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AN APPROXIMATE GENERALIZED EXPERIMENTAL DATA BASED MODEL FOR PROCESS TIME IN HUMAN POWERED ENERGIZED FERTILIZER MIXER

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ABSTRACT

Since creation , Flywheel motor is in effect widely utilized as a part of different application. Literature overview uncovers that a framework for pumping energy in flywheel using muscular energy is feasible and the energy put away in flywheel can be utilized for various applications [1]. In an endeavour this paper shows development of a Human Powered Flywheel Motor (HPFM) energized Nursery Fertilizer Mixer to blend nursery manures in legitimate extent which is then utilized for plantation in little size farming .Since this is a man-machine framework, it is fairly troublesome and inconsistent to adopt total theoretical approach for the development, hence, the experimental approach is used. **Human powered stimulated Flywheel motor machine** comprises of three unique frameworks . (i) Human powered flywheel motor (HPFM) i.e. Energy unit comprise of a flywheel and pedalling mechanism similar to bicycle. (ii)Torque intensification gear pair and (iii) Process unit i.e. Fertilizer Mixer. This paper reports the development of model through dimensional and regression analysis for dependent variable mixing time in the phenomena of mixing of different elements of composts. Dimensional analysis is used to make the dependent and independent variables dimensionless to get dimensionless condition. Afterward, by applying multiple regression analysis to this dimensionless equation, index values are obtained. The mathematical model for Process time is then figured utilizing these obtained index values .With the present work plan , design data for low to medium limit nursery compost mixer stimulated by human powered fly wheel motor can be built up with the assistance of which the particular unit of mixer can be designed

Keywords: Nursery Fertilizer Mixer, Human Powered Flywheel Motor (HPFM), Process unit, Energy unit, Experimental data based Model, Mathematical model, Dimensional Analysis, Buckingham's π theorem

I. INTRODUCTION

Electricity is a crucial input for economic growth and sustaining development processes. Most of theworld's population mostly consisting of the poor in rural areas of developing countries doesn't have access to electricity. Lack of access to cheap energy is a vital issue contributing to the comparatively poor quality of life in rural areas of developing countries. This, however, is clearly unsustainable position and solely emphasizes the imperative necessity for developing some alternative source of energy that are economically viable, environmentally sound, socially acceptable, and. Human power is one such sort of renewable energy which which may be used as opportunity source of energy appropriate to use any time at anyplace. In the recent years, several scientists like Dr J P Modak and others doing vast research within the field of use of human powered machines in numerous applications.[1]

Any material, natural or artificial origin, applied to soils or to plant tissues (usually leaves) to provide one or additional plant nutrients essential for the expansion of plant is understood as Fertilizers. Generally nutrients exist naturally within the soil , atmosphere and in the animal manure. However, nutrients. aren't continuously obtainable within the forms that plants will use, or within the quantities required. Therefore it is augmented by applying nutrients to create plants grow to their most potential. Plants acquire carbon, hydrogen, and element from air and water. The remaining necessary nutrients are taken from the medium like mixture of soil, sand and animal manure.[5]

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II. NECESSITY FOR EXPERIMENTAL

Data based model

The phenomenon of mixing in HPFM enabled mixer is exceptionally complex as the way toward mixing is to a great degree unpredictable as mixing is in a transient state due to continuous variation of angular velocity of the mixing blades. Consequently it is difficult to re-enact mechanics of such a transient mixing phenomena in light of logic. In view of forgoing it is obvious that one will have to choose what ought to be the minimum processing torque and energy required to be feed to the system for getting suitable mixing of various ingredients in the least time. This would be possible if we have a quantitative relationship among different dependent and independent factors related with the mixing and is known as the mathematical model of this man-machine system It is eminent that such a model for the machine energized by HPFM can't be figured applying logic [7]. The main option with which one is left is to detail an experimental data based model [13]. Hence, in this research work, it is chosen to establish an exploratory information based model to produce design data and validation of performance characteristics of such complex phenomenon of mixing stimulated by HPFM [1-4].

