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A Performance Evaluation of MOPPM by Simulating ANN based model. A Mathematical Approach

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Abstract:- India is the world's second largest producer of potatoes. Potato is probably the most popular food and widely consumed item in the diet throughout the world. It is consumed after peeling in most of food items. Hence its peeling is an important preliminary stage of processing. Peeling of potato by human is time consuming and tedious process. As traditional process suffers from various drawbacks like high human energy expenditure, uneven peeling, injury to hand and low production rate. To overcome above drawbacks, machine was designed for peeling process.

Potato peeling machine can be electrically operated. If such machine is energized by manual power then it will bring innovation in the field of food processing engineering. Innovation of such an energy source machine can be utilized to energize different form of process machines. Regular power cut off hampers the day to day life of people living in rural based areas. It was felt that research should be done which can used manual power for different process unit instead of electric power. Such manual machine will not need electricity.

A machine has been fabricated which will perform the peeling operation by manual power. It is not easy to simulate mechanics of such a manually operated potato peeling operation based on logic In the present work, formulation of mathematical model was done based on empirical data for manually operated potato peeling machine[MOPPM] using dimensional analysis technique. The influence of output parameters such as peeling time, output weight of peeled potato, average resistive torque and flywheel speed up time was studied critically.

The data of Potato peeling operation are collected by performing actual experimentation with more than 72 tests. Experimental readings on the machine [MOPPM} and mathematical models in this research were verified and validated by Artificial Neural Network simulation. The model's optimization, reliability, and sensitivity analysis were completed successfully..

Finally the performance evaluation of machine was carried out by comparing of values of experimental readings with values of mathematical model and ANN simulation. The results of various tests have shown that changing the input parameters has a significant effect on processing time, potato output weight, average resistive torque, and flywheel speed up time..

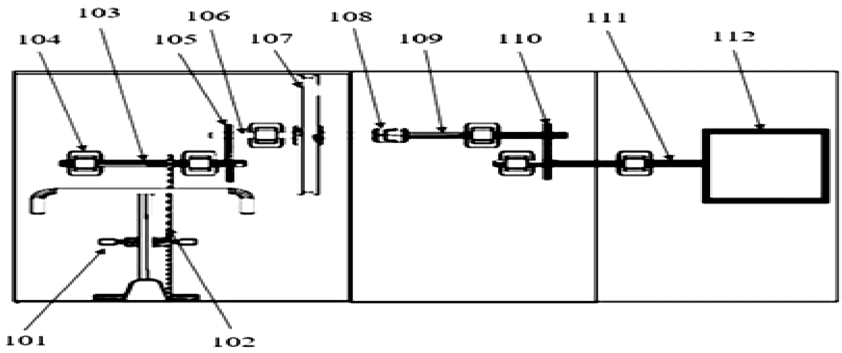
The present machine has a capacity of 77.45 kg/hr. The peeling efficiency and flesh loss was 87.98 % and 7.8%.respectively

Keywords: Manually operated potato peeling machine[MOPPM], Emperical model , regression analysis, reliability, sensitivity , Theory of experimentation, Artificial Neural network(ANN).

Introduction

1. Back-Ground Of The Present Research:

Modak J.P (1–11) created a Flywheel-based energy system that can generate 0.075KW to 5.25KW. The machine's various components are as follows:101- Pedal with sprocket configuration Chain 102, Bearings 103, Shaft Driven 104 Raising Gear Arrangement with 105 Speeds Shaft 106 Flywheel 107 Spiral Jaw Clutch 108 Shaft 109, 110- Gearbox with a Single Stage Shaft 111 Processing Unit 112-



. The said machine is operated by a pedal (101) peddled by a human which is transferred to the transmission system for operation. A speed raising gear arrangement (105) is used to increase the rpm of the flywheel (107) where the flywheel is used to store excess energy and reduce fluctuations to the main system caused by the non-uniform force applied by the human on pedal. A spiral jaw clutch (108) is used to provide unidirectional motion to the shaft which connects the flywheel to the single stage gearbox (110). The single stage gearbox (110) is meant for changing the rpm being provided to the processing unit (112). The processing unit (112) is internally coated with the abrasive material to peel the potatoes.

In 2019, innovative electrically potato processor was developed and tested for its performance [16,17].The same machine was tested using the concept of flywheel based energy source system

2. Scope of Present Research:

The goal is to create design data for a manually operated potato peeling machine [MOPPM]. The machine unit can be designed and built by proper design procedure. The utility of such a machine will benefit small business owners by enabling low-cost automation. Such research may also aid in the resolution of socioeconomic issues. The proposed work will benefit low-profile businessmen, specifically hotels, restaurants, and canteens.

