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Design and Fabrication of Hump Operated Power Generation System With Uncertainty Analysis In Measurement Of Voltage.

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ABSTRACT: In the present day scenario, we have design hump operated power generation system with classical method of calculations also we modeled it in inventor 2014 student version then we fabricated it using local available material in our college workshop after that we did it's experimental study in measurement of output voltage uncertainty when input variable parameter is load also output voltage uncertainty when input variable parameter is speed .
Keywords: Renewable Energy, Uncertainty analysis, Inventor Student version 2014, Hump etc.

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I. INTRODUCTION:

In the present scenario power has become a major need for human life. Energy is an important input in all the sectors of any countries economy. Energy crisis is due to two reasons, firstly the population of the world has been increased rapidly and secondly standard of living of human beings has increased. India is the country, which majorly suffers with lack of sufficient power generation.

Therefore, we have to investigate other types of renewable sources, which produce electricity without using any commercial fossil fuels, which is not producing any harmful products. The latest technology which is used to generate the power by such renewable energy" **POWER HUMP**". Considering this aspect we thought of utilizing this cushioning effect of the shock absorber of the vehicle, some part to be borrowed by the hump, to cushion the hump by at least one and half inches which will not affect the principle of the hump of the speed breaker.

II. PROJECT DETAILS

2.1Applied methodology:

This chapter describes the method which will be used to implement this project. This project is divided into two main parts which are design and fabricate. For the design, it is focus on the mainly 3D model and design calculations.

2.2 Principle of operation:

Basically hump operated power generation works on this principle.

1. The main part of the concept is depends on hump arrangement as like a heart of the project. When the vehicles passed over the hump its downwards and upward movement moves the Rack which is meshed with the pinion and gear assembely.
2. This motion is transmitted to gear with help of rack. Gear rotation is depends on rack arrangement which is attached to the hump.
3. Rack is used to convey the motion to the main arrangement. At the end of the hump arrangement there is a Gear and Pinion arrangement.
4. On the metal plate gear drive is mounted which are used for conveying the motion at the end of the shaft. The one gear is meshing with the pinion and that pinion is mounted on the shaft of the generator.
4. There is a copper winding inside the generator. After the rotation of copper winding the electromagnetic flux (EMF) is generates in the armature winding. By this way we can generate the electricity and used for various purposes.

2.5 Block Diagram:

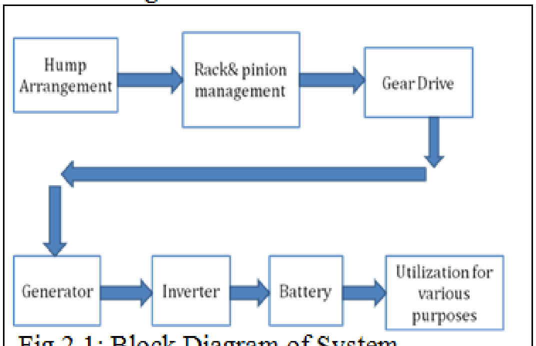

Fig 2.1: Block Diagram of System

III. DESIGN & FABRICATION:

3.1 Design:-

3.1.1 Design of Gear:-

Material = Alloy steel having $S_{ut} = 745 \frac{N}{mm^2}$

$z_p = 32$, $Z_g = 100$

Sup = 745$\frac{N}{mm^2}$, Sug = 745 $\frac{N}{mm^2}$

$K_a = 2$, $K_m = 1.6$, BHN = 400, $N_f = 3$

Beam Strength,

$\sigma_{bp} = 248 \frac{N}{mm^2}$ $\sigma_{bg} = 248 \frac{N}{mm^2}$

Assuming 20° Full Depth Involutes Tooth System

As Material Is Same, We Need To Design Pinion

$F_t = \sigma_{bp} \times b \times M \times Y_p$

$= 248 \times 10M \times M \times 0.484 \times \frac{2.87}{32}$

$= 1219.29M^2$

$F_w = d_p \times K \times Q \times b$

$K = 0.16 \times \left(\frac{BHN}{100}\right)^2$

$$Q = \frac{2 \times Z_g}{Z_g + Z_p}$$

$= 32M \times 1.5151 \times 2.56 \times 10M$

$=1241.16M^2$

Calculating parameters of gear by comparing with $F_{effective}$

$F_{effective} = \frac{K_a \times K_m \times \frac{P}{V}}{\frac{6}{6+V}}$

$= \frac{1.25 \times 1.6 \times \frac{1}{3351.33M}}{\frac{6}{6+3351.33M}} = \frac{F_w}{F.O.S}$

