Analysis & Investigation on Watt Governor to Improve the Speed Range of the Governor

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Abstract: **There are many types of governors. Watt governor is the simplest form of governors. It is known that the watt governor has low speed range because in watt governor controlling force is less. To improve the range various governor was invented some of them are Porter governor, Proell governor & Hartnell governor in the mentioned the controlling force is increased by dead weight on the sleeve in Porter & Proell governor and by spring in Hartnell governor. In the current investigation watt governor is modified such that it increases the controlling force .in modification the fly-ball is fixed on the lower arm at the small distance below from the point of intersection of arms. The analysis is carried out by mounting the flyball at the various positions on the lower arm.**

***Keywords*: Arm, range, speed & flyball**

I. INTRODUCTION

The function of governor is to minimize the variation of speed where the variation in speed is due to the variation in load. Governor may be centrifugal or inert type depending upon the action against the variation in speed. In centrifugal governor a pair of balls known as flyball rotates with the spindle of the governor. the spindle is coupled with the engine shaft. The fly balls rise or fall by the centrifugal action when there is a variation in spindle speed. The governor consists of two pair of arms i.e. upper pair of arms and lower pair of arms. The upper pair is pivoted to the spindle axis and lower pair is pivoted on the sleeve which can move up and down along the axis of spindle. The movement of sleeve is due to the centrifugal force on the pair of ball or we can say that the action of the governor depends upon the Centrifugal effects produced by masses of the two balls. When the load on the engine decreases the speed of spindle increases and the balls tends to rotate at greater radius from the axis due to the centrifugal action on the balls. This causes the sleeve to slide up on spindle and this movement of the sleeve is communicated to the throttle through a bell crank lever. This closes the throttle valve to the required extent. When the load on the engine increases the speed of spindle decreases and the balls tends to rotate at smaller radius from the axis and the valve is opened according to the requirement.

II. ABOUT WATT GOVERNOR

Watt governor is designed by James Watt in 1788 for his steam engine therefore it is called watt governor. It is the simplest form of centrifugal governor The spindle is driven by the output shaft of the prime mover. The balls are mounted at the junction of the two arms. The upper arms are connected to the spindle and lower arms are connected to the sleeve. The watt governor is suitable for low speed i.e. 60 to 80 rpm.

The height of the governor

$$h = \frac{895}{N^2}$$

Where N=rpm

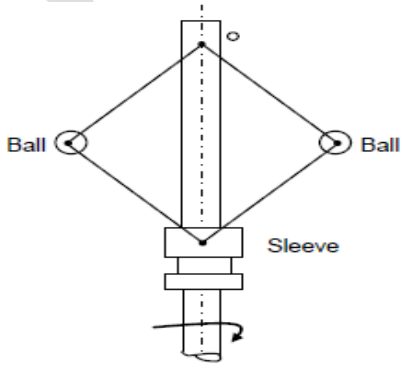

Figure-1

III. MODIFICATION IN WATT GOVERNOR

A small modification is made by mounting the balls slightly below the point of intersection of arms.