3. Need For Formulating Generalized Experimental Data Based Model:

It is important to estimate amount of human energy required to man machine system for proper peeling in minimum period of time. The modeling of such man machine system became tedious by applying basics [12]. This can be achieved by establishing quantitative relationship between various independent and dependent parameters of the system[15]. In this approach , experimentation is done on the basis of experimental plan where independents parameters are varied within possible range and data for dependent variable is estimated. Based on such type of data generated, generalized experimental data based model is developed. Further method of optimization is to be applied to get minimized or maximized dependent variable [15].

As this man made system have various independent variables such as dimensions of the peeling drum (drum diameter, drum length) The other parameters are lower plate diameter, clearance**,** size of abrasive material, size of potato, quantity of water ,gear ratio ,etc whereas the dependent variables would be processing time, weight of potato peeled , average resistive torque , total torque , time required to speed up flywheel .
The approach adopted for formulation was suggested by SchenckH. Jr [15] as under

1. Variables that are independent, dependent, and superfluous are identified.
2. Formulation of Pi terms for dependent and independent variables.
3. Dimensional equation for dependent variable (Mathematical model)
4. Experimental setup physical design.
5. Test planning comprising of determination of test envelope, test points, test sequence and experimentation plan.
6. Experimental procedure and readings (Execution of experiment)
7. Mathematical model formation
8. Reliability and sensitivity analysis of Model
9. ANN Simulation

4. Details of Formulation of Generalized Experimental Data Based Model.

4.1. Formulation of Dimensional Equations -

The various independent and dependent variables for manual potato peeling process with their symbols and dimensional formulae are given in Table 1

Dimensional Equation for Response Variable Time of processing, tp.

Following nomenclature for dependant and independent given in Table 1 below stated relation stands correct variables.

$t_{p} = f(E_f, \omega_f, G, g, E_A, C, D_O, L, D_L, Q_W, W_{PI}, d_P, E_p, A_Z)$………..…..(4.1)

Where *f* stands for a "function of" Relationship in terms of dimensionless terms between these quantities can be derived as stated below

Substituting the dimensional formula for various variables in Equation (4.1)

$\theta = (M L^2T^{-2})^a, (T^{-1})^b, (M^0 L^0 T^0)^c, (LT^{-2})^d, (ML^{-1}T^{-2})^e, L^f, L^g L^h, L^i, (L^3)^j, M^k, L^l, (ML^{-1}T^{-2})^m, L^n$…..(4.2)

If equation (4.2) is to be dimensionally homogenous, the following relationships amongst the exponents must apply.

For M 0 = a+e+k+m

For L 0 = 2a-e+f+g+h+i+3j+l-m+n ……………………………………………………. (4.3)

For θ 1 = -2a-b+c-2d-2e-2m

Let us simplify as far as possible eliminating d, g and k

Then, k= -a-e-m

g= -2a+e-f-h-i-3j-l+m-n ………………………………………………………..……………… (4.4)

d = -a-0.5b+b+0.5c-e-0.5

Substituting for k, g, d in Equation 4.2, from Equations 4.4 one has,

$$t_{p}/\sqrt{\frac{g}{D_o}} = k1 \left[\frac{E_F}{g\, D_O W_{PI_1}}\right]\left[\omega_f\sqrt{\frac{D_O}{g}}\right][G]^{c1}\left[\frac{{D_O}^4 E_A E_P}{g2W_{PI}2}\right]\left[\frac{C\, L\, D_L d_P A_Z}{{D_O}^5}\right]\left[\frac{Q_W}{{D_O}^3}\right] \text{……………………….………..(4.5.1)}$$

Now substituting for $\pi_1 = \frac{E_F}{g\, D_O W_{PI}}$

$\pi_2 = \omega_f\sqrt{\frac{D_O}{g}}$;………………………………………………… (4.5.2)

$\pi_3 = G$

$\pi_4 = \frac{{D_O}^4 E_A E_P}{g2W_{PI}2}$

$\pi_5 = \frac{C\, L\, D_L d_P A_Z}{{D_O}^5}$

$\pi_6 = \frac{Q_W}{{D_O}^3}$

R1= f[$\pi_1,\pi_2,\pi_3,\pi_4,\pi_5, ,\pi_6$]………………………………………………………………………...…..(4.5.3)

Similarly procedure is applied for dimensional Equation for remaining response variable

Table 1.Variables, Symbols, Dimensional Formula.