So M = Module = 2mm

Dimensions of Gear Pair

$d_p = M \times Z_g = 64mm$, $d_g = M \times Z_g = 190mm$

b = 10m = 30mm, ha = 2m

$h_f = 1.25M = 3.75mm$, a = $\frac{d_g + d_p}{2} = 132mm$

$F_{t=4837.16N}$

Induced stress can be calculated as

$\frac{F_t}{b \times Y_p \times P} = 903.32N$

So induced stress is less than allowable so gear design is safe.

3.1.2 Design of Spring:

$F_{max} = 4905N$, C = 6

G = 84 $\frac{N}{mm^2}$, δ = 100 mm (Deflection) assume.

Wire Diameter:-

Wahl Factor (K_w) = 1.2525

Shear Stress Induced, $\tau = K_w \times \left(\frac{8Fmax \times C}{\pi d^2}\right)$

d = 14.9495 ≈ 11mm

Mean Coil Diameter = D = C × d = 85mm

Number of Coils,

Stiffness, K = $\frac{F_{max}}{\delta_{max}} = 49.5 \frac{N}{mm}$

$K = \left(\frac{g \times d}{8 \times n \times C^3}\right)$

n = 14.7306 Turns

Total No of Coils, n'(n+2) =16.730

Solid Length, L = (N+2)×d = 250.959mm

Free Length, Lf = L + X + (n'-1) Clarence
= 366.689mm

Pitch of Coil = $L_f \times P \times n \times 2 \times d$ = 8.077mm

3.2 Drafting:-

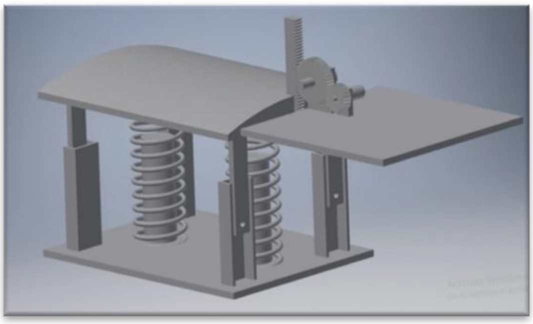

Fig3.2: Drafting of System

Above figure shows the drafting work for the system which is done with the help of inventor student version 2014.The above figure also shows the complete pictorial view of a complete assembly along with Hump and Gear assembly.

IV. EXPERIMENTAL SET UP:

4.1 Fabrication

Above Figure shows the actual fabrication of the Hump Operated Power Generation which has rack attached to the upper plate on which the hump rests.

The figure shows the gear and pinion assembly arrangement along with dynamometer coupled with the pinion shaft through locks and nut arrangement.

4.2 Experimental Analysis:

4.2.1 Actual set up:

Fig4.3: Actual assembly set up

Above fig shows actual installed assembly of hump operated power generation system. The complete assembly is installed below the road surface only the hump is above the road.

4.2.2 Uncertainty Observation Table of Voltage Vs Load:

Table 4.1: Uncertainty Observation Table of Voltage Vs Load

Sr.No.	load (N)	voltage	voltage	voltage	voltage	voltage	voltage	voltage	voltage	voltage	voltage
1	2158	7.1	6.9	6.8	5.4	5.6	5.5	5.5	6.8	6.5	6.1
2	2060	6.3	6.4	6.2	5.9	6	6.1	5.5	5.5	5.3	5.2
3	1962	3.85	3.6	3.7	3.1	3.85	3.73	4.2	3.4	3.45	3.1
4	1912	3.45	3.2	3.5	3.4	3.1	3.4	3.3	3	3.1	2.9
5	1863	2.98	2.81	2.88	2.83	2.91	2.7	2.75	2.85	2.8	2.2

