DESIGN AND FABRICATION OF HARTNELL GOVERNOR

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Abstract: The aim of our work is to develop prototype of a product "Hartnell Governor" the function of governor to maintain the speed of an engine within specified limits and improves the sensitivity of an engine whenever there is a variation of load.it is dynamic device done in the field of manufacturing technology. It is rather inexpensive and can be used in all vehicles.

***Index terms* - Speed, Motion, Sensitivity.**

I. INTRODUCTION

A governor, or speed limiter, is a device used to measure and regulate the speed of a machine, such as an engine. A classic example is the centrifugal governor, also known as the watt or fly ball governor, which uses weights mounted on spring loaded arms to determine how fast a shaft is spinning, and then uses proportional control to regulate the shaft speed.

II. HARTNELL GOVERNOR

A Hartnell Governor is a spring loaded Governor. It is a device which controls the Speed of an engine, a motor or other machine by regulating the fuel or power supply. The controlled speed is called the 'isochronous speed'. Electronic systems are also available. Hartnell governor. If a governor is in equilibrium at one particular speed at all radii of rotation, it is called isochronous governor. The sensitiveness of an isochronous governor is infinite, because the range of an isochronous governor is zero.

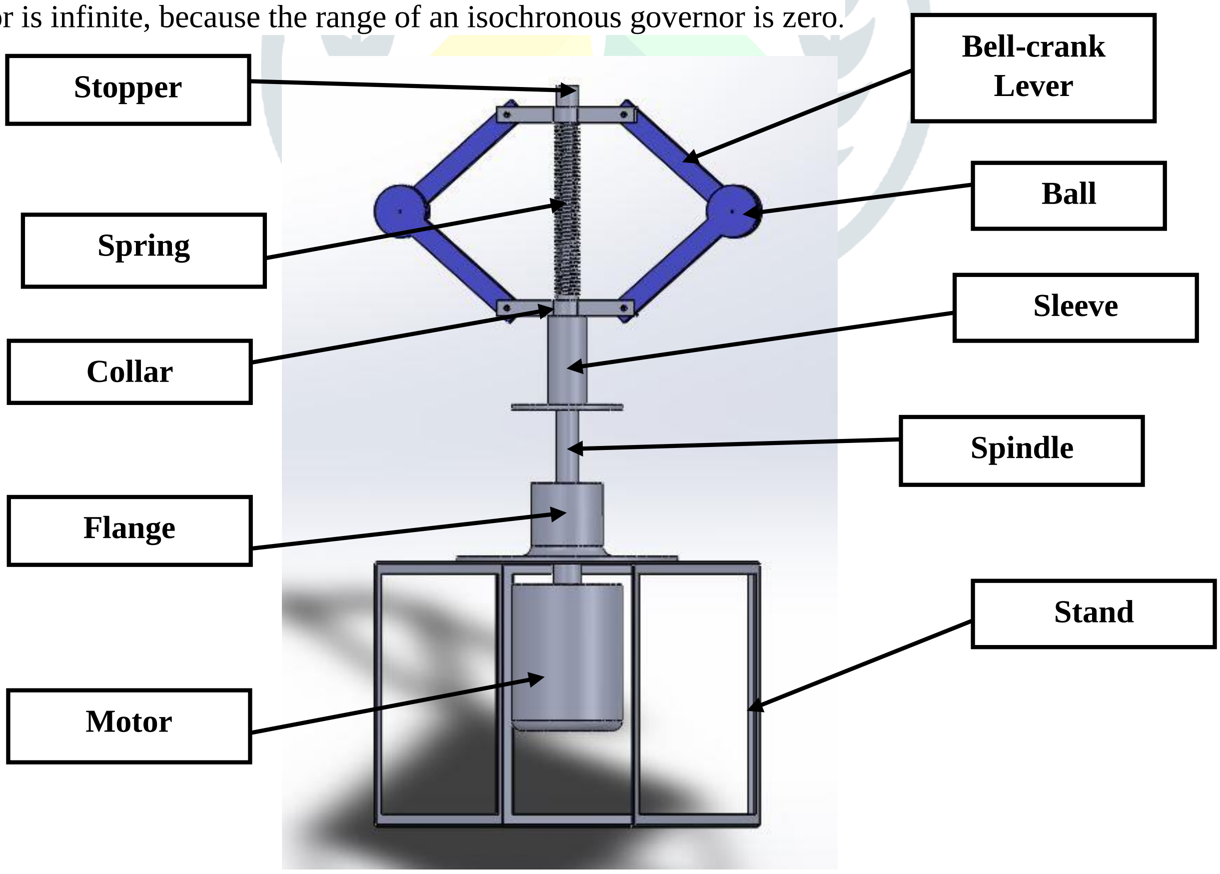

Fig.1 3D Model of Hartnell Governor

III. PROSPECT OF HARTNELL GOVERNOR

In engineering, the applications of A governor helps to maintenance the required constant speed of any device with the help of centrifugal force , in automobiles it controls the speed and keeps the speed within the pre desired speed by operating the throttle valve. Its application also involves in speed control of Turbine shaft in Hydro-electric power plants since the varying water pressure may increase or decrease the speed, the governor operates the water nozzle. Governors were also used in speed control of mechanical Music box.

3.1. Controlling Force, Stability and Sensitivity.

The centrifugal governors are based on the balancing of centrifugal force on the rotating balls by an equal and opposite radial force known as the Controlling Force.
A governor is said to be stable when there is one radius of rotation of the balls for each speed which is within the speed range of the governor

The smaller the change in speed from no load to the full load, the more sensitive the governor will be. According to this definition, the sensitiveness of the governor shall be determined by the ratio of speed range to the mean speed. The smaller the ratio more sensitive the governor will be

3.2. Isochronism, Efforts and Power.

A governor is said to be isochronous if equilibrium speed is constant for all the radii of rotation in the working range. Therefore, for an isochronous governor the speed range is zero and this type of governor shall maintain constant speed.
Governor effort and power can be used to compare the effectiveness of different type of governors.