S.N	Description of variable	Type of Variable	Symbol	Dimensions
1	Flywheel energy , N-mm	Independent	E_F	$M L^2 T^{-2}$
2	Average speed of flywheel, rad/sec	Independent	W_F	T^{-1}
3	Gear ratio of torque amplification	Independent	G	Dimension less
4	Acceleration due to gravity , m/s^2	Independent	g	LT^{-2}
5	Modulus of elasticity of abrasive material, N/mm^2	Independent	E_A	$M^1 L^{-1} T^{-2}$
6	Clearence between plate and drum,mm	Independent	C	L
7	Diameter of Drum ,mm	Independent	D_O	L
8	Length of drum ,mm	Independent	L	L
9	Lower plate diameter, mm	Independent	D_L	L
10	Quantity of water ,m^3	Independent	Qw	L^3
11	Quantity of potato ,kg	Independent	W_{PI}	M
1 2	Average size of potato	Independent	d_P	L
13	Modulus of elasticity of potato, N/mm^2	Independent	E_P	$M^1 L^{-1} T^{-2}$
14	Abrasive grid size, mm	Independent	A_Z	L
15	Processing time of peeling	dependent	t_P	T
16	Weight of peeled potato	dependent	W_{PO}	M
17	Average resistive torque on Shaft	dependent	T_{AVG}	$ML^2 T^{-2}$
18	Time required to speed up flywheel	dependent	t_f	T

Table 2. Description of Pi-terms

Pi-term	Definition of Pi-term
π_1	The term related energy of flywheel.
π_2	The term related with speed of flywheel
π_3	The term related with gear ratio
π_4	The term related with elasticity of material.
π_5	related to dimension of process unit.
π_6	The term related to quantity of water.
π_{01}	related with Processing time (T_p)
π_{02}	The term related with Quantity of potato peeled (W_{Po})
π_{03}	The term related with Avg. Resistive Torque (T_{AVG})
π_{04}	The term related with speed of flywheel during the process (t_f)

4.2 Test Planning

The plan should provide information about gear ratio, speed, average size of potato , quantity of potato, diameter and length of drum and lower plate diameter that can be used and varied. According to experimental plan shown in table 3, total 72 set of readings are possible.

Table 3: Experimental Plan

1	2	3	4	5 (Machine Parameters)		
Gear ratio	**Speed RPM**	**Avg.size (Length) of Potato**	**Quantity of potato admitted**	**Drum Diameter**	**Length of Drum**	**Lower Plate Diameter**
G	**Ns**	**Dp**	**WPI**	**Do**	**L**	**DL**
1.5	200	30	1	330	330	300
2	300	60	1.5	280	400	250
3	400					
3	3	2	2	2		
Total Number of Experiments=3*3*2*2*2=72						

The decision on the range of parameter is important during experimentation in order to finalize test point and test envelop. In study of manual operated potato peeling phenomenon, experiment plan is used in which only test points are varied over the widest range in sequential order decided by test envelop one at a time and all other independent pi terms are kept constant.

5. Formulation of Model for Dependent Pi –Term, π_{01}

A probable exact mathematical form for the dimensional equations 5.1, 5.2, 5.3, and 5.4 could be as stated below respectively.

$\pi_{01} = K_1 (\pi_1)^{a1}. (\pi_2)^{b1}. (\pi_3)^{c1.} (\pi_4)^{d1} (\pi_5)^{e1}(\pi_6)^{e1}$------------------------------------- (5.1)

$\pi_{02} = K_2 (\pi_1)^{a2}. (\pi_2)^{b2}. (\pi_3)^{c2.} (\pi_4)^{d2} (\pi_5)^{e2}(\pi_6)^{e2}$------------------------------------- (5.2)

$\pi_{03} = K_3 (\pi_1)^{a3}. (\pi_2)^{b3}. (\pi_3)^{c3.} (\pi_4)^{d3} (\pi_5)^{e3}(\pi_6)^{e3}$------------------------------------- (5.3)

$\pi_{04} = K_5 (\pi_1)^{a4}. (\pi_2)^{b4}. (\pi_3)^{c4.} (\pi_4)^{d4} (\pi_5)^{e4}(\pi_6)^{e4}$------------------------------------- (5.4)

