Concrete Mixer Energized By Human Powered Flywheel Motor (Hpfm): A Concept

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Abstract: ***World of today is facing the problem of power crisis, because most of the power generation units are running on thermal energy. Those basically need coal for the generation of energy. Since, it is well known fact that, the coal as a natural wealth is depleting day by day and very few sources are remaining where the coal could be found easily. Therefore people are looking for an alternative energy sources. Apart from these energies, the most economical source for the generation of employment is considered to be the human energy. Therefore, the use of human power has great scope particularly in rural and remote areas.***

Index Terms**:** ***Mathematical Model Optimization, Sensitivity, ANN, RSM***

I. INTRODUCTION

Study reveals that ample evidences are available which show that the human power was extensively used for several applications since ancient period. Indeed, the use of this mechanism was greatly helpful to supply the human energy to the end applications with different speed ratios. Thus man could get an idea that how to use human energy for several applications, like (a) Agricultural equipment (b) House hold equipment (c) Low horse power equipment [2]. Amongst these, Agricultural based applications were considered at prime importance. However, this mechanism was useful for limited applications, who have demanded horse power requirement less than 0.1 hp. Afterwards, Prof Modak [3] had developed a concept of Human Powered Flywheel Motor, which is contributing in the area of human energy. Because of this, the amount of energy can be accumulated in flywheel at 3 to 5 h.p. The heavy process units are now possible to be attached with this energy source. It became as one of the alternative energy source. It is thought that the HPFM concept could further be used for several applications; therefore to have new research assignment the concrete mixer which is driven by the mechanism of human energy.

1.2 The Inherent Details of Concrete Mixing Process

In general a concrete is defined as a combination of following entities, (a) cement, (b) sand and (c) aggregate. The concrete has been designated on different grades like M7.5…M20 etc on the basis of their proportions of mixing. Each grade also indicates its strength after curing.

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In the past the mixing of concrete was carried out by manual operation which is shown in Figure1.4. This process is quite tedious and laborious as far as ergonomics is concerned. Over the period of time the concrete mixer machines were developed. If one makes the market survey then he could find the classification of concrete mixer as discussed above. Further, he may also find the additional classification as electrically driven and fuel engine driven. Indeed these concrete mixers facilitate good mixing than the manual operation. The most prominent and important term related to mixing of the concrete is the mixing efficiency. This mixing efficiency is dependent on various parameters such as: drum speed, shape of the drum, number of blades, mixing time, etc. The quality of concrete is also dependent on homogeneity of mix, mixing efficiency; period of curing, quality of cement, aggregate, sand, acquired strength, slump height. Most of the factors are mainly moving around one epic centre that is the mixing process. As such, all the concrete mixers are fabricated on thumb rule basis but one has to investigate the optimum design parameters on which the concrete mixer will perform well.

1.3 Need and Scope of the Present Research

As we know the current trends in the world is enhancing gradually with the demands of civil constructional purpose. There are many differences in rural and urban localities in civil constructional point of view which indeed makes the utilization of automation necessary for the enhancement of the efficiency. This is due to unavailability of the electrical power and non renewable sources which are the main resources of energy to run the civil equipments. Concrete mixer is one of the prime important machinery in civil construction equipments. Therefore there is need to use a Concept of Human Powered Concrete Mixer.

Presently, the mixing methods used in remote and rural areas are namely (a) Traditional manual Mixing and (b) Machine Operated mixing.

If one scrupulously sees the above two mixing methods, then he may come out with following conclusions.

1. The machine operated concrete mixers require the natural energy recourses to run which could otherwise be used for relatively more important work.
2. The machine operated concrete mixers put the economical burden which crosses the budget of rural people.

3. In the case of traditional manual mixing, the process becomes hectic because of following reasons.

(a) During mixing, the posture of a person is generally not appropriate which culminated into permanent damage of spinal chord if the work is executed for longer period.

(b) The use of hand gloves and foot shoes are not generally practiced by worker in traditional mixing process leading to skin irritations and permanent skin problems.

