Experimental Investigation on Watt Governor to Increase Minimum Speed

GiriBabu Surarapu[1], Shashidar PeddiReddy[2], Nagamani Uotkuri[3]

[1]M Tech (Machine Design) SIT, Khammam, Telengana, India
[2]M Tech (Machine Design) KITS, Khammam, Telengana, India
[3]M Tech (Cad / Cam) S.V.E.C, Suryapet, Telengana, India

Abstract- The function of the governor is to maintain the mean speed of the engine with in specified limits whenever there is a variation of the load. The objective of our investigation is modifying the Watt Governor (pendulum type) to increase minimum speed limit. [2] Generally we seen that watt governor is best suitable for 60-80r.p.m minimum speeds only, in our study we extend lower arm and fly ball position of the watt governor to the downside from the intersection of link and arm, and then we derive the equation for governor speed. We fabricated the model of governor and observed effect of the extension of lower link and fly ball weight on minimum speed of the governor. This analysis carried out by extension of lower links of the governor and position of fly balls.

Index Terms- Extension of lower links, position of fly balls, minimum speed of the governor, central sleeve load.

I. INTRODUCTION

A Governor, or speed limiter is a device used to measure and regulates the fuel supply to the engine with respect to the engine load variations, when a load on the engine increases sleeve move downwards and due to attached bell crank lever to the supply valve, the fuel supply will decreases and vice-versa. This can regulate the fuel supply to the engine automatically. A classic example is the centrifugal governor, Also known as the watt. [1] Centrifugal governors were used to regulate the distance and pressure between millstones in windmills since the 17th century. Early stem engines employed a purely reciprocating motion, and were used for pumping water an application that could tolerate variations in the working speed. It was not until the Scottish engineer James Watt introduced the rotative steam engine, for driving factory machinery, that a constant operating speed became necessary. Between years 1775 and 1800, Watt, in partnership with industrialist Mathew Bolton, produced some 500 rotati-vebeam engines. At the heart of these engines was Watt self designed " conical pendulum" governor: a set of revolving steel balls attached to a vertical spindle by links and arms, where the controlling force consists of the weight of the balls. Building on Watt design was American engineer Willard Gibbs who in 1872 theoretically analyzed Watt's conical pendulum governor from a mathematical energy balance perspective. During his graduate school years at Yale University, Gibbs observed that the operation of the device in practice was beset with the disadvantages of sluggishness and a tendency to overcorrect for the changes in speed it was supposed to control. The objective our investigation to increase the minimum speed of the Watt Governor from 60-80 r.p.m by extending lower arm to the down side from the intersection of upper and lower arm position and fly ball position, and noted that how the minimum speed will changes in different positions of fly ball weight.

II. MODIFICATION OF WATT GOVERNOR

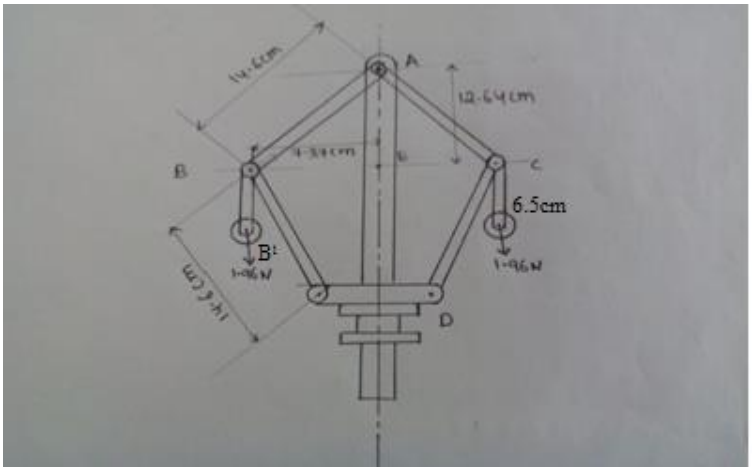

Fig. 2.1: Modification of Watt Governor [1]

[2] It consists of a pair of two balls which are attached to the spindle with the help of links and arms .the upper links are pinned at 'A' and lower arms are fitted to the sleeve.

Which is similar to the watt governor, but it differs from Watt Governor in the arrangement of fly balls .the fly balls are carried on the extension of lower arm to the downside from the intersection of upper links and lower arms, instead of at junction of upper and lower arms. The action of this Governor is similar to watt governor.

2.1 FROM INSTANTANEOUS CENTER METHOD

In this method, equilibrium of the forces acting on the link BD is considered. The instantaneous centre 'I' lies at the point of intersection of AB produced and a line through D perpendicular to the spindle axis, as shown in figure. 2.2

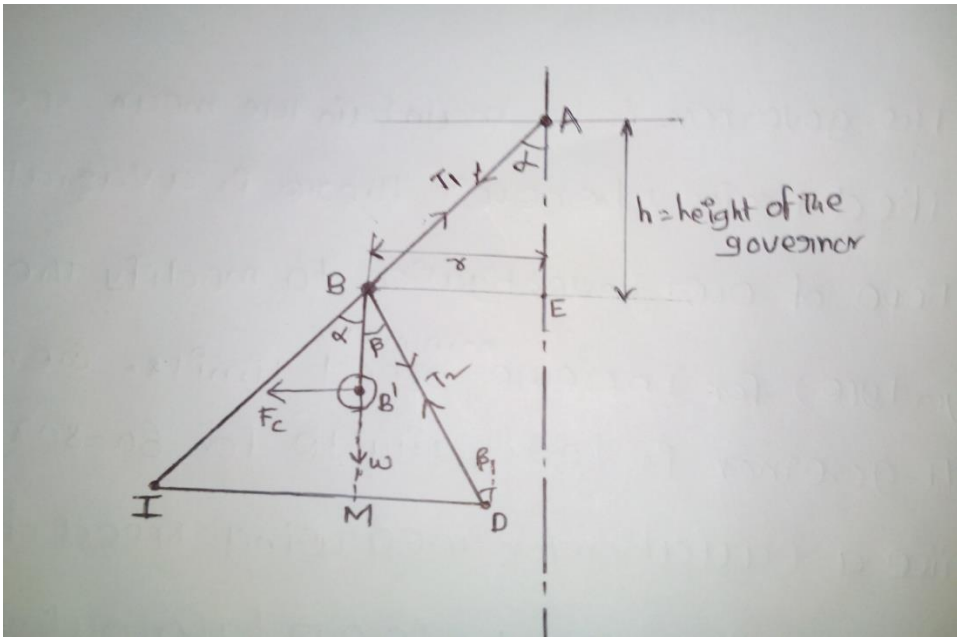

Fig. 2.2: Instantaneous Centre Method

Now taking moments about 'I'

F_c X B'M–w X IM =0, Where F_c = m ω^2 r, w = mg and IM = r, $\omega = 2\Pi N/60$

$m\omega^2 r \times B'M - mg \times r = 0$

$m\omega^2 r \times B'M = mg \times r$

$\omega^2 x (BM - BB') = g$

$$\omega^2 = \frac{g}{BM - BB'}$$

$$N^2 = \frac{895}{BM - BB'}$$

[1] As sown in fig. 2.1. Here AB- length of the arm (cm), BE = r = Radius of rotation (cm), AE = h = Height of the governor (cm), 30^0= α = Angle of inclination, BB^1-Length of extension of lower arm, Length AB = 14.6 cm= 146 mm, BE = 7.37 cm =73.7 mm, BB^1 = 6.5 cm = 65 mm, Height of the governor WKT h1= AB* cosα = 14.6 * $\cos 30^0$ = 12.64 cm = 0.126 m

For minimum speed (N_1)

$N_1^2 = \frac{895}{BM - BB'}$ Where BM = AE = h_1 =12.64cm = 0.126m and BB' = 6.5cm = 0.065m.

$N_1^2 = \frac{895}{0.126 - 0.065}$, N_1=121.2 r.p.m -------- (1)

For maximum speed ($N_{2)}$

Assume sleeve to be lift 20 mm

$h_2 = h_1 - 0.02 = 0.126 - 0.02 = 0.106$ m

$N_2^2 = \frac{895}{0.106 - 0.065}$, N_2 = 147 r.p.m.

The range of speed of the governor is $N=N_2-N_1$= 147-121.2 =25.8r.p.m

If we take the length of extension link (i.e.BB^1) more than 65mm, it had some structural problem may happened and also below that length it gives < 120 r.p.m, minimum speeds.

2.2 In a Watt Governor

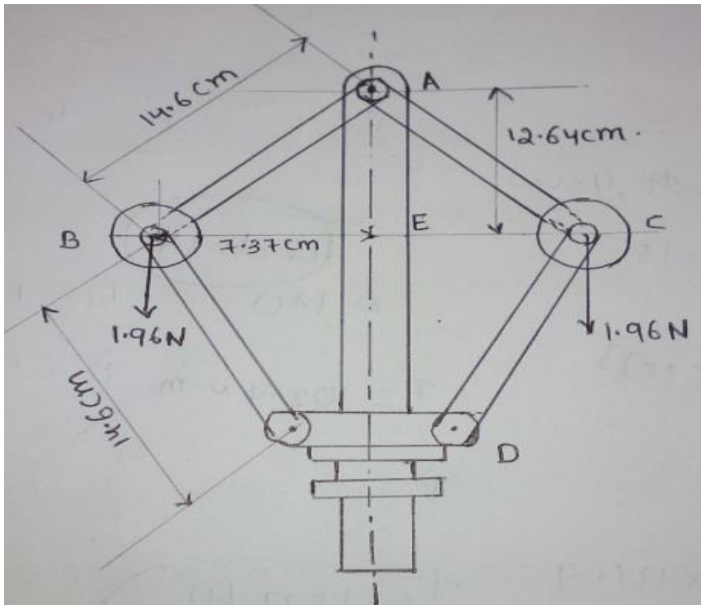

Fig. 2.3: Watt Governor [1]

Here AB- length of the arm (cm), BE = r = Radius of rotation (cm), AE = h = Height of the governor (cm), 30^0= α = Angle of inclination, Length AB = 14.6 cm= 146 mm, BE = 7.37 cm =73.7 mm, Height of the governor We Know That, h_1 = AB* cosα = 14.6 * $\cos 30^0$ = 12.64 cm = 0.126 m

Minimum speed: $N_1^2 = \frac{895}{h_1} = \frac{895}{0.126}$,

$N_1 = 84.2$ r.p.m. ---------- (2)

Assume sleeve to be lift 20 mm,

Maximum speed: $N_2^2 = \frac{895}{h_2} = \frac{895}{0.106}$,

$N_2 = 91.77$ r.p.m.

2.3 In a Porter Governor

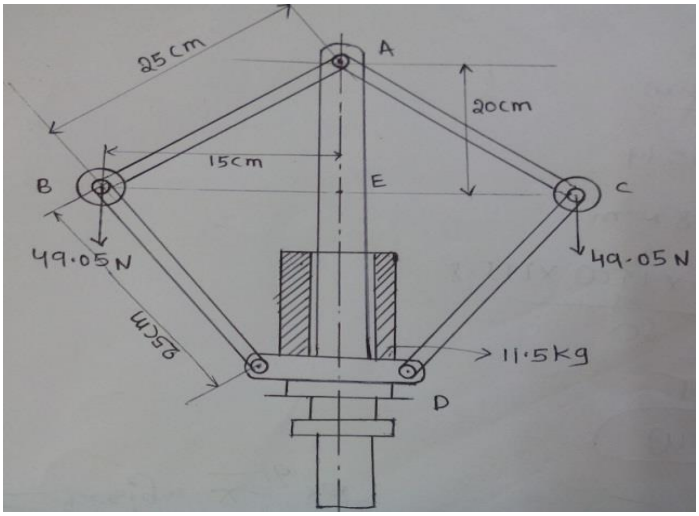

Fig .2.4: Porter Governor [2]

Here AB- length of the arm (cm), BE = r = Radius of rotation (cm), AE = h = Height of the Governor (cm), $30^0 = \alpha$ = Angle of inclination, Mass of Fly ball (m) in Kg's,

Mass of Central Sleeve (M) in Kg's, Length AB = 25 cm= 250 mm , BE = 15 cm =150 mm , Height of the Governor We Know That , $AB^2 - BE^2 = h1^2$, $25^2-15^2=h1^2$, h1 = 20 cm = 0.2 m and m = 5 Kg, M =11.5 Kg, For **minimum speed:**

$N_1^2 = \frac{m+M}{m} \times \frac{895}{h1} = \frac{5+11.5}{5} \times \frac{895}{0.2}$, $N_1 = 121$ r.p.m.-------- (3)

From comparing equations 1, 2, 3 we observed that how the minimum speed of the governor will changes.

III. RESULTS AND DISCUSSIONS

i. The small modification of Watt Governor will give better results in operating speed limits. We have been fabricated this governor in our laboratory and observed working of this governor.

ii. Generally we seen that the Watt Governor is suitable for lower speeds only (i.e. 60-80 r.p.m), but by small modification it can also used for above the lower speeds (i.e. 120 -130 r.p.m).

iii. The modification of Watt Governor will may replace the porter governor some extent

iv. In generally To maintain 120r.p.m minimum speed by porter governor it needs 250mm arm lengths, 5kg fly ball weight, 11.5kg central sleeve load. but by small modification of Watt Governor it needs only 146mm arm lengths, 0.126 kg fly ball weight and no central sleeve load.

v. So that to maintain 120r.p.m with modified Watt Governor, it minimizes the arm lengths, weight of the fly balls, central sleeve loads when compare with Porter Governor.

IV. FUTURE SCOPE

i. Analysis of Stress concentration on various elements of the governor which minimizes the failures.

ii. Analysis on different materials for sleeve, spindle and arms.

iii. Vibration analysis will give better results in accuracy.

iv. Study on various factors (i.e. stability, sensitivity, and hunting) of the governors.

V. CONCLUSIONS

i. Modification of Watt Governor gives better results when compare with Watt and Porter Governor.

ii. To study the effect of extension of lower arm on variation in minimum speed of the governor

iii. To maintain 120 r.p.m, minimum speeds by Porter Governor it needs 250mm arm lengths, 5kg fly ball weight, 11.5kg central sleeve load whereas modified Watt Governor needs only 146mm arm length, 0.126kg fly ball weight and no central sleeve load.

ACKNOWLEDGEMENT

We are thanking to our teaching and non teaching members in our college (i.e. S.V.E.C, Suryapet). Giving their valuable support and time.

REFERENCES

[1] IJSRP, Volume 2, Issue 6, June 2012 ISSN 2250-3153

[2] A TEXT BOOK OF THEORY OF MACHINES, Fifth Edition by Dr. R.K. Bansal and Dr. J.S. Bra, with Laxmi Publications (P) L.t.d.

[3] THEORY OF MACHINES, Third Edition by S S RATTAN, with Tata McGraw Hill Education (p) L.t.d.

[4] WWW.ANSWERS.COM/TOPIC/GOVER-DE

[5] HTTP//EN.WIKIPEDIA.ORG/WIKI/GOVER-DE.

AUTHORS

First Author- GiriBabu Surarapu, M Tech (Machine Design) SIT, Khammam, Telengana, India, Email: giribabuglory@gmail.com

Second Author- Shashidar PeddiReddy, M Tech (Machine Design) KITS, Khammam, Telengana, India. Email: psr326@gmail.com

Third Author- Nagamani Uotkuri, M.Tech (cad cam), Department of mechanical Engineering S.V.E.C, Suryapet, Nalgonda, Telengana, India, Email:glorygiribabu@gmail.com.

Correspondence Author- GiriBabu Surarapu, Email: giribabuglory@gmail.com, mobile: 8125590627.