The curve fitting constant K1 and the indices a1, b1, c1, d1, e1,f1 are the seven unknown terms in Equation (5.1). Similarly seven unknown terms are calculated by using equation (5.2), (5.3) and (5.4).. To figure out these unknowns,, seven values of $\pi_{01,}$ $\pi_{02,}$ π_{03} and π_{04} are calculated. As per the plan of experimentation, there are 72 sets. If any arbitrary seven sets of observations from these are selected the values of unknown's curve fitting constant and corresponding indices can be computed. To follow this method, it is necessary to have the equations in the form as under

Z=a + b × x + c × y + d × z…… --- (5.3)

The Equation(5.1) can be brought in the form of Equation(5.3) by taking the log on both the sides of these equations, 5.1 and 5.2

Log π_0 = logK$_1$+ a_1 * log (π_1) + b_1 * log ((π_2) + c_1 * log (π_3) + d_1 * log (π_4) + e_1 * log (π_5) + f_1 * log (π_6) ----------5.4

Let, Log π_0 = $Z_{1,}$ log K_1=K1, log (π_1) = A, log (π_2) = B, log (π_3) = C, log (π_4) = D, log (π_5) = E and log (π_6) = F then the equation (5.3) can be written as

Z_1 = K1 + a1 * A + b_1 * B + c_1 * C + d_1* D + e_1 * E + f_1 * F--------------------------(5.5)

Equation (5.5) is a regression equation of Z on A, B, C, D, E. and F In an n-dimensional co-ordinate system this represents a regression hyper-plane. To determine the regression hyper-plane, it is necessary to determine a_1, b1, c1, d1, e_1 f_1 of Equation (5.5) following models are obtained

$$t_p = k1\sqrt{\frac{D_O}{g}}\left[\frac{E_F}{g\,D_O W_{PI_1}}\right]^{a1}\left[\omega_f\sqrt{\frac{D_O}{g}}\right]^{b1}[G]^{c1}\left[\frac{{D_O}^4 E_A E_P}{g2W_{PI}2}\right]^{d1}\left[\frac{C\,L\,D_L d_P A_Z}{{D_O}^5}\right]^{e1}\left[\frac{Q_W}{{D_O}^3}\right]^{f1}$$

a1 = 0.0465,b1 = 0.0282,c1 = 0.4201,d1 = -0.0458,e1 = 0.0216,f1=-0.071,K_1 = 1.7505

Therefore above equation can be written as

$$t_p = 56.233\sqrt{\frac{D_O}{g}}\left[\frac{E_F}{g\,D_O W_{PI_1}}\right]^{0.0465}\left[\omega_f\sqrt{\frac{D_O}{g}}\right]^{0.3282}[G]^{0.4201}\left[\frac{{D_O}^4 E_A E_P}{g2W_{PI}2}\right]^{-0.0458}\left[\frac{C\,L\,D_L d_P A_Z}{{D_O}^5}\right]^{0.0216}\left[\frac{Q_W}{{D_O}^3}\right]^{-0.071} \quad \text{……..(5.7)}$$

Similarly Formulation of remaining Model are as follows

$$W_{PO} = 1.04\,W_{PI}\left[\frac{E_F}{g\,D_O W_{PI_1}}\right]^{-0.0311}\left[\omega_f\sqrt{\frac{D_O}{g}}\right]^{-0.0125}[G]^{-0.0356}\left[\frac{{D_O}^4 E_A E_P}{g2W_{PI}2}\right]^{-0.0152}\left[\frac{C\,L\,D_L d_P A_Z}{{D_O}^5}\right]^{0.0209}\left[\frac{Q_W}{{D_O}^3}\right]^{-0.0175} \quad \text{…(5.8)}$$

$$T_{AVG} = 0.00642\,g\,D_O\,W_{PI}\left[\frac{E_F}{g\,D_O W_{PI_1}}\right]^{-0.127}\left[\omega_f\sqrt{\frac{D_O}{g}}\right]^{-0.1107}[G]^{-1.1887}\left[\frac{{D_O}^4 E_A E_P}{g2W_{PI}2}\right]^{0.4976}\left[\frac{C\,L\,D_L d_P A_Z}{{D_O}^5}\right]^{-0.0453}\left[\frac{Q_W}{{D_O}^3}\right]^{1.2673} \quad \text{…(5.9)}$$

$$t_F = 0.176\sqrt{\frac{D_O}{g}}\left[\frac{E_F}{g\,D_O W_{PI_1}}\right]^{-0.2026}\left[\omega_f\sqrt{\frac{D_O}{g}}\right]^{1.355}[G]^{0.0991}\left[\frac{{D_O}^4 E_A E_P}{g2W_{PI}2}\right]^{0.0124}\left[\frac{C\,L\,D_L d_P A_Z}{{D_O}^5}\right]^{0.0322}\left[\frac{Q_W}{{D_O}^3}\right]^{-0.1189} \quad \text{... (5.10)}$$