(c) The traditional manual mixing method is a time consuming and found to be costlier as compared to machine operated mixing. On the other hand, the quality of mix obtained by traditional mixing is inferior compared to machine operated mixing. These forms the basis for adopting machine operated mixing over the traditional manual mixing.

Keeping the above problems the concept of solution is proposed as a human powered flywheel motor as an energy source for running the concrete mixer.

1.4 Why to Use Human Power?

The human energy could be seen as a best source of energy which is available universally. It is known that a normal human being can produce approximately 0.13 hp or 75 watts as a continuous duty [17] Even, it is also studied that he or she expenses their energy in daily routine work namely (1) Morning walk (2) Daily house hold work (3) The farm related work (4) The physical activities related to their field. The expended energy could be regenerated by taking daily food. If one considers a family of four persons, then power of 300 watts is available. If a nation is taken into consideration and let the population be 100 Corer then it could produce power to the tune of 100 corer × 75 watts i.e. equal to 7500 corer watts which is readily available energy to perform any work. Human Energy must be utilized for the following prominent reasons.

(a) The availability of energy at any place and any time.

(b) It does not produce any harmful emission so it could be considered as clean energy source and thus it may help us to preserve our environment.

(c) It is economical and by expensing the energy a human can maintain himself/herself physically fit.

(d) And most importantly, it is in exhaustive renewable energy source as against of depleting non renewable sources of energy.

This human energy could be stored in a mechanical capacitor which is known as a Flywheel using appropriate speed amplification mechanisms. Thus, one can store the energy to the tune of 7 to 10 h.p. and could be utilized for the required work. Therefore a concept of Concrete Mixer energized by Human Powered Flywheel Motor is presented through the present research.

1.5 Abstract idea for Concrete Mixer Energized By HPFM

The medium duty concrete mixer driven by HPFM is depicted in Figure1. 5 In this machine, five shafts S1, S2, S3, S4 and S5 are used. On shaft S1, three components one pinion of gear box, Flywheel (FW) and half portion of clutch are placed. On shaft S2, two mechanical elements are placed, such as, Pinion (P1), and half portion of clutch. Pinion (P2) and Gear (G1) are placed on shaft S3 while shaft S4 possesses two pinions (P3, P4) of equal sizes. Pinions P2and P3 is also same in size. Shaft S5 is a process unit shaft on which Gear (G2) is placed. Clutch (TFC) is used to connect the shafts S1 & S2. Initially, the clutch is in disengaged position. A human does the process of pedaling. The energy is transmitted to the flywheel for storing this energy through speed amplification elements i.e. gear pairs. After certain duration the sufficient amount of energy is stored in the flywheel. This stored energy in the flywheel is now useful to energize any process machine. Hence, a clutch is now engaged and available stored energy in the flywheel is fed to medium duty concrete mixer through gear pairs.