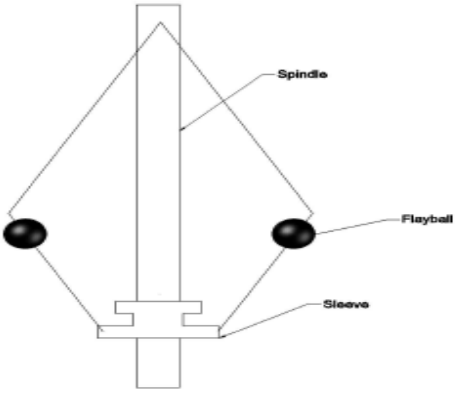

Figure-1.1

III. INSTANTANEOUS CENTER METHOD

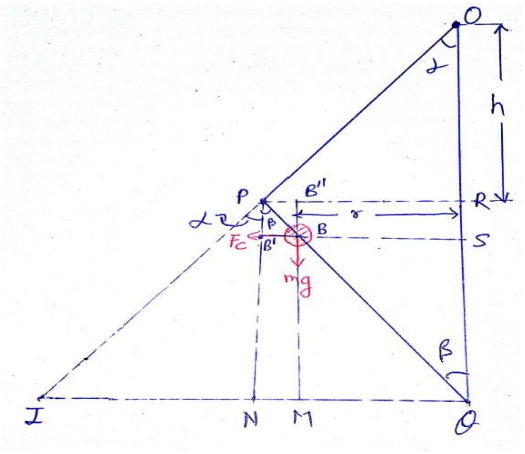

Figure-1.2

Let m= mass of each flyball

N= equilibrium speed

OP= length of upper arms

PQ= length of lower arms

Point B is selected on link PQ such that PQ=cPB (PQ is c times of PB)

In similar triangles Δ BMQ & Δ PQN

NQ = c NM, NM = $\frac{NQ}{c}$

Taking moment about I

F_C x BM = mg x IM

F_C = mg x $\frac{IM}{BM}$ ……..….1.1

Now IM = IN + NM

=PN Tanα + $\frac{NQ}{C}$

= PN Tanα + $\frac{PN\ Tan\beta}{C}$

(NQ= PN Tanβ)

= PN Tanα(1 + $\frac{Tan\beta}{Tan\alpha}$ x $\frac{1}{C}$)

= PN Tanα(1 + $\frac{q}{c}$) ……1.2

($\frac{Tan\beta}{Tan\alpha} = q$)

And BM= NB' =PN-PB'

=PN- $\frac{PN}{C}$

=PN (1- $\frac{1}{C}$) ……..1.3

From the equations 1.1, 1.2 & 1.3

F_C = mg x $\frac{PN\ Tan\alpha(1+\frac{q}{c})}{PN\ (1-\frac{1}{c})}$

F_C = mg x $\frac{Tan\alpha(c+q)}{(c-1)}$

Put Tan α= $\frac{PR}{h}$=$\frac{NQ}{h}$

mrω^2 = mg x $\frac{NQ(c+q)}{h(c-1)}$

{r=NQ- NM

= NQ- $\frac{NQ}{c}$ = NQ (1- $\frac{1}{c}$) }

NQ (1- $\frac{1}{c}$) ω^2 =g x $\frac{NQ(c+q)}{h(c-1)}$

ω^2 =$\frac{C(C+q)}{(C-1)(C-1)}$ x $\frac{g}{h}$

N^2 =$\frac{C(C+q)}{(C-1)(C-1)}$ x $\frac{985}{h}$

$$h = \frac{C(C+q)}{(C-1)^2} \times \frac{985}{N^2}$$

h(modified watt governor) =$\frac{C(C+q)}{(C-1)^2}$ x h(watt governor)

The value of $\frac{C(C+q)}{(C-1)^2}$ > 1 always

IV. OBSERVATION

By the comparison of expression of height for watt governor and Modified watt governor it is observed that the speed can be increased $\sqrt{\frac{C\{C+q\}}{(C-1)^2}}$ times at same height.

It is further studied by taking a suitable example.

Example

A watt governor has equal arms each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 Kg. radius of rotation of ball is 150 mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find out the maximum & minimum equilibrium speed.

Solution:

From the configuration for given radius we can easily find height of governor

For watt governor

At r_1=150 mm

h_1=200 mm (from the configuration)

Now $N_1^2 = \frac{895}{h_1}$

N_1 =66.89 rpm (minimum equilibrium speed)

At r_2=200 mm

h_1=150 mm (from the configuration)

Now $N_2^2 = \frac{895}{h_2}$

N_2 =77.24 rpm (maximum equilibrium speed)