6. Analysis of Results

6.1 Model Interpretation

The indices of the models i.e (Eqs. No. (5.7), (5.8), (5.9), (5.10)) are the indicators which gives details how entire phenomenon gets affected with the change in inputs are shown and discussed below

6.1.1.Analysis of the Phenomena for Interpretation of Model for Dependent π Term π_{01}

The model π_{01} is as under

π_{01}= 1.7505 $(\pi_1)^{0.0465}(\pi_2)^{0.3282}(\pi_3)^{0.4201}(\pi_4)^{-0.0428}(\pi_5)^{0.0216}(\pi_6)^{-0.072}$…………..(6.2.1)

The deducted equation for this π term is given by

$$\pi_{01} = \left[t_p\sqrt{\frac{g}{D0}}\right]$$

The following primary conclusions for first dependent variable have been drawn from equation No.(6.2.1) as under

1] The $\pi3$ refers to the gear ratio, which has the highest index of 0.42 and is the most influential term in the above model. l. The positive value of index indicates that it is directly proportional to $\pi_{01.}$

2] The π_5 relates with dimension of process unit posses lowest index viz. 0.0216 which is less influencing terms. Low value means, dimensional parameters for machines can be improved.

3] The π_4 and π_6 relates with modulus of elasticity of material and quantity of water respectively is negative viz. -0.0458,-0271 respectively. The negative values of indices indicates it is inversely proportional to π_{01}

4] The constant in this model is 56.29 posses a very high magnification effect. This constant represents the effect of all extraneous variables collectively.

6.1.2 Analysis of the Phenomena for Interpretation of Model for Dependent Pi Term π_{02}

The model π_{02} is as under

$\pi_{02} = \pi_{02} = (\pi_1)^{-0.0311}(\pi_2)^{-0.0125}(\pi_3)^{.-0.0356}(\pi_4)^{-0.0152}(\pi_5)^{0.0209}(\pi_6)^{-0.0175...}$..... ..(6.2.2)

The deducted equation for this π term is given by $\pi_{02} = \frac{W_{Po}}{W_{PI}}$

The following primary conclusions for second dependent variable have been drawn from equation No.(6.2.2) as under

1] The index for the Process unit is 0.0209, which is the most impacting term in the aforementioned model.. The positive value of index indicates that it is directly proportional to $\pi_{02.}$

2] The independent pi terms present in this model are π_1, π_2, π_3. π_4 and π_6 posses negative indices which requires improvement. The negative value of index indicates that it is directly proportional to $\pi_{02.}$

3] This model's constant, 1.049059208, has a good magnifying impact. This constant represents the effect of all extraneous variables collectively.

6.1.3Analysis of the Phenomena for Interpretation of Model for Dependent Pi Term π_{03}

The model for π_{03} is as under

$\pi_{03} = (\pi_1)^{-0.127}(\pi_2)^{-0.1107}(\pi_3)^{-1.1887}(\pi_4)^{0.04976}(\pi_5)^{-0.0453}(\pi_6)^{1.267\ ...}$..... ..(6.2.3)

The deducted equation for this π term is given by $\pi_{03} = \pi_{02} = \left[\frac{T_{Avg}}{g\,D_O W_{PI_1}}\right]$

The following primary conclusions for third dependent variable have been drawn from equation No.(6.2.3) as under

1] The $\pi6$ pertains to water amount and has the highest index, 1.2673, which is the most impacting term in the aforementioned model.. The positive value of index indicates that it is directly proportional to $\pi_{03.}$

2] The π_4 relates with elasticity of material posses lowest index viz. 0.4976 which is less influencing terms. Low value means, better elasticity is required

3] The π_1, π_2, π_3 and π_5 are negative hence inversely proportional to π_{03}

4] The constant in this model is 0.006421 . Because this value is less than one, it has a very minimal magnification impact.