4.2.2.2 Individual Uncertainty Chart of Voltage Vs Load:

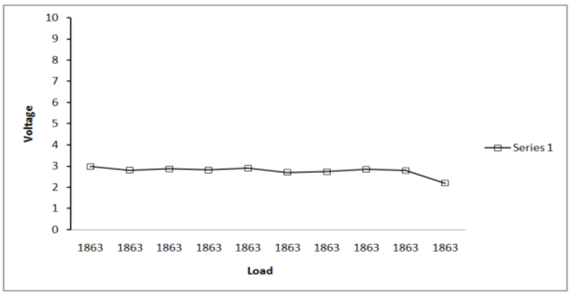

Fig4.4: Voltage Vs Load Chart for 1863N

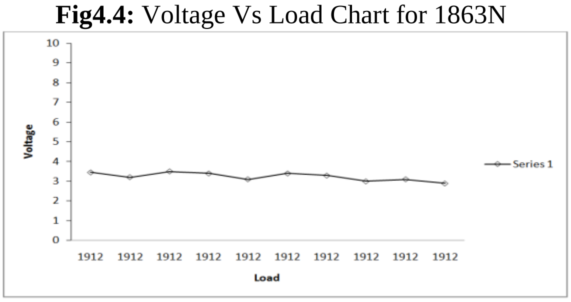

Fig4.5: Voltage Vs Load Chart for 1912N

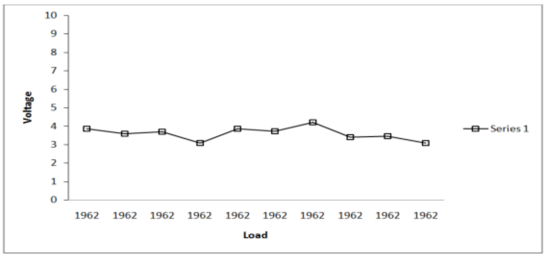

Fig4.6: Voltage Vs Load Chart for 1962N

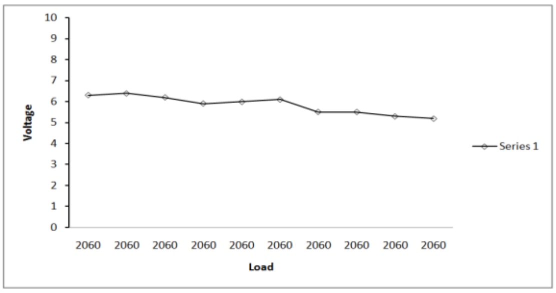

Fig4.7: Voltage Vs Load Chart for 2060N

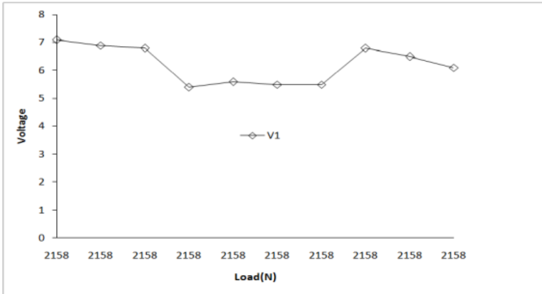

Fig4.8: Voltage Vs Load Chart for 2158N

Above five graphs shows individual uncertainty graph between voltage and load. It consists of loads ranging from 1863N to 2158N.

4.2.2.3 Combine Uncertainty Chart of Voltage Vs Load:

The standard uncertainty (u) of the mean is calculated from

$$u=\frac{\sum \bar{x}}{N}$$

The combine standard uncertainty for the whole fence panel can be calculated by squaring by individual uncertainty, adding them all together, and then taking square root of total.

$$u_{combine} = \sqrt{(\mu_1{}^2 + \mu_2{}^2 + \mu_3{}^2 \ldots\ldots)}$$

Following graph shows Combine Uncertainty Chart of Voltage Vs Load

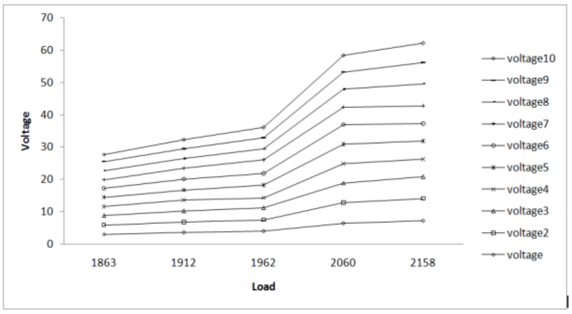

Fig4.9: Combine uncertainty chart of Voltage Vs Load

$$u_{combine} = \sqrt{(19.66^2 + 10.53^2 + 12.52^2 + 18.46^2 + 8.47^2)} = 32.65$$

Hence the maximum uncertainty for the voltage is obtained from load 2158N.