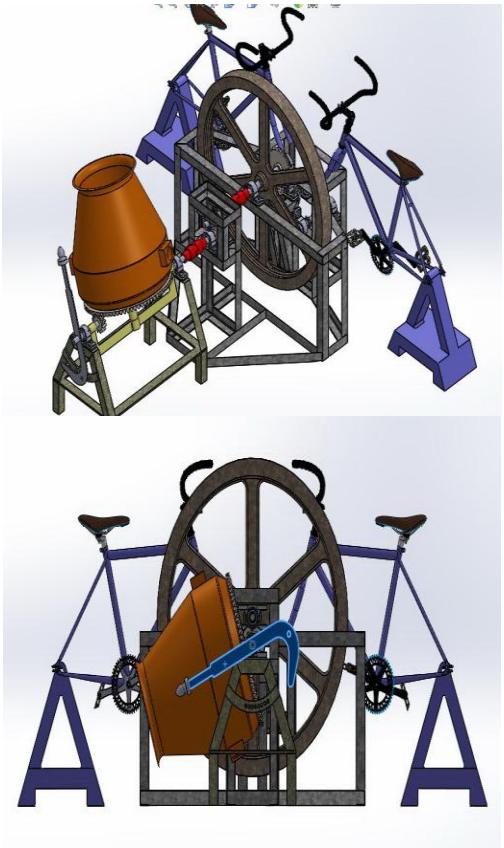


Figure1.6: Pictorial view of Concrete Mixer Energized by HPFM

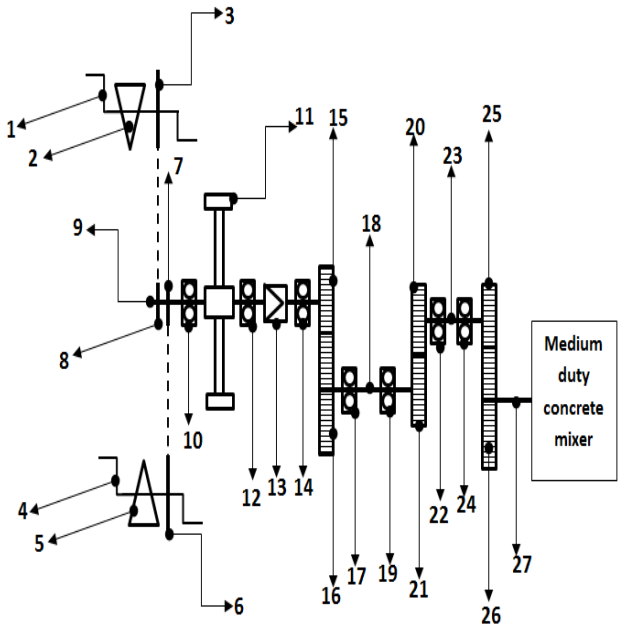


Figure 1.5: Schematic Diagram of Concrete Mixer Energized by HPFM

1. Pedal, P1;
2. Seat, S1;
3. Big chain sprocket, BCS1;
4. Pedal, P2;
5. Seat, S2;
6. Big chain sprocket, BCS2,
7. Small chain sprocket, SCS2,
8. Small chain sprocket, SCS1;
9. Shaft, S1,
10. Bearing, B1;
11. Flywheel, FW;
12. Bearing, B2;
13. Clutch;
14. Bearing, B3;
15. Pinion, P1;
16. Gear, G1;
17. Bearing, B4;
18. Shaft, S3;
19. Bearing, B5;
20. Pinion, P3;
21. Pinion, G2,
22. Bearing, B6;
23. Shaft, S4;
24. Bearing, B7;
25. Pinion, P4;
26. Gear, G2;
27. Shaft, S5.

1.6 Research Methodology

(Generation of Design Data for the Proposed Concrete Mixer Energized By Human Power Flywheel Motor)

Proposed concept should be viable so that it can work efficiently. Hence through the present investigation experimentation is executed by developing proposed concept for establishing the quantitative relationship between various performance parameters of concrete mixing process energized by Human Power Flywheel Motor. This attempt becomes helpful to generate the design data of the proposed concept.

In the present research, empirical relationships of the parameters have been established by adopting the procedure stated in H. Schenk Jr. [4]. The procedure included (a) Identification of Variables (b) Reduction of Variables (c) Design of Concrete mixture energized by HPFM (d) Development of Concrete mixture energized by HPFM (e) Plan of experimentation (c) Procedure of Experimentation (f) Establishment of Empirical Relationships.

The parameters involved in concrete mixing phenomenon are identified. Which are given as below

