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FORMULATION OF DATA BASED ANN MODEL FOR HUMAN POWERED OIL PRESS

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Research Article

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ABSTRACT

In this study, an artificial neural network (ANN) model for a human-powered oil press is developed using experimental data. The design of the experiments for the creation of such a model was proposed by the authors in their previously published research article. A human-powered oil press has been used for the experiment. In accordance with the recommended process, mathematical models have been developed, verified, and optimized. The ANN model is developed in this paper to produce the appropriate output parameter values for the different input parameter values. This best fit model is supported by the regression coefficient between the observed values and the response variable values calculated by the ANN. In order to maximize the quantity of oil extracted and minimize the instantaneous torque and angular velocity of the presser's shaft, the developed ANN can now be used to choose the optimal values of the various independent parameters for the designed oil press to match the characteristics of the machine operator performing the oil press task. The efficiency of an experimental setup may now be increased by the entrepreneur utilizing this ANN to choose the optimal combinations of the input parameters.

Keywords: Human Powered Flywheel Motor, Spiral jaw Clutch, Oil Press, Models, Optimization, ANN Simulation.

INTRODUCTION

Hilbert's theory of experimentation [1] is a useful method for describing any phenomenon's reaction in terms of the appropriate interplay of its different inputs. In the end, this method creates a model for any phenomena based on experimental data. Experiments have been conducted and models have been developed, as this article suggests. The models (henceforth referred to as mathematical models) have been developed using Spiegel's [2] notion of least-square multiple regression curves. To get focused replies, an entrepreneur sets up optimal inputs. The creation of such models is the only way to accomplish this goal. In the end, an industry entrepreneur is constantly concerned in setting up optimal inputs to get targeted answers. The creation of such models is the only way to accomplish this goal. After models are created, the optimization process is used to optimize them.

MATERIALS AND METHODS

Experimental Approach

No known logic can be used to correlate the several dependent and independent characteristics of the system in the oil pressing activity powered by human power under examination. According

to Murrel [3], any quantitative associations that are accessible for a particular group are statistical in nature. Therefore, the only option left is to create models based on experimental data that are more precise than those based on field data.

The following steps are typically used in order to formulate the generalized experimental model proposed by Hilbert for any complicated physical phenomena.

1. Determining the independent, dependent, and extraneous variables.
2. Dimensional analysis-based reduction of independent variables
3. Determining the test envelope, test points, test sequence, and experimentation strategy are all part of test planning.
4. An experimental setup's physical layout.
5. Conducting experiments
6. Data purification for experiments
7. Model formulation.
8. Model dependability.
9. Model refinement.
10. ANN simulation of the data from the experiment.

The design of experimentation consists of the first six phases listed above. Model formulation is the seventh phase, whereas model reliability and optimization are the eighth and ninth, respectively. The model's ANN simulation is the last stage.

Identification of Independent and Dependent Variables

The independent and dependent variables for the human-powered oil seed press were determined and are listed in Table No. 1. Using the Buckingham π theorem, dimensional analysis was performed to create dimensional equations that showed correlations between dependent and independent π terms.

Table No. 1 Description of Dependent and Independent Variables

Sr. No.	**Description of variables**	**Types of variables**	**Symbols**	**Dimensions**
1	Base dia. Of screw shaft	Independent	d_b	L
2	Max. dia. Of screw shaft	Independent	d_m	L
3	Length of Taper	Independent	L_t	L
4	Diameter of Barrel	Independent	D	L
5	Speed of Rotation at engagement	Independent	ω_e	T^{-1}
6	Pitch of Helix	Independent	P	L
7	Input energy to Machine	Independent	E	$ML^{-2}T^{-2}$
8	Aceleration Due to gravity	Independent	g	LT^{-2}
9	Gear ratio of torque amplification	Independent	G	$M^0L^0T^0$