4.2.1.4 Scatter Chart For Voltage Vs Load:

Following graph shows Scatter Chart for Voltage Vs Load

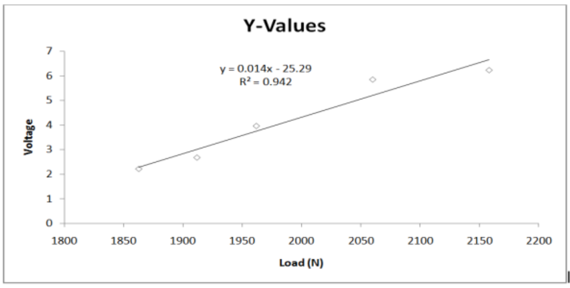

Fig: Scatter Chart for Voltage Vs Load

Hence from the above graph the obtained line equation is, Y = 0.014x -25.29, R^2=0.942

Hence combine uncertainty analysis for the voltage with respect to load is correct.

4.2.3 Uncertainty Observation Table of Speed Vs Voltage

4.2.3.1 Uncertainty Chart of Speed Vs Voltage:

Table4.2: Uncertainty Observation Table of Speed Vs Voltage

Sr No	speed	voltage	voltage	voltage	voltage	voltage	voltage	voltage	voltage	voltage	voltage
1	5	3.85	3.6	3.7	3.1	3.85	3.73	4.2	3.4	3.45	3.1
2	10	3.45	3.2	3.5	3.4	3.1	3.4	3.3	3	3.1	2.9
3	15	2.98	2.81	2.88	2.83	2.91	2.7	2.75	2.85	2.8	2.2
4	20	2.45	2.2	2.5	2.4	2.1	2.4	2.2	2	2.1	1.9
5	25	2.1	1.9	1.2	1.3	1.4	1.6	1.4	1.5	1.6	1.8

4.2.3.2 Individual Chart of Speed Vs Voltage:

Following five graphs shows individual uncertainty graph between Speed Vs Voltage.