Table 1.1: List of Dependent and Independent Variables

Sr. no.	Name of variable	Variable	Symbol	MLT Form
1	Resisting Torque	Dependent	Tr	$ML^2 T^{-2}$
2	Mixing Time	Dependent	Tm	T
3	Compressive Strength	Dependent	S	$ML^{-1} T^{-2}$
4	Slump Height	Dependent	Sh	L
5	Speed of mixer shaft	Dependent	Nms	T^{-1}
6	Weight of sand	Independent	Ws	M
7	Weight of Aggregate	Independent	Wa	M
8	Weight of Cement	Independent	Wc	M
9	Quantity of water	Independent	Qw	M
10	Diameter of Drum	Independent	Dd	L
11	Depth of Drum	Independent	Ld	L
12	No. of Blades	Independent	Nb	$M^0L^0T^0$
13	Inclination of Blade	Independent	β	$M^0L^0T^0$
14	Length of blade	Independent	Lb	L
15	Width of blade	Independent	Wb	L
16	Space between Drum and blade	Independent	Sdb	L
17	Space between strips of blade	Independent	Ssb	L
18	Speed of mixer shaft	Independent	Nms	T^{-1}
19	Flywheel Energy	Dependent	Fe	ML^2T^{-2}
20	Gear ratio	Independent	Gr	$M^0L^0T^0$
21	Acceleration due to gravity	Independent	g	LT^{-2}
22	Time	Independent	T	T

The parameters involved in this phenomenon are more and it is difficult to establish relationship between the dependent and independent parameters individually. Therefore the parameters are clubbed into dimensionless groups generally known as pie terms. These groups are obtained by Relighs method. This process is coined as reduction of variables. The glimps for resisting torque is given as below,

$$Tr = f\left[Ws^a, WA^b, Wc^c, Ww^d, Dd^e, Ld^f, Lb^g, Wb^h, Sdb^i, Ssb^j, fe^k, g^l t^m\right]$$

------ (1.1)

The MLT form of the above equation is,

$$M^1L^2T^{-2} = f\left[(M)^a, (M)^b, (M)^c, (M)^d, (c)^e, (L)^f, (L)^g, (L)^l, (L)^i, (L)^j, (ML^2T^{-2})^k, (LT^{-2})^l, T^m\right]$$

The solution for the above MLT equation is,

For M:

1 = a +b +c + d + k

$\Rightarrow$ b =1 -a –c –d –k

For L:

2 = e + f +g + h + i + j + 2k + l

$\Rightarrow$ e =2 - f - g - h - i - j - 2k - L

For T:

-2 = -2k -2L +m

$\Rightarrow$ m =-2+2k+2L

Resultant equation is putting the values in general equation one find, After rearranging the terms in the above equation one will get the model for resisting torque as,

$$\frac{Tr}{WAD_d^2 t^{-2}} = \left[\frac{Ws}{Ww}\frac{Wc}{WA}\right]^a \left[\frac{Ld}{Lb}\frac{Wb}{Dd}\frac{Sdb}{Ssb}\frac{Nb}{D}\right]^b \left[\frac{Fet^2}{WADd^3}\right]^c \left[\frac{gt^2}{D_d}\right]^d [Gr]^e$$

---------- (1.2)

$$\Pi 1 = \left[\frac{Ws}{Ww}\frac{Wc}{WA}\right]^a \quad \Pi 2 = \left[\frac{Ld}{Lb}\frac{Wb}{Dd}\frac{Sdb}{Ssb}\frac{Nb}{D}\right]^b \quad \Pi 3 = \left[\frac{Fet^2}{WADd^3}\right]^c$$

$$\Pi 4 = \left[\frac{gt^2}{D_d}\right]^d \quad \Pi 5 = [Gr]^e$$

The setup has been designed and developed according to the plan of experimentation which considers Test Points, Test Envelope and Test Sequence.

Test Point: These are the discreet values of the pie terms at which one decides to execute the experimentation.

Test Envelope: It is the range of pie terms within which one executes the experimentations

Test Sequence: it would be reversible or irreversible.

In the present research, 472 test points were decided along with their test envelopes. Some sample points of one empirical relationship along with their test envelopes are given below. The irreversible sequence for the test has chosen.