6.1.4 Analysis of the Phenomena for Interpretation of Model for Dependent Pi Term π_{04}

The model π_{03} is as under

$$\pi_{04} = (\pi_1)^{-02026}\ (\pi_2)^{1.355}\ (\pi_3)^{0.0991}(\pi_4)^{0.0124}(\pi_5)^{0.0322}\ (\pi_6)^{-0.1189} \text{.... ..(6.2.4)}$$

The deducted equation for this π term is given by $\pi_{04}=\left[t_f\sqrt{\frac{g}{D0}}\right]$

The following primary conclusions for first dependent variable have been drawn from equation No.(6.2.4) as under

1] The π_2 relates with speed of flywheel posses highest index viz.1.355 which is most influencing terms in above model. The positive value of index indicates that it is directly proportional to $\pi_{04.}$

2] The π_4 relates with elasticity of material posses lowest index viz. 0.013 which is less influencing terms. Low value means, better elasticity is required

3] The π_1 & π_6 are negative. The negative indices are indicating need for improvement.

4] The constant in this model is 0.176177. Because this value is less than one, it has a very minimal magnification impact.

7. Sensitivity Analyses

By analysing the indices of the various independent terms in the models, the influence of the various independent terms has been explore (Eqs.6.2.1,6.2.2,6.2.3 and 6.2.4). The following procedure have been used for conducting sensitivity analysis are as

1. The value of first independent π term (π_1) is changed independently (one at a time) within limit ±10%.
2. The effect of these changes is evaluated with respect to the first dependent π term(π_{01}) and is calculated.
3. The value of second independent π term (π_2) is changed independently with limit ±10% . Its effect is again evaluated with respect to first dependent π term(π_{01})
4. The process of evaluation of first dependent π term(π_{01}) is repeated till it reaches to sixth independent π term (π_6)
5. Corresponding changes are noted in first dependent π term (π_{01}) due to ±10% change in value of $\pi_{1,}$ π_2, π_3, π_4, π_5, π_6 respectively.
6. The same procedure is applied to evaluate $\pi_{02,}$ π_{03} and π_{04}
7. Nature of variation in dependent Pi term due to change in the values of independent pi terms are given in table 8.2
8. Graph of sensitivity analysis for Pi01,Pi02,Pi03 and Pio4 is shown in figure 8.10

.The figure 7. 1 gives the details outcome of sensitivity analysis.