III. WORKING OF FERTILIZER MIXER ENERGIZED BY HPFM

Working principle of Nursery Fertilizer Mixer energized by Human Powered Flywheel Motor is described in Figure 1.The ingredients of the fertilizer viz Soil, Sand, Cow dung and water in required proportion as per the plan of experimentation is admitted in the drum. The rider accelerates the flywheel to the desired speed while the clutch is in disengage position. When enough energy is put in the flywheel, accelerating is ceased and energy unit is engaged with mixer unit through the torque amplification gear by engaging clutch that enables mixer to mix the ingredients in the drum .The blended item is then expelled from the opening given at the bottom of the drum.

Fig.1. Human Powered energized Nursery Fertilizer Mixer

IV. DESIGN OF EXPERIMENTATION

While performing experiments, one needs to manage factors, variables or components associated with the phenomena. We intentionally transform at least one process variable (factors) to watch the impact the progressions have on at least one reaction variable that are probably going to change. The main intention of the exploratory investigation is to figure out which factors is having high effect on the reaction finding where to set the most persuasive controllable factors with the goal that the reaction is quite often close to the desired optimal value to have the variability in the response small.

As expressed before that in the phenomenon of mixing empowered by HPFM is very complex hence it is exceptionally hard to reproduce mechanics of such a transient mixing phenomena based on logic. Just option left for such complex phenomena is to formulate experimental data based model. Subsequently it is proposed to detail such model in this examination utilizing the approach of experimentation recommended by Hilbert Schenk

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Jr. [10] for forecasting behaviour of this complex phenomenon.

The Design of Experimentation includes following steps

a) Identifying the independent /dependent variables which influence the phenomenon and setting up the dimensional equations for the phenomena
b) Using dimensional analysis technique , lessening number of factors and henceforth brings about diminishment of number of dimensional equations which are the focused form of mathematical models,
c) Test planning comprising of choosing test envelope, test sequence and plan of experimentation for the set of deduced dimensional equations.
d) Evolving physical design of experimental set up in setting up the test points.
e) Execution of proposed experimental plan.

Arrangement for important instrumentation for finding relation of dependent pi terms of the dimensional equation in terms of independent pi terms.

A. Identification of variables

In the present work of human controlled Nursery Fertilizer Mixer, different recognized independent /dependent variables in mixing phenomena are recorded in the table 4.1 beneath

Table I: variables involved in the phenomena of mixing of nursery fertilizers energized by hpfm.

SN	Variable	Nature (Independent / Dependent)	Nomenclature	M.L.T.
01	Quantity of Sand	Independent	Ws	M
02	Quantity of Soil	Independent	Wso	M
03	Quantity of cow-dung	Independent	Wcd	M
04	Quantity of water	Independent	Ww	M
05	Quantity of Mixture	Independent	W	M
06	Diameter of Blade tip	Independent	Dt	L
07	Blade Pitch	Independent	P	L
08	Length of mixing drum	Independent	L	L
09	Shaft diameter	Independent	d	L
10	Diameter of Drum	Independent	D	L
11	Input energy to the machine	Independent	E	ML^2T^{-2}

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12	Acc. due to gravity	Indepen dent	g	LT^{-2}
13	Torque amplification Gear ratio	Indepen dent	G	Dimens ion less
14	Instantaneous Torque on shaft	Depende nt	Tr	ML^2T^{-2}
15	Time of Mixing	Depende nt	Tp	T

B. Dimensional Analysis

In the past dimensional analysis was essentially utilized as an experimental tool whereby several experimental variables could be consolidated to shape one. Utilizing this principle present day investigations can significantly enhance their working systems and be made shorter requiring less time without loss of control. Deriving the dimensional condition for a phenomenon diminishes the number of independent variables in the experiments. The exact mathematical form of this dimensional equation is the targeted model.. This is accomplished by applying Buckingham‟s π hypothesis (Hibert, 1961). Buckingham pi theorem, states that if an equation involving n variables is dimensionally homogeneous, then it can be reduced to a relationship among (n-m) independent dimensionless products, where m is the minimum number of reference dimensions required to describe the variable. At the point when n is huge, even by applying this hypothesis number of π terms will not be lessened significantly than number of all independent variables. Along these lines much lessening in number of variables isn't accomplished. It is clear that, if we take the product of the terms it will likewise be dimensionless number and consequently a π term. This property is utilized to accomplish further reduction of the number of variables.

The Buckingham's π Theorem is used for the dimensional analysis of proposed machine. The process of dimensional analysis using Buckingham's Π- Theorem ,is followed step by step as explained below.