10	Crushing strength of material process	Independent	T_c	$ML^{-1}T^{-2}$
11	Avg. size of oil seed	Independent	S	L
12	Quantity of raw material admitted per cycle pressing	Independent	Q_R	M
13	Instantaneous time	Independent	t	T
14	Crushing strength of material of screw	Independent	T_s	$ML^{-1}T^{-2}$
15	Load Torque	Dependent	T_{shaft}	ML^2T^{-2}
16	Quantity of oil extracted	Dependent	Q_o	M
17	Instantaneous angular velocity of the shaft of presser	Dependent	ω_r	T^{-1}

Reduction of the Variables

It is evident that this man-machine system involves a lot of variables. The number of variables has been reduced to a small number of dimensionless pi terms using the dimensional analysis approach. Table No. 1 displays the formulated independent and dependent pi terms. As a result, this experiment has three dependent pi terms and fourteen independent pi terms. The dimensional equations for the presser's shaft's instantaneous angular velocity, quantity of oil extracted, and instantaneous load torque are developed using the Buckingham π theorem.

Instantaneous Load Torque

$$\omega^8 T = f[\{(\omega^2 d)(\omega^2)(\omega^2 L)(\omega^2 D)(\omega^2 P)\}^{(Tc)}\}(\omega^2)(\omega t)G]\text{---(1)}$$

$$d \qquad S)(\omega^6 Q$$

$$shaft$$

$$t$$

$$\overline{Eg4} \quad \overline{g} \quad b \quad \overline{g} \quad \overline{m} \quad \overline{g} \quad \overline{g} \quad \overline{(Ts)} \quad g \overline{\overline{Eg2}} \quad R$$

$$t \qquad g$$

Quantity of Oil Extracted

$$Qo\ \omega^6 = f[\{(\omega^2 d)(\omega^2 d)(\omega^2 L)(\omega^2 D)(\omega^2 P)\}^{(Tc)}\}(\omega^2 S)(g^2 Q)(\omega t)G] \quad (2)$$

$$\overline{E}\,\overline{g2} \quad \overline{g} \quad b \quad \overline{g} \quad \overline{m} \quad \overline{g} \quad \overline{t} \quad \overline{(Ts)} \quad g \overline{\overline{E\omega^2}} \quad R$$

$$g \qquad g$$

Instantaneous angular velocity of the shaft of the presser

$$\underline{\omega r} = f\ [\{(\omega^2\ d\ )(\omega^2\ d\ )(\omega^2\ L\ )(\omega^2\ D)\ (\omega^2\ P)\}\{(Tc)\}(\omega^2\ S)(\ g^2\ Q\ )(\omega t)G] \quad (3)$$

$$\overline{\omega}\quad \frac{3}{b}\quad g\quad \overline{g}\quad \frac{\overline{m}}{g}\quad \frac{\overline{g}}{g}\quad \overline{t}\quad \overline{(Ts)}\quad g\quad \overline{\overline{E\omega}^2}\quad R$$

In Eq. 1,2 and 3 '*f*' stands for 'function of'.

Test Planning

For the inferred sets of independent pi terms, this includes selecting the test envelope, test points, test sequence, and experimental strategy []. In order to determine the test envelopes, it is important to determine the range of variation of the variable regulated by the restrictions of cost, time of production and testing, and calculation accuracy. The ranges of variation of independent dimensionless groups have been computed based on the ranges of variation of the independent variable.

One of the independent dimensionless groups' values will be changed throughout the experiment while the values of the other independent dimensionless groups remain unchanged. As a result, the traditional experimental strategy is used. Since experimentation is reversible, the test sequence is arbitrary.