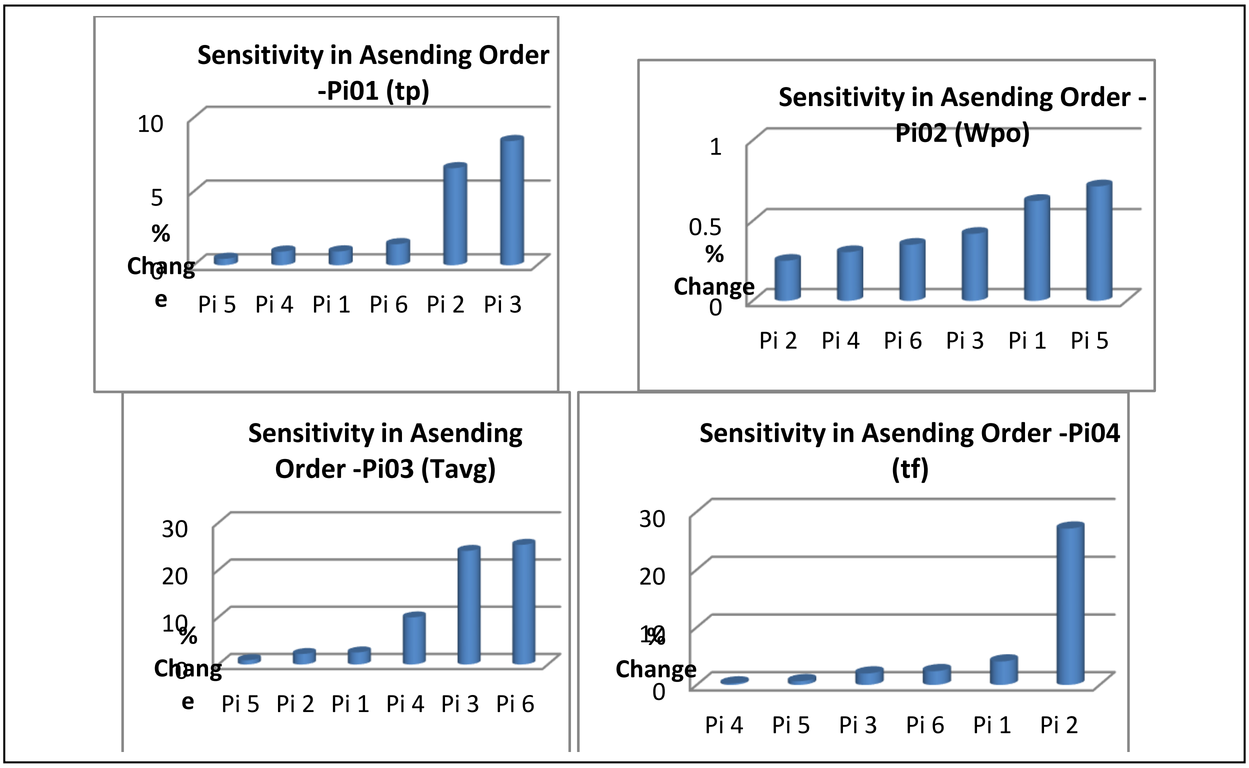


Figure 7.1 Graph of sensitivity analysis of for all dependent Pi terms

8. ANN Artificial Neural Network Simulation of the Experimental Data.

To design an ANN simulation, various software/tools have been developed. For the development of ANN Simulation for the complicated phenomenon, MATLAB was chosen

Comparison of Phenomenal Response by Conventional Approach, ANN and by Model Simulation

Comparison Statement for mean value of output and percentage error between experimental, ANN and by Model for Output (π**01**), (π**02**) (π**03**), (π**04**) are as shown in Tables 6 while its comparison in graphical form is shown in figure 8.

Table 6.Comparison for mean value of Output

π terms	Response Variable	Mean		
		Tp (Expem)	Tp (Math Model)	tp (ANN)
Π_{01}	Processing Time	33.833	33.37	34.647
Π_{02}	Output weight of Potato	0.868	0.8662	0.8668
Π_{03}	Avg. Resistive Torque	1534.9	1503.7	1636.4
Π_{04}	Flywheel speed up time	25.014	24.781	24.778

Table 7. Comparison for Percentage Error

π terms	Response Variable	% Error compared with Experimental Data	
		% Error betn Math and EXP	% Error betn ANN and Exp
Π01	Processing Time	1.3707	2.4056
Π02	Output weight of Potato	0.2138	0.1352
Π03	Avg. Resistive Torque	2.0341	6.6168
Π04	Flywheel speed up time	0.9316	0.9433