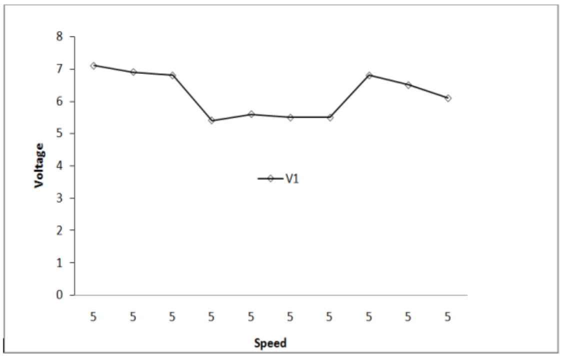

Fig: Speed vs voltage chart for speed 5km/hr

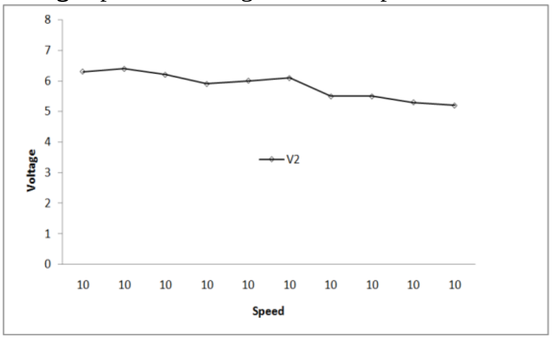

Fig: Speed vs voltage chart for speed 10km/hr

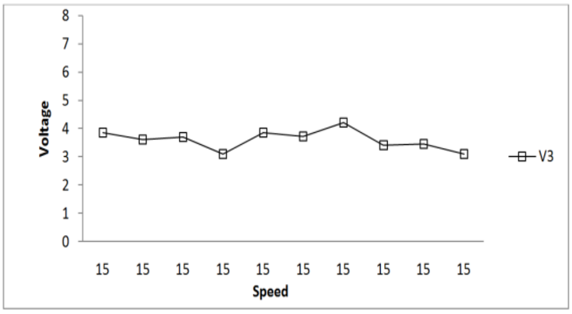

Fig: Speed vs voltage chart for speed 15km/hr

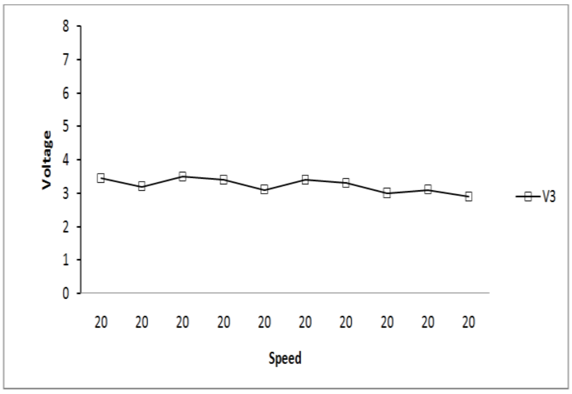

Fig: Speed vs voltage chart for speed 20km/hr

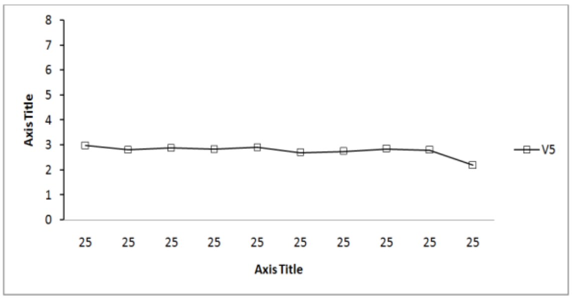

Fig: Speed vs voltage chart for speed 25km/hr

Above five graphs shows individual uncertainty graph between voltage and speed. It consists of speed ranging from 5 to 25km/hr.

4.2.3.3 Combine Uncertainty Chart of Voltage Vs Speed:

The standard uncertainty (u) of the mean is calculated from

$$u = \frac{\sum \bar{x}}{N}$$

The combine standard uncertainty for the whole fence panel can be calculated by squaring by individual uncertainty, adding them all together, and then taking square root of total.

$$\mu_{combine} = \sqrt{(\mu_1{}^2 + \mu_2{}^2 + \mu_3{}^2 \ldots\ldots)}$$

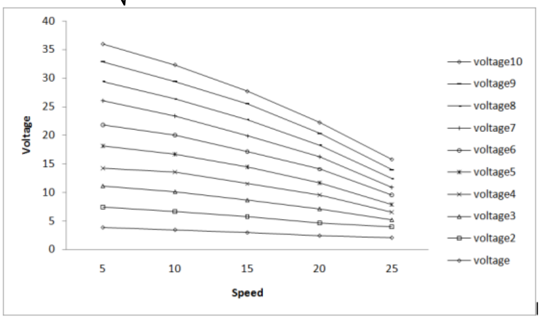

Fig: Combine Uncertainty Chart of Voltage Vs Speed

Following graph shows Combine Uncertainty Chart of Voltage Vs Speed.

$$u_{combine} = \sqrt{(19.66^2 + 10.53^2 + 12.52^2 + 18.46^2 + 8.47^2)}$$

= 32.65

Hence the maximum uncertainty for the voltage is obtained from speed 5km/hr.

4.2.3.4 Scatter Chart For Voltage Vs Speed:

Following graph shows Scatter Chart for Voltage Vs Speed.

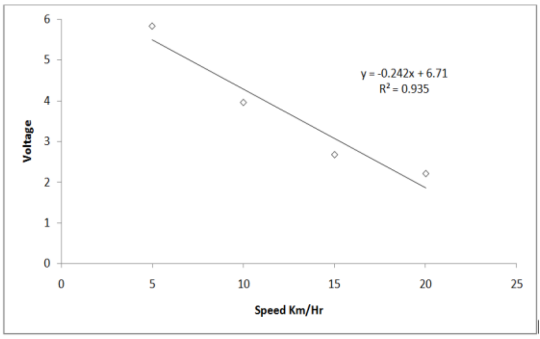

Fig: Scatter Chart For Voltage Vs Speed

Hence from the above graph the obtained line equation is, Y = -0.242x +6.71, R^2=0.935

Hence combine uncertainty analysis for the voltage with respect to load is correct.