3.3. Preferable environmental adaptability, Remote Measurement.

It is defined as the mean force exerted on the sleeve during a given change in speed. When governor speed is constant the net force at the sleeve is zero. When governor speed increases, there will be a net force on the sleeve to move it upwards and sleeve starts moving to the new equilibrium position where net force becomes zero.

IV. PROBLEM FORMULATION

4.1. Formulae:

1) Height of Governor, $h = h_o - (x/2)$ (mm)
2) Link angle,(α) $\cos\alpha = (h/L)$ (degree)
3) Radius of rotation, $R = 50 + L \times \sin\alpha$ (m)
4) Angular velocity of Governor, $\omega = \frac{2\pi N}{60}$ (Rad/sec)
5) Centrifugal force, $F = m \times \omega^2 \times R$ (N)
6) Stiffness of the spring, $S = \frac{S_2 - S_1}{h}$ (N/mm)

   Where

   S_1 = Spring load at lowest equilibrium speed

   $S_1 = 2F_1x$ (N/m)

   S_2 = Spring load at highest equilibrium speed

   $S_2 = 2F_2x$ (N/m)
7) Sensitiveness of Hartnell governor, $S_H = \frac{N_2 - N_1}{N}$

   Where $N = \frac{N_1 + N_2}{2}$

4.2. Observations:

- Initial Height (**h_o**) = 120 mm

- Mass of the ball (**m**) = 250 g = 0.25 Kg
- Length of the arms (**L**)= 150 mm

4.2.1 Observation Tabular-form:

Sl.no	Sleeve Displacement, X (mm)	Speed, N (rpm)	
		N_1	N_2
1.	120	310	320

Table.1 Observation table

4.3. Calculations:

1) **Height of Governor (h)**

$h = h_o - (x/2)$

$h = 120 - (120/2)$

$h = 60$ mm

$h = 60 \times 10^{-3}$ m.

2) **Link Angle (α)**

$\cos\alpha = h/L$

$\alpha = \cos^{-1}(h/L)$

$\alpha = \cos^{-1}(60/150)$

$\alpha = 66.42^o$.

3) **(i) Radius of rotation (R_1)**

$R_1 = 50 + L \times \sin\alpha$

$R_1 = 50 + 150 \times \sin(66.42)$

$R_1 = 187.47$ mm

$R_1 = 187.47 \times 10^{-3}$ m.

(ii) Radius of rotation (R_2)

$R_2 = R_1 + hx$

$R_2 = 187.47 \times 10^{-3} + 60 \times 10^{-3} \times 120 \times 10^{-3}$

$R_2 = 0.367$ m.

4) **(i) Angular velocity of Governor (ω_1)**

$\omega_1 = \frac{2\pi N_1}{60}$

$\omega_1 = \frac{2\pi * 310}{60}$

$\omega_1 = 32.44$ rad/sec.

(ii) Angular velocity of Governor (ω_2)

$\omega_2 = \frac{2\pi N_2}{60}$

$\omega_2 = \frac{2\pi * 320}{60}$

$\omega_2 = 33.49$ rad/sec.

5) **(i) Centrifugal force (F_1)**

$F_1 = m \times \omega_1^2 \times R_1$

$F_1 = 0.25 \times (32.44)^2 \times 187.47 \times 10^{-3}$

$F_1 = 49.321$ N.

(ii) Centrifugal force (F_2)

$F_2 = m \times \omega_2^2 \times R_2$

$F_2 = 0.25 \times (33.49)^2 \times 0.367$

$F_2 = 102.90$ N.

6) Stiffness of the spring, $S = \frac{S_2 - S_1}{h}$ (N/mm)

Where

S_1 = Spring load at lowest equilibrium speed

$S_1 = 2F_1x$ (N/m)

$S_1 = 2 \times 49.321 \times 120.10^{-3}$

$S_1 = 11.83$ N/m.

S_2 = Spring load at highest equilibrium speed

$S_2 = 2F_2x$ (N/m)

$S_2 = 2 \times 102.90 \times 120 \times 10^{-3}$

$S_2 = 24.69$ N/m.

Stiffness of the spring (S)

$S = \frac{S_2 - S_1}{h}$

$S = (24.69-11.83)/ (60*10^{-3})$

$S = 214.33$ N/mm.

7) Sensitiveness of the Hartnell governor (S_H)

$S_H = \frac{N_2 - N_1}{N}$

Where $N = \frac{N_1 + N_2}{2}$

$N = (310+320)/2$

$N = 315$

$S_H = \frac{N_2 - N_1}{N}$

$S_H = (320-310)/315$

$S_H = 0.031$

4.3.1 Calculation Tabular-form:

Sl.no	Stiffness of the spring, S (N/mm)	Sensitiveness of the Hartnell governor, S_H
1.	214.33	0.031

Table.2 Calculation table

V. RESULT

(i) Stiffness of the spring, S = **214.33 N/mm**

(ii) Sensitiveness of the Hartnell governor, S_H = **0.031**

By comparing the above results, we can say that there is a variation between stiffness, sensitiveness and load variation on governors and Isochronism Factor of Hartnell Governor.

VI. CONCLUSIONS

The governors are control mechanisms and they work on the principle of feedback control. Their basic function is to control the speed within limits when the load on the prime mover changes. They have no control over the change is speed within the cycle. The speed control within the cycle is done by the flywheel.

- Thus governor plays an important role in speed control.
- It ensures regulation of speed at any conditions
- To study the effect of varying the mass of the center sleeve in porter governor.

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