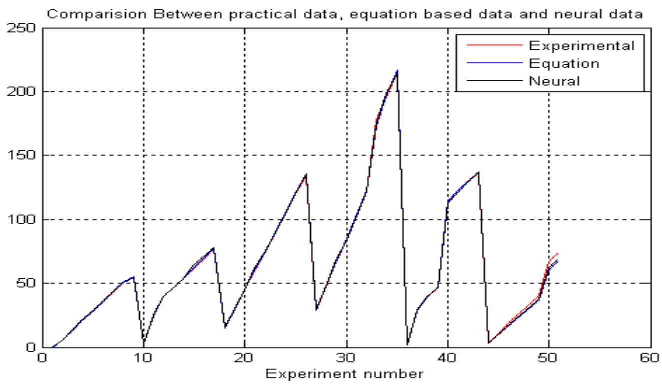

Figure: 3(c)

Figure .3(a,b,c) Comparison between Experimental Data ,Mathematical Modelling Equation and Neural data of π_{D1}, π_{D2}, π_{D3}.

Table 2: Comparison between observed and Computed Values of Dependent term

DEPENDENT PI TERMS	π_{D1}	π_{D2}	π_{D3}
Experimental	0.1773	33.588	63.276
A.N.N	0.1866	32.965	63.337
Empirical	0.2155	34.069	63.042
Standard error of estimation	0.026	3.39	0.639

9 Conclusion

Empirical models predict the performance of the manually energized kadwa cutting machine to cut kadwa were established and simulated. The values of various parameters were arrived at on the basis of experiments involving the manually energized kadwa cutting system.
A new theory of cutting the fodder from the manually energized kadwa cutting machine is proposed. This hypothesis states that on engagement of the clutch, the speed of flywheel suddenly falls indicating energy loss. A part of this energy loss is subjected to decline because of the load torque acting on the blades due to persistent presence of cutting action. It is further hypothesized that the cutting time is a function of available energy for cutting, resisting torque and average angular speed of the kadwa cutter shaft.The proposed fly wheel motor can be used as an energy source for any process unit that can operate with its input element in a transient state of motion.

This flywheel motor is applied to brick making, low head water pumping and wood turning the performance is found to be functionally satisfactory and economically viable the flywheel motor can be used as an energy source for process unit that need have continuous operation and have an upper limit of about 3 h .P. The mathematical models and an ANN developed for the phenomenon truly represents the degree of interaction of various independent variables this is made possible only approach adopted in this investigation.
The Standard error of estimate of the predicted / computed values of the dependent variable is found to be very low. This gives authenticity to the developed mathematical models and an ANN.
The trends for the behaviour of the models demonstrated by graphical analysis, sensitivity analysis were found complementary to each other these trends are found to be truly justified through some possible physics of phenomenon. This Innovation in the machine will bring mechanization in Agricultural Engineering. The rural population including unemployed and unskilled Women in addition male may also get employment. Development of such an energy source which have tremendous

utility in energizing many rural based process machines in places where reliability of availability of electric energy is much low.

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