Table 1.2: Test Envelope, Test Points for Human Powered Concrete Mixer

Pi Term Equation	Test Envelope	Test Point	Independent Variable in its own range
Π1=Term for the ingredients $\Pi 1 = \left[\frac{Ws}{Ww}\frac{Wc}{WA}\right]^a$	57.97, 8.55	57.97,34.6,15.4,8.55	WA = 15,20,30,40 kg Ws = 7.5,10,15,20 Kg Ww = 2.3,2.5,2.6,3 Kg Wc = 5 Kg
Π2=Term for geometric variable of mixer $\Pi 2 = \left[\frac{Ld}{Lb}\frac{Wb}{Dd}\frac{Sdb}{Ssb}\frac{Nb}{\beta}\right]^b$	18.86, 9.43	18.9, 14.2, 9.4	Ld = 0.7 m, Lb = 0.39 m, Dd = 0.72 m, Wb= 9 m, Sdb = 0.11 m, Ssb = 0.03 m, Nb = 2,3,4, β = 0.17
Π3=Term for energy in flywheel $\Pi 3 = \left[\frac{Fet^2}{WADd^2}\right]^c$	2195393, 31.36	2195393, 31.36	Inertia ,If = 11.87 kg-m^2 Angular Velocity, ω = 6.28, 12.56, 18.84. 25.12, 31.4, 37.68 rad/s Fe = 237.17, 936.7, 2107.57, 3746.8, 5854.38, 8430.31, Nm , WA = 15,20,30,40 kg
Π4=Time interval $\Pi 4 = \left[\frac{gt^2}{D_d}\right]^d$	306250, 13.61	306250, 13.61	t = 10 Sec, g = 9.8 m/s, , Dd = 0.72 m
Π5=Gear Ratio $\Pi 5 = [Gr]^e$	8,4	8,6,4	8, 6, 4

Model of Resting Torque (Tr)

The equation (1.2) is formulated based on experimental data obtained during experimentation. In this model, the highest influencing pie term is considered as a π4.This pie term is related to time interval. Whereas, the least influence is observed for π5 as -0.6783, this pie term relates to Gear ratio. The π1, π2, π3 relate to weight of ingredients, Geometrical parameters, stored flywheel energy, have moderate influence as -0.5015, 0.3176, and -0.009 respectively.

Interpretation of curve fitting constant (K)

The value for curve fitting constant for the model is 1.4443. This value shows the combined effect of extraneous variables. As this value is only 1.4443 approximately the combined effect of extraneous variables is not much amplifying the mode. Then here are extraneous variables are

1. Impact at the clutch.
2. Energy lost at various sliding pairs of the system.
3. The misalignment of the shafts.
4. Continuous variation in instantaneous speed of the load shaft.
5. A deficiency in assembly of varies components.

Similarly, the value is positive; which indicates that, there are good numbers of causes, which have influence on increasing effect.

The quantitative analysis comprises of sensitivity analysis, optimization of models and reliability of model.

Sensitivity Analysis: To check how much the independent pie term is sensitive compared with other independent pie terms.

Optimization of Model: To ascertain the best set of independent pie terms for either minimizing or maximizing the dependent pie term.

Reliability of Model: To check the quality of model. These analyses are executed for the established models. The results mathematical models are given below.