As seen from the table , total number of Variable indentified in the phenomena of Nursery fertilizer mixing are 15.

Total number of Variable = 15

Number of dependent variable = 02

Number of independent variables, n = 13

Hence we have equation

Tr = f (Ww ,Wcd , Wso , Ws , W , Dt , P , L , d , D , E , g , G)

Or

f_1 = f (Ww ,Wcd , Wso , Ws , W , Dt , P , L , d , D , E , g , G)

Considering W , g , D as the repeating variables i.e. m = 3

So as per Buckingham's Π- Theorem ,

No. of Π terms = n – m = 13 - 3 = 10

Hence in the phenomena of mixing here , there will be 10 pi terms

$\Pi_{D1} = f_1 (\Pi_1, \Pi_2, \Pi_3, \Pi_4, \Pi_5, \Pi_6, \Pi_7, \Pi_8, \Pi_9, \Pi_{10}) = 0$

First Π term:

$$\Pi_1 = (W)^{a1}(g)^{b1}(D)^{c1}W_w$$

$$(M)^0(L)^0(T)^0 = (M)^{a1}(LT^{-2})^{b1}(L)^{c1}M$$

The values of a_1, b_1 and c_1 are computed by equating the powers of M, L and T on both sides as given below

For 'M'

M→0 = a_1+1

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a_1= -1
For 'L'
L→0 =b_1+ c_1
(From eq. of T, subst. b_1 = 0)
0=0+ c_1 ,Hence c_1= 0
For 'T'
T→ 0 = -2b_1
0 = - 2b_1 , Hence b_1 = 0

Substituting the values of a_1, b_1 and c_1 in the eq. of Π_1 term, we have:

$\Pi_1 = (W)^{a1}(g)^{b1}(D)^{c1}W_w$
$\Pi_1 =(W)^{-1} (g)^0(D)^0W_w$
$\Pi_1 = W_w/W$

Similarly other Pi terms are calculated and shown in Table II and III

Table II reduced pi terms for independent variables

pi terms	pi terms equations	Description
π_1	$\left(\frac{W_s.W_{so}\,W_{cd}\,W_w}{W^4}\right)$	Ingredients of Fertilizers
π_2	$\left(\frac{D_t.P.L.d}{D^4}\right)$	Geometrical parameters of process unit
π_3	$\left(\frac{E}{W.g.D}\right)$	Energy of flywheel
π_4	(G)	Gear Ratio

Table III pi terms for dependent variables

Sr No	Description of π - term	Equation of π - term
01	π - term relating to response variable Time of mixing	Π_{01}= = $Tp\sqrt{\frac{g}{D}}$

C. Dimensional Equation for Response Variable Processing Time (Tp)

Four independent pi terms (i.e. $\pi_1, \pi_2, \pi_3, \pi_4$) and two dependent pi terms (π_{01}, π_{02},) have been identified in the design of experimentation and are available for the formulation of dimensional equation for response variable. Each dependent π is assumed to be function of the available independent π terms

$$\Pi_{01} = f_1(\Pi_1, \Pi_2, \Pi_3, \Pi_4)$$
$$\Pi_{02} = f_1(\Pi_1, \Pi_2, \Pi_3, \Pi_4)$$

Dimensional equation for first response variable, processing time (Tp) in terms of all other independent variables can be expressed as:

$$\Pi_{01} = f_1(\Pi_1, \Pi_2, \Pi_3, \Pi_4)$$

$$\pi_{01} = f_1\left\{\left(\frac{W_s.W_{so}.W_{cd}.W_w}{W^4}\right)\left(\frac{D_t.P.L.d}{D^4}\right)\left(\frac{E}{W.g.D}\right)(G)\right\}$$

$$\pi_{01} = \left(t_p\sqrt{\frac{g}{D}}\right) = f_1\left\{\left(\frac{W_s.W_{so}.W_{cd}.W_w}{W^4}\right)\left(\frac{D_t.P.L.d}{D^4}\right)\left(\frac{E}{W.g.D}\right)(G)\right\}$$

D. Developing Models for Dependent Pi terms Process Time , Tp.

Generalized experimental models for predicting processing time for fertilizer mixing process by human powered flywheel motor has been established as