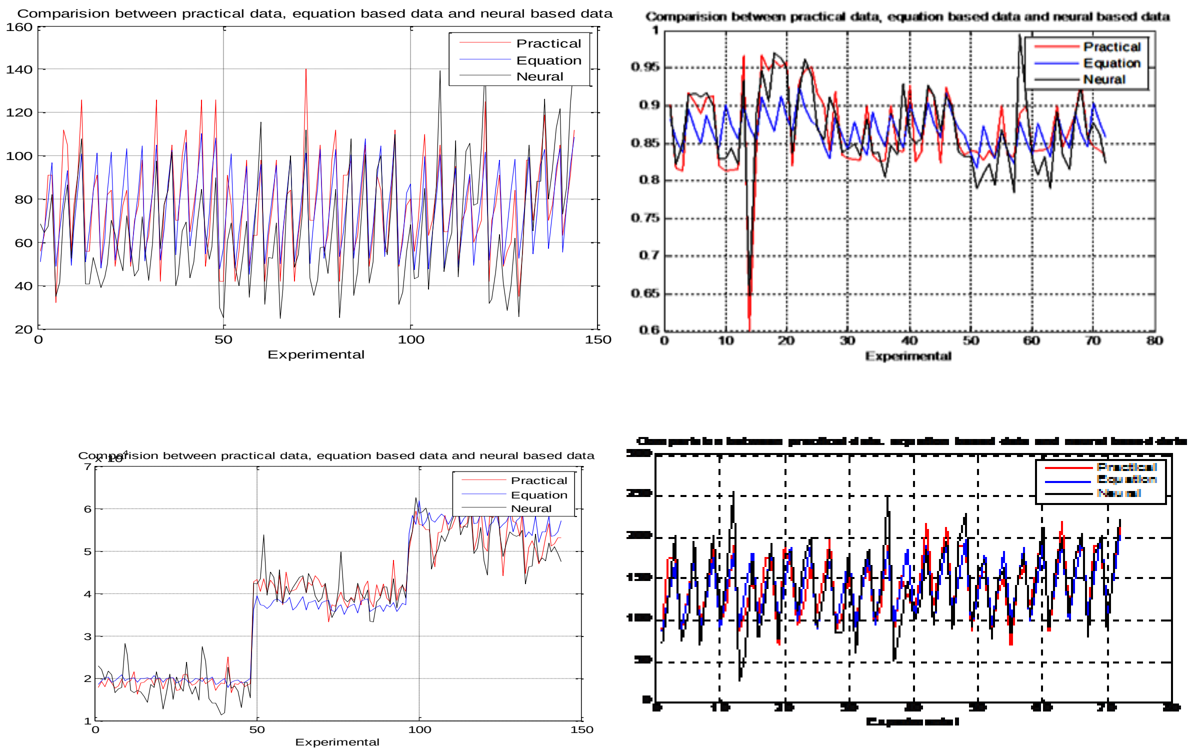


Fig. 8.Graphical Representation of mean value of Output

Comparison of Experimental, ANN Prediction and Percentage Error in ANN

Comparison Statement for percentage error between experimental, ANN and by Model for Output (π**01**), (π**02**) (π**03**), (π**04**) are as shown in Tables 7.

From the comparison, it seems that the output graph for(P**01**,) (P**02**) (P**03**,) and (P**04**) are merging more which is a positive indication.

9 Conclusions

The following conclusions are drawn as under

1] Traditional manually potato peeling suffers from various drawbacks like excess human energy expenditure, uneven peeling, injury to hands and low production rate. As per literature survey, a little work is carried out on potato peeling operation by manual power. The manually operated potato peeling machine [MOPPM] was designed to overcome above drawbacks involved in peeling by hands.

2] The dimensions of the machine [MOPPM] are 1900 mm × 867 mm× 615 mm. The weight of machine is 120 kg .The machine was tested for its performance. The best speed at which machine should be operated is 200 rpm. The output capacity was found to be 77.45 kg/hr. Peeling efficiency and flesh losses was found to be 87.98 % and 7.8 % respectively. It has zero electrical energy consumption.

3] Quality of peeling depends on method of peeling. Abrasive method of peeling was selected for the machine [MOPPM]. Silicon carbide granule of 16 grit size (1.18 mm) was used for peeling action to resolve uneven peeling problem.

4] Graphical study of indices and sensitivity analysis of independent Pi terms successfully revealed the behaviour of mathematical models... It was analyzed that gear ratio (π_3), dimensions of process unit,(π_5) quantity of water(π_6) and speed of flywheel(π_2) have strong impact on processing time (Pi01), weight of potato (Pi02), average resistive torque(Pi03) and flywheel speed up time (Pi04) respectively.

5] The mathematical model was also checked for its reliability. From reliability analysis of mathematical model, reliability of processing time, output weight of Potato , resistive torque-average and flywheel speed up time was found to be 88.86%, 96.19%,84.75%, 89.44 % respectively. Therefore total reliability of mathematical model was found as 89.64% **.**

6] The mathematical model's sensitivity analysis was successfully tested to determine the impact of each independent Pi term on the dependent Pi term.. The behaviour of the model was investigated. as follows

a) The processing time (Pi01) mostly depends on process unit dimension(π_5) and least depends on speed of flywheel(π_2).
b) The output weight of potato (Pi02) depends on gear ratio (π_3) and least depends on process unit dimension(π_5).
c) The average resistive torque (Pi03) mostly depends on quantity of water (π_6) and least depends on process unit dimension (π_5) .

d) The flywheel speed up time (Pi04) mostly depends on speed of flywheel (π_2) and least depends on elasticity of material (π_4).mostly

7] The verification and validation of experimental model, mathematical model and ANN was carried out on MATLAB-15.

a) The graph of mean values of experimental model, mathematical models and ANN were obtained for each dependent Pi term. As there is less % error between the experimental model, mathematical model, and ANN, the curves obtained overlap.

b] The mean value of dependent variable viz processing time (tp), weight of peeled potato(Wpo), average resistive torque (Tavg), flywheel speed up time(tf) was nearly same in experimental model, mathematical models, and ANN simulations

8) From reliability analysis of ANN**,** reliability of processing time, output weight of Potato , resistive torque-average and flywheel speed up time was found to be 89.66%, 97.27%, 87.75%, 87.05 % respectively. Therefore total reliability of ANN model was found as 91.24% **.** It was concluded that ANN developed for the machine [MOPPM] was found to be better in all respect.

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