Design of Experimental Setup

An experimental setup's physical design must grow to include provisions for establishing test points, modifying the test sequence, carrying out the suggested experimental plan, and providing the equipment required to record answers and independent variables. The dependent and independent pi-terms of the dimensional equation may be inferred from these provisions. The physical characteristics of its components are taken into consideration while designing the experimental setup. For instance, if a gear is involved, it must be developed using the gear design process. From a strength perspective, there is room for design in this experiment with regard to the oil seed presser. Under the assumption of process operation at constant feed conditions, the oil seed presser's other dimensions were built utilizing prior mechanical design expertise and practice. Because only that data is accessible, this is the case.

In order to appropriately arrange the predetermined test points inside the test envelope suggested in the experimental plan, the experimental setup is constructed for the aforementioned requirements. However, field testing cannot fully adhere to the experimental setup design process. This is the case because, in order to determine the value of the dependent variable, we conduct the field trial utilizing the available ranges of the numerous independent variables.

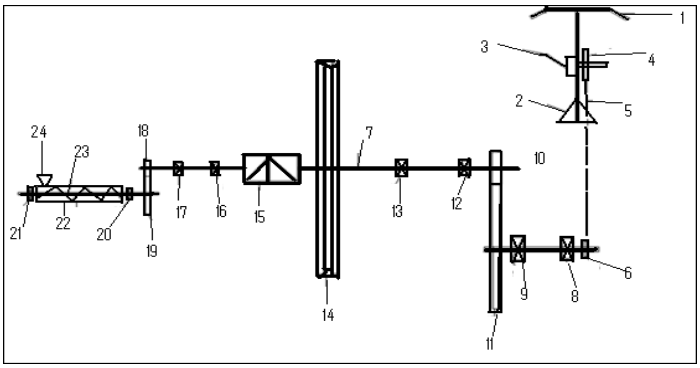


Fig. 1 Assembly drawing of Human Powered oil press

Handle 13- Bearing

Seat for Driver 14- Flywheel
Paddles 15- Spiral Clutch
Sprocket wheel 16- Bearing
Roller chain 17- Bearing
Free wheel with smaller sprocket 18- Pinion
Flywheel shaft19- Gear
Bearing 20- Bearing
Bearing 21- Bearing
Gear 22- Barrel of oil seed presser
Pinion 23- Wire wound Presser shaft
Bearing 24- Hopper

Collection and Purification of the Experimental Data

Every test run is conducted in accordance with the experimental strategy and the values of the independent and dependent pi terms. Precautions were taken throughout the test run, and the test is redone if any incorrect data was found.

Developement of Experimental Data Based Model

It is necessary to create a quantifiable link between the inputs and responses. Experimental changes are made to the inputs, and the resulting responses are measured. These connections are referred to as models. For the system's revised independent parameters, the observed dependent parameter data has been summarized. Both dependent and independent pi terms are present in this instance. The several independent and dependent pi terms involved in this man-machine system must be quantitatively correlated.

This association is only a mathematical model used as a design tool to build up such workstations experimentally. By optimizing these models for maximum oil extraction quantity, angular velocity of the presser shaft, and minimal load torque, the optimal values of the independent pi terms may be determined.

For the human-powered oil press system, an approximate generalized experimental data-based model has been developed for system responses including Instantaneous Load Torque ($\pi 01$), Quantity of Oil Extracted ($\pi 02$), and Instantaneous Angular Velocity of the Presser Shaft ($\pi 03$).

The models are:

$$\pi 01 = 1(\pi 1)^{0.8186} (\pi 2)^{2.6086} (\pi 3)^{-5.1109} (\pi 4)^{1.9233} (\pi 5)^{0.1025} (\pi 6)^{1.7301} \quad (4)$$

$$\pi 02 = 1(\pi 1)^{0.1063} (\pi 2)^{0.3919} (\pi 3)^{0.4819} (\pi 4)^{0.7519} (\pi 5)^{-0.0135} (\pi 6)^{0.1903} \quad (5)$$

$$\pi 03 = 1(\pi 1)^{-0.1874} (\pi 2)^{-0.9761} (\pi 3)^{1.4477} (\pi 4)^{-0.0745} (\pi 5)^{-0.5860} (\pi 6)^{-0.5550} \quad (6)$$

Thus corresponding to the three dependent pi terms we have formulated three models from the set of observed data.