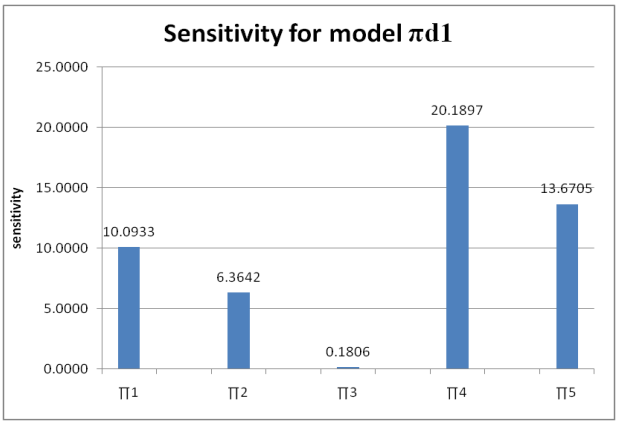


Figure1.7: Sensitivity graph for models πd1

1.3: Table: Sensitivity value for different models

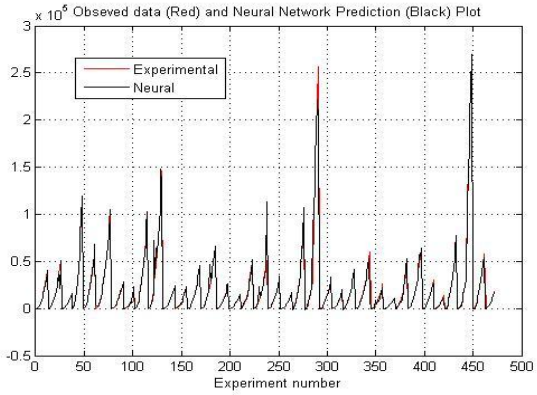
Pie term	For model **πd1**	For model **πd2**	For model **πd3**	For model **πd4**	For model **πd5**
π1	10.0933	3.1773	21.6066	0.4113	4.9713
π2	6.3642	0.2970	0.6661	2.7632	1.4494
π3	0.1806	0.0241	0.0040	0.0120	5.5135
π4	20.1897	10.0468	20.0080	0.0080	1.5366
π5	13.6705	0.4415	1.1482	8.6018	19.0659

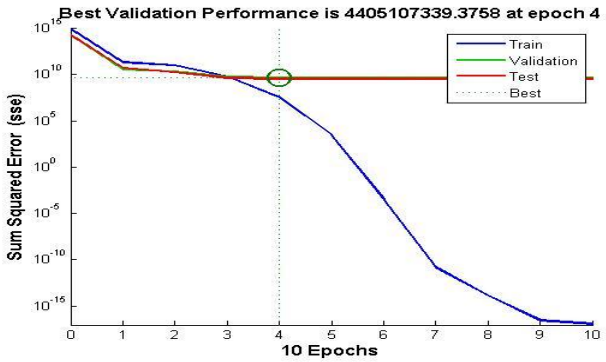
Table1.4: Optimized value for different models

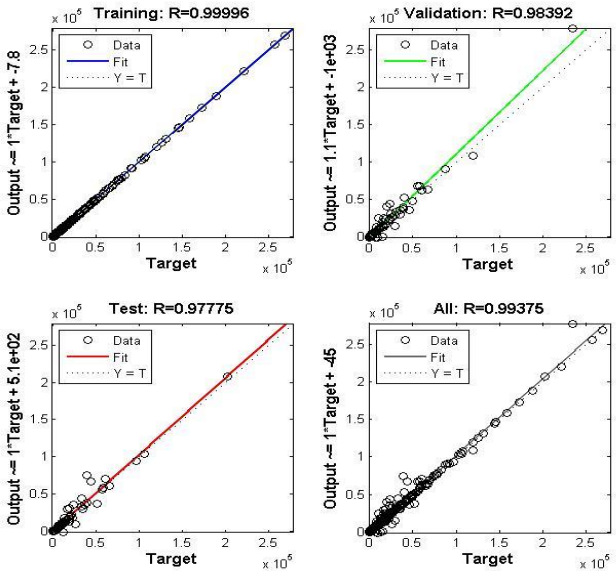
Pie term	For model **πd1**	For model **πd2**	For model **πd3**	For model **πd4**	For model **πd5**
Opt	1.139	0.678356	25341.39	0.163356	0.533487
π1	57.97	57.97101	8.555133	57.97101	57.97101
π2	9.434	18.86811	18.86811	9.434055	18.86811
π3	2195394	31.36994	31.36994	31.36994	31.36994
π4	13.61111	306250	306250	13.61111	13.61111
π5	8	8	4	4	8

II. SIMULATION USING ANN METHOD:

The established empirical relationship (model) is an approximate and it needed to have exact simulation therefore ANN simulation and RSM simulation for each model is performed. For one model the **ANN simulation [11]** is depicted as below.