Π_{D1} = k1 x (Π_1)a1 x (Π_2)b1 x (Π_3)c1 x (Π_4)d1

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The values of exponential a1, b1, c1 and d1 are established, considering exponential relationship between dependent pi term Tp and Independent Π terms Π_1, Π_2, Π_3, Π_4 independently taken one at a time, on the basic of data collected through classical experimentation. There are five unknown terms in the above equation. These are curve fitting constant K1 and indices a1, b1, c1, d1. To get the values of these unknown we need minimum five sets of values of (Π_1, Π_2, Π_3, Π_4). Taking log on the both sides of equation for Π_{D1}, to get four unknown terms in the equations,

Log Π_{D1} = log k1+ a1log Π_1+ b1log Π_2+ c1log Π_3+ d1log Π_4
Let, Z1= log Π_{D1}, K1 = log k1, A = log Π_1, B = log Π_2, C = log Π_3, D = log Π_4
Putting the values in equations the same can be written as
Z1 = K1+ a1 A + b1 B + c1 C + d1 D ---------------(I)

This represents a regression hyper plane. To determine the regression hyper plane, determine a1, b1, c1 and d1, in above equation so that,

Equation I is a regression equation of Z on A, B, C and D in n dimensional co-ordinate system. This represents a regression hyper plane. To determine the regression hyper plane, determine a_1, b_1, $c_1$and d_1 in equation 3 so that,

$\Sigma Z_1 = nK_1 + a_1*\Sigma A + b_1*\Sigma B + c_1*\Sigma C + d_1* \Sigma D$
$\Sigma Z_1*A = K_1*\Sigma A + a_1*\Sigma A*A + b_1*\Sigma B*A + c_1*\Sigma C*A + d_1* \Sigma D*A$
$\Sigma Z_1*B = K_1*\Sigma B + a_1*\Sigma A*B + b_1*\Sigma B*B + c_1*\Sigma C*B + d_1* \Sigma D*B$
$\Sigma Z_1*C = K_1*\Sigma C + a_1*\Sigma A*C+ b_1*\Sigma B*C + c_1*\Sigma C*C + d_1* \Sigma D*C$
$\Sigma Z_1*D= K_1*\Sigma D + a_1*\Sigma A*D + b_1*\Sigma B*D + c_1*\Sigma C*D + d_1* \Sigma D*D$

In the above set of equations the values of the multipliers of K_1, a_1, b_1, c_1, d_1 are substituted to compute the values of the unknowns (viz. K_1, a_1, b_1, c_1, d_1). The values of the terms on L H S and the multipliers of K1, a_1, b_1, $c_1$andd_1 in the set of equations are calculated. After substituting these values in the equations 4 ,one will get a set of 5 equations, which are to be solved simultaneously to get the values of K_1, a_1, b_1, c_1, d_1. The above equations can be verified in the matrix form and further values of K_1, a_1, b_1, c_1, d_1 can be obtained by using matrix analysis.

X_1 = inv (W) x P_1

The matrix method of solving these equations using 'MATLAB' is given below.
W = 5 x 5 matrix of the multipliers of K_1, a_1, b_1, c_1, and d_1
P_1 = 5 x 1 matrix of the terms on L H S and
X_1 = 5 x 1 matrix of solutions of values of K_1, a_1, b_1, c_1, and d_1

Then, the matrix obtained is given by,

$$Z_1 \quad x \begin{bmatrix} 1 \\ A \\ B \\ C \\ D \end{bmatrix} = \begin{bmatrix} n & A & B & C & D \\ A & AA & BA & CA & DA \\ B & AB & BB & CB & DB \\ C & AC & BC & CC & DC \\ D & AD & BD & CD & DD \end{bmatrix} \quad x \begin{bmatrix} K_1 \\ a \\ b \\ c \\ d \end{bmatrix}$$

$$\begin{bmatrix} 515.4 \\ -1643 \\ -686.2 \\ -647.2 \\ -239 \end{bmatrix} = \begin{bmatrix} 216 & -688.7 & -287.3 & -272.3 & -99.68 \\ -688 & 2199.8 & 916.2 & 868.6 & 317.8 \\ -287 & 916.2 & 383.2 & 362.3 & 132.6 \\ -272 & 868.6 & 362.3 & 354.4 & 125.7 \\ -99.6 & 317.8 & 132.6 & 125.7 & 49.31 \end{bmatrix} \begin{bmatrix} K \\ a_1 \\ b_1 \\ c_1 \\ d_1 \end{bmatrix}$$