Computations of the Predicted Values by 'ANN'

Predicting future outcomes is one of the research's primary concerns. The dependent π terms were modeled using mathematical models based on experimental data. The development of

models using Artificial Neural Networks (ANN) is also envisaged for such complicated phenomena involving nonlinear systems. By contrasting the network's output with both actual data and data derived from mathematical models, it may be assessed. The designer must identify the innate patterns in order to construct an ANN. Training the network is essentially a fine-tuning process after this is completed.

The input layer, the hidden layer or layers (which represent the synapses), and the output layer are the three layers of nodes that make up an ANN. The brain's neurons are represented by nodes, and these layers are joined to one another in the processing layer. The design of the ANN and the values of the synaptic weights between neurons determine the precise mapping that it does. These black box principles were used to construct ANN. An ANN trains itself within the historical pair of input and output data, often without proxy theory that directs or limits a connection between the inputs and outputs, much as the human brain learns via repetition of comparable stimuli. The model's objective is the ultimate accuracy of the projected output, not the description of the particular route or link between the input and output. A nonlinear transfer function provides weights to the information as it goes through the hidden layer nodes, simulating the modification of information as it passes through the synapses in the brain. The input data is then transferred via the nodes of the hidden layer or layers to the output layer. The ANN model's job is to create the response by allocating the weights in a manner that accurately reflects the actual connection between the input and output. The ANN efficiently interpolates the function between the input and output neurons during training. This function is not explicitly described by ANNs. Structural pattern recognition is the archetypal use of artificial neural networks. The ANN is given a set of features in this job, and it must be able to classify the input feature pattern as belonging to one or more classes. In these situations, all pertinent data is simultaneously delivered to the network.

Procedure for Model Formulation in ANN

To build ANNs, many tools and software have been created. The ANN model for these intricate phenomena has been developed using MATLAB, a widely recognized tool. The processes used in creating the algorithm to create an ANN are listed below.

i. The experiment's observed data is divided into two categories: input data, or the data of independent π terms, and output data, or the data of dependent π terms. The test.txt and target.txt files contain the input and output data, respectively.

ii. The DLMREAD function is then used to read the input and output data.

iii. The input and output data are normalized during the preprocessing stage.

iv. The normalized data is uncorrelated using principle component analysis. The PREPCA function is used to do this. Next, the input and output data are divided into three categories: training, validation, and testing. Selecting the first 75% of the data for testing, the last 75% for validation, and the intermediate overlapping 50% for training is standard procedure. This is accomplished by creating appropriate code.

v. After then, the data is kept in training, validation, and testing structures.

vi. A feed-forward back propagation neural network is selected by looking at the data's pattern.

vii. The training data is then used to train this network. The actual and target data's calculation errors are calculated. After that, graphs are displayed and the network is simulated. The actual data (A) and the error in the target (T) are shown graphically.

viii. The POSTSTD function is used to return the uncorrelated output data to its original form. Appendix C has the ANN programming.