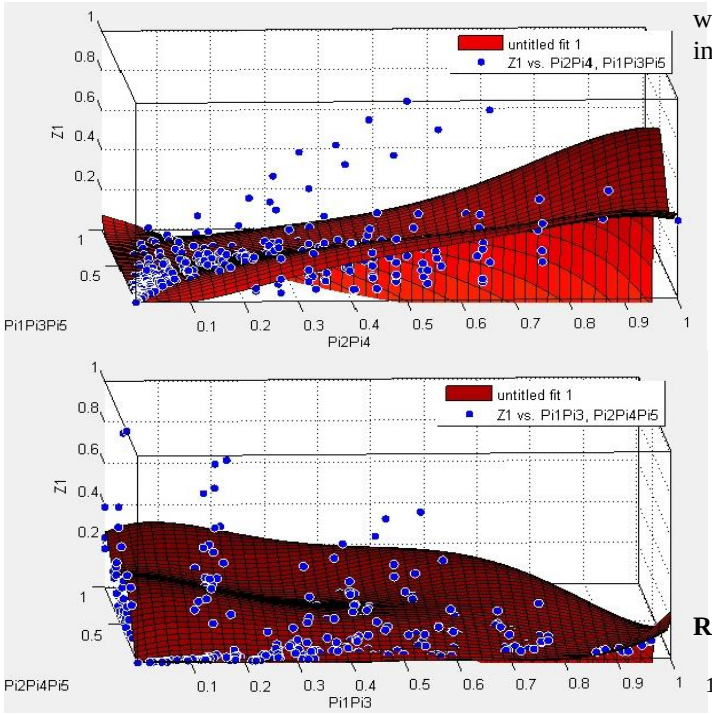




Response Surface Methodology:

The response Surface methodology or RSM is the combination of Mathematical and Statistical techniques. This technique becomes helpful for the analysis and modeling. The response is affected by several variables to optimize the response. This technique is adopted for each model.

RSM Model of πd1:



From the present research some prominent and important conclusions have been made.

The best mixing could be achieved by keeping the drum speed less than 30 rpm. [41]. Literature is only available about the performance of the concrete mix. Most of the manufacturers follow thumb rules and generally taking higher order of factor of safety. It is due to transient dynamics of mixing phenomenon. Therefore through the present research an attempt is made to understand its dynamics and even ascertained the most prominent parameters of concrete mixing considering the HPFM as an eco friendly solution.

The performance of the concrete mixer energized by Human Powered Flywheel Motor is governed by two aspects (a) Machine aspects (b) Product aspects. Machine aspects governed by the parameters like (i) Mixing time, (ii)Flywheel energy, (iii) Speed of Drum, whereas Product aspect is governed by the Quality of mix produced. As such the quality of mix can be ascertained by estimating following parameters (a) Slump height (b) Compressive Strength (c) Homogeneity etc. So considering these aspects the experimentation is executed. Through this experimentation, it is observed that, the sufficient amount of flywheel energy becomes available. The drum spins at required speed in various ranges with appropriate mixing time. The quality of mix also indicates fairly good as the values of slump height and compressive strength are observed within the desirable ranges. Homogeneity of mix has been observed orally and it shows good condition.

The empirical relationship established for this concrete mixing phenomenon. The quality of relation has ascertained by the term reliability. Thus one can say that relations have fair reliabilities as it is above 75% although it is as an approximate relationship.

The comparison between the values obtained from experimentation, empirical relationship and from ANN simulation has meager variation, which show that the attempt was adequate and needs to be apply at various rural and interior places.

III. CONCLUSIONS:

1. The empirical relationship established for this concrete mixing phenomenon. These relations show enough good results by substituting the desired ranges of variables.
2. The quality of relation has ascertained by the term reliability. Thus one can say that relations have fair reliabilities as it is above 75% although it is as an approximate relationship.
3. The comparisons between the values obtained from experimentation, empirical relationship and from ANN simulation has meager variation, which show that the attempt was adequate and needs to be apply at various rural and interior places.

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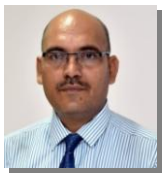

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