$[P_1] = [W_1]\ [X_1]$

Using Mat lab, $X_1 = W_1 \backslash P_1$, after solving X_1 matrix with K_1 and indices a_1, b_1, c_1, d_1 are as follows

K_1	1.9711
a_1	0.0358
b_1	-0.524
c_1	0.2541
d_1	-0.331

But K_1 is log value so to convert into normal value taking antilog of K_1

Antilog (1.9711) = 93.56211

Hence the model for dependent term π_{01}

$\pi_{01} = k_1 \text{ x } (\pi_1)^{a1} \text{ x}(\pi_2)^{b1} \text{ x}(\pi_3)^{c1} \text{ x}(\pi_4)^{d1}$

$$\pi_{01} = \left(Tp\sqrt{\frac{g}{D}}\right) = K_1\left\{\left(\frac{W_s.W_{so}.W_{cd}.W_w}{W^4}\right)^{a1}\left(\frac{D_t.P.L.d}{D^4}\right)^{b1}\left(\frac{E}{W.g.D}\right)^{c1}(G)^{d1}\right\}$$

$$(\boldsymbol{T_P}) = \mathbf{93.5611}\sqrt{\frac{D}{g}}\left\{\begin{matrix}\left(\frac{W_s.W_{so}.W_{cd}.W_w}{W^4}\right)^{0.0358}\left(\frac{D_t.P.L.d}{D^4}\right)^{-0.524} \\ \left(\frac{E}{W.g.D}\right)^{0.2541}(G)^{-0.331}\end{matrix}\right\}$$

E. Analysis of the model for dependent pi term , Process time, tp, π01

The following primary conclusions can be advocated from the above investigated models.

1)The outright index of π3 and π2 is most noteworthy for response π01 viz 0.2541 . The factor π3 and π2 concerned with the energy in the flywheel and geometrical parameters of the mixer are the most impacting terms in this model and being positive value it reveals that the energy in the flywheel and geometrical parameters of the mixer has solid effect on π01 and directly varying with respect to π3 and π2

2) The outright index of π1 is most minimal for responses Π_{01} viz. 0.0358.Hence the term π1,term identified with weight of elements of fertilizer which is the minimum affecting term in this model . Low value of absolute index indicates that the factor, weight of ingredients of mixer needs improvement.

3)The negative indices are demonstrating requirement for improvement. The negative indices of Π_{01} are inversely varying with respect to π_2 and π_4

4) It is also cleared from the models that the value of constant is more than 1 for model Π_{01}, hence it has magnification effect in the value computed from the product of the various terms of the model.

F. Limiting values of responses

The primary target in this examination work isn't just defining the models however to discover the best arrangement of factors which will bring about minimization /maximization of the response variables. To accomplish this, limiting values of the independent π term from π1 to π4 are placed in the individual models. In the process of maximization, the maximum value of independent π term is placed in the model if the index of the term is positive and the minimum value is placed if the index of the term is negative. The limiting values of these response variables are estimated as given in Table IV

Table IV: limiting value of response

Max and Min. of Response π terms	Processing Time (Tp),sec
Maximum	75.28122
Minimum	32.71701

V. CONCLUSIONS

- By this examination work another hypothesis of mixing the ingredients of the Nursery Fertilizer utilizing the Human Powered simulated Flywheel Motor is proposed which has huge utility in empowering numerous rural based process machines where unwavering quality of accessibility of electric vitality is much low.
- The most of the available manual mixing machines are operated by means of hand, but the present machine energized by HPFM can be operated by means of leg and the leg muscles are proven the best over the arm muscle through different literatures.
- Present research is an experimental approach base research to generate design data for Nursery Fertilizer Mixer. In the research, HPFM is used as an energy source. This energy source can be executed by different cranking arrangement, different speed rising ratio and different flywheel sizes. In the past literatures, it is indicated that researchers have proposed several cranking arrangement on several speed rise ratio for several flywheel sizes. In this research work, one particular size conventional cranking arrangement and some speed rise ratio are considered for generating design data with the help of which the specific unit for a low to medium capacity can be designed

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