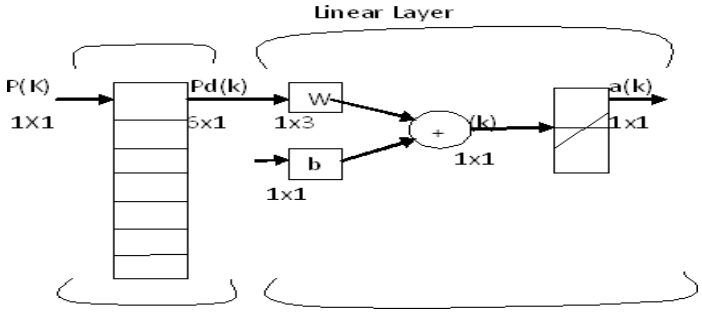


Fig. 2 Network of ANN

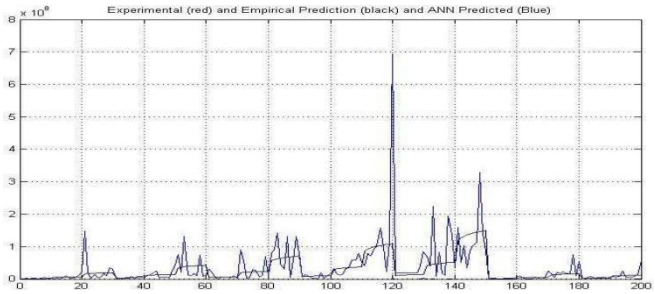


Fig. 3 Comparison of Experimental and Empirical prediction and ANN prediction for output π01

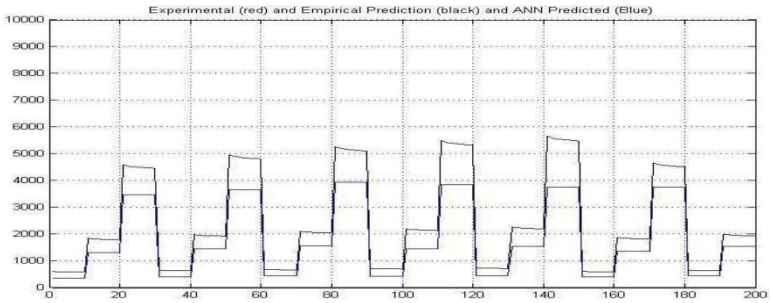


Fig. 4 Comparison of Experimental and Empirical prediction and ANN prediction for output π02

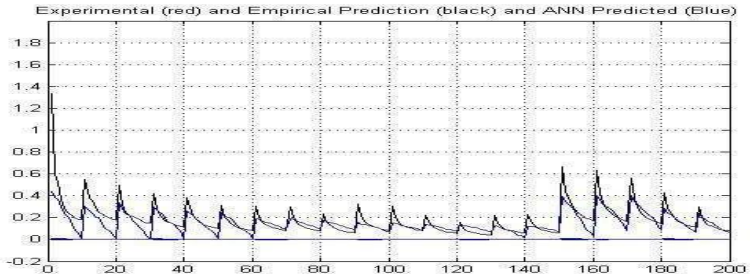


Fig. 5 Comparison of Experimental and Empirical prediction and ANN prediction for output π03

CONCLUSION

The human-powered oil press's performance is predicted by the empirical models. Based on model optimization, the ideal values of many independent parameters were determined. The independent Pi terms' ideal values are

$\pi1 = 82869.5$, $\pi2 = 0.01999999836$, $\pi3 = 3.624$, $\pi4 = 3700.8$, $\pi5 = 5.8629$, and $\pi6 = 1.999953$.

$\pi1 = 6769175.3$, $\pi2 = 0.01999999836$, $\pi3 = 3.624$, $\pi4 = 18747$, $\pi5 = 2450$, and $\pi6 = 5.999991$ in order to minimize the instantaneous load torque.

In order to maximize the amount of oil extracted, $\pi1 = 82869.5$, $\pi2 = 0.01999999836$, $\pi3 = 3.624$, $\pi4 = 3700.8$, $\pi5 = 2450$, and $\pi6 = 1.999953$.