V. RESULT & DISCUSSION:

5.1 Power Calculations:

5.1.1 Theoretical Power:

$$= \frac{Displacement\ \ of\ the\ Spring\ \times Maximum\ \ Load}{60}$$

$$= \frac{0.1 \times 4909}{60} = 8.18\text{watt}$$

5.1.2 Actual Power:

5.1.2.1 Voltage with respect to speed

For power calculations we have taken five individual readings for different speed and load their respective voltages for power calculations.

Table 5.1 Observation table for different speed and theirs voltages

Sr.No	Speed(km/Hr)	Voltage(volts)
1	5	6.22
2	10	5.84
3	15	3.96
4	20	3.33
5	25	2.69

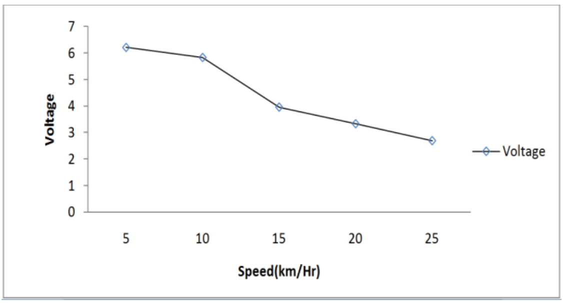

Fig 5.1: Graph between voltage and speed

Above is the Graph between voltages generated for different speed

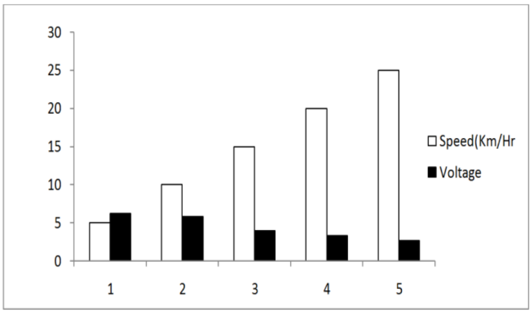

Fig 5.2: Bar graph between voltages generated under different speed

From above graphs we can see the voltage is changes as speed increases or decreases as speed increases the voltage decreases a vice versa. At speed 5Km/Hr voltage is 6.55Volts and at speed 25km/hr it is 2.69volts this reading we taking calculating for maximum and minimum power.

According to Ohms law,

Maximum power can be calculate as:

$$P = V \times I$$
$$= 6.55 \times 0.75$$
$$= 0.4\text{Watt}$$

Minimum power can be calculate as:

$$P = V \times I$$
$$= 2.69 \times 0.03$$
$$= 0.1\text{W}$$

5.1.3 Difference between Theoretical Power and Actual Power:

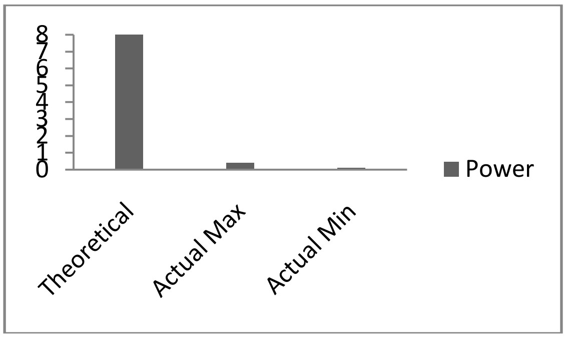

Fig 5.3: Difference between Theoretical Power and Actual Power

VI. CONCLUSIONS

1. After designing and fabrication of hump operated system the following results were obtained, 1.Theorotical power = 8.1 watt, Maximum actual power= 0.4 watt, Minimum actual power= 0.1 watt.
2. We have studied the uncertainty analysis of output voltage when the input is load. We found maximum uncertainty at 2158N also the combine uncertainty for the same is 32.65
3. We have studied the uncertainty analysis of output voltage when the input is speed. We found maximum uncertainty at 5km/hr also the combine uncertainty for the same is 32.65

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