For modified watt governor

Let the ball are fixed at the lower arms such that

Length of lower arm= 10 x position of balls from the point of intersection

i.e. PQ=10 PB (from diagram)

c=10

At r_1=150 mm

h_1=200 mm (from the configuration)

$$N_1^2 = \frac{C\{C+q\}}{(C-1)^2} \times \frac{895}{h_1}$$

q=1

$$N_1^2 = \frac{10(10+1)}{(10-1)^2} \times \frac{895}{.2}$$

N_1 =77.72 rpm (minimum equilibrium speed)

At r_2=200 mm

h_1=150 mm (from the configuration)

$$N_2^2 = \frac{C\{C+q\}}{(C-1)^2} \times \frac{895}{h_2}$$

q=1

$$N_1^2 = \frac{10(10+1)}{(10-1)^2} \times \frac{895}{.15}$$

N_2 =90.01 rpm (maximum equilibrium speed)

V. RESULT & DISCUSSION

It is observed from the example taken that the speed range for watt governor was from 66.89 rpm to 77.24 rpm. And in modified watt governor by taking c=10 range was 77.72 rpm to 90.01 rpm. Over all we can say that working range is increased.

Further, the working range can be adjusted by selecting the suitable value of c. following table shows the variation of speed with the value of c.

Table 1

C	50	40	30	25	20
$N_{1\ (rpm)}$	68.94	69.46	70.35	71.06	72.16
$N_{2\ (rpm)}$	71.05	72.13	73.97	75.49	77.83
N2-N1	2.11	2.67	3.63	4.43	5.67

Table 2

C	15	10	8	6	4
N_1 (rpm)	74.02	77.96	81.09	86.71	99.72
N_2 (rpm)	81.91	90.85	98.30	112.38	148.66
N2-N1	7.89	12.89	17.21	25.68	48.93

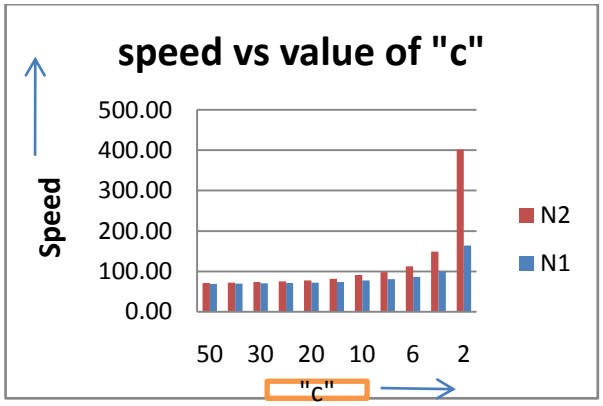

Figure-1.4

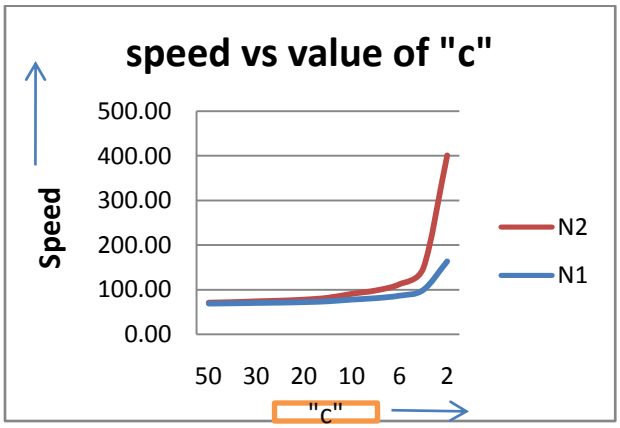

Figure-1.5

VI. CONCLUSION & SUMMARY

Watt governor is the oldest governor. And the various modifications are made in the watt governor according to the requirement. Porter and Proell are the modified form of the watt governor. Here in the current paper the modification is made for increase the working range of the watt governor. And it is concludes that the working speed range can be enhanced by the modification discussed. From the example it is found that the speed range is increased from 66.89 - 77.24 rpm to 77.72 - 90.01 rpm by taking c= 10. Range can be enhanced by selecting the suitable value of c.

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