to maximize the presser's shaft's instantaneous angular velocity.
A novel hypothesis for pressing oil seeds using a human-powered oil press machine is put forward. According to this theory, when the clutch is engaged, the flywheel's speed first increases abruptly to its maximum value, signifying the loss of stored energy. The load tension applied to the shaft as a result of the continuous pressing motion is mostly responsible for this energy loss.
Additionally, it is theorized that the amount of oil extracted depends on the average rotational speed of the oil press shaft, the resistance torque, and the energy available for pressing. Any process unit that can run with its input shaft in a transitory state of motion without significantly

affecting product quality may utilize the suggested flywheel motor as an energy source.
This flywheel motor is used for wood turning, low head water pumping, and brickmaking. It is determined that the performance is both economically feasible and functionally adequate. If the final product quality is not significantly impacted by the decreasing speed, the human-powered flywheel motor may be used as an energy source for operations requiring up to 6 horsepower.
The degree of interaction between different independent variables is accurately represented by the mathematical models and an ANN simulation created for the phenomena.

For (π01= Eg4 Tshaft), (π3= g S) is the most sensitive, (π5 =ωt) is the least sensitive, (π6 Q) is the most sensitive, and (π =ωt) is the least sensitive for (πQo ω6).

4=Eg2 R 5

02 = E g2

The most sensitive is (π [G]), and (π

The least sensitive is 6 = Q. for (π)

( )

6 = 4

Eg2 R

03 = ω

This is only made feasible by the methodology used in this study.

Sensitivity analysis yields trends for the least sensitive models' behaviors. The projected or calculated values of the dependent variables have extremely low standard errors of estimation (π01 = 0.0807, π02 = 0.0698, and π03 = 0.0586). This lends legitimacy to an ANN and the created mathematical models. Graphical analysis, influence analysis, and sensitivity analysis show tendencies in the models' behavior that are complimentary to one another. It is determined that these developments are really warranted.
In addition to males, jobless and unskilled women in rural areas may also find work. creation of an energy source that would be very useful for many process equipment located in rural areas where the supply of electricity is unreliable.

LIMITATIONS OF THE PRESENT WORK

The training determines how well the ANN performs. One of the dependent Pi terms' comparatively lower regression coefficient value might be the result of the network's incorrect training. Beyond the range of independent Pi words for which it has been taught, the ANN cannot make predictions.

a) The models used in this research are designed for peanuts. Other oil seeds cannot be used with these models.

b) The mathematical models are created specifically for the test envelope. The models cannot forecast the system's performance outside of this envelope.

c) Using the idea of fundamental mechanics, the instantaneous load torque is calculated.It is not quantified by experimentation. Due to the assessment of slope at different places in the oil press speed versus time plot, this might result in an inaccuracy of up to 1%.

REFERENCES

[1]H. Schenck Jr., "Reduction of variables Dimensional analysis," Theories of Engineering Experimentation, McGraw Hill Book Co., New York, pp. 60–81, 1961.

[2] Spiegel, "Theory and problems of problems of probability and statistics," 1980 Schaum outline series, McGraw-Hill book firm [3] Murrel K. F. H., "Ergonomics, Man in his Working Environment," Chapman & Hall, London, 1986

[4] Elaine Rich, Kevin Knight, and Shivashankar B. Nair, "Artificial Intelligence," Third Edition, Tata McGraw-Hill Publishing Company Limited, 2009.

[5] H. Sehenck Jr., "Test Sequence And Experimental Plans," Theories of Engineering Experimentation, Mc Graw Hill Book Co., New York, P.P. 6 (1961).

[6] Singiresu S. Rao, "Engineering Optimization," Third Edition, New Age International (P) Ltd. Publishers, 2004.

[7] Modak J.P. Moghe S.D., "Design and Development of a Human Powered Machine For Manufacture of Lime–Flyash–Sand Bricks," Human Power, Technical Journal of The IHPVA, Spring 1998, Vol. 13 No.2, pp. 3–7.

[8]A. Hemantha Kumar, Krishnaiah G., and V. Diwakar Reddy, "Ann Based Prediction of Surface Roughness in Turning," International Journal of Mechanical Engineering & Technology (IJMET), Volume 3, Issue 2, 2012, pp. 162–170, ISSN Print: 0976–6340, ISSN Online: 0976–6359.