

Modification of Structurer Design and Analysis of Hartnell Governor to Improve Sensitivity with in Alteration Speeds

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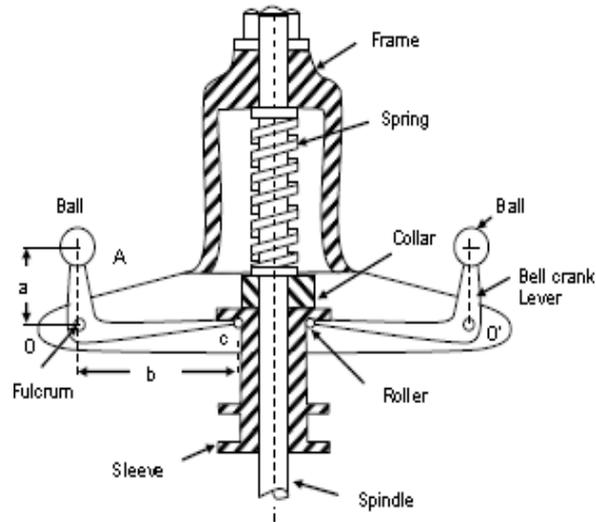
ABSTRACT: The objective of this work is to modify the structure design of Hartnell governor to improve the sensitivity within alteration speeds by reducing the friction between sleeve and spindle and also analyze the modified structure of Hartnell governor. The governor assembly is modified by introducing ball bearings between sleeve and spindle to reduce friction and to change the dimensions of sleeve without change the dimensions of remaining parts of governor assembly. To identify the stress concentration areas which are most susceptible to failure when the new designed governor is rotating with maximum speed about its axis, and also the maximum value of these stresses is measured. The design of the governor to be modified based on the measured stress values. This analysis is carried out with the help of solid works software.

In the current investigation Hartnell governor is modified such that it increases the sensitivity and decreases the friction between spindle and sleeve. In this modification, ball bearings are placed between spindle and sleeve. To plot the graph between alteration speed vs friction, measured the stress values at different portions of the governor and also modified the structure of governor to reduce the stress concentration.

I.INTRODUCTION

A Hartnell governor is a spring loaded governor as shown in Fig. It consists of two bell crank levers, frame. The frame is attached to the governor spindle and therefore rotates with it. Each lever carries a ball at the end of the vertical arm and a roller at the end of the horizontal Arm. A helical spring in compression provides equal downward forces on the two rollers through a collar on the sleeve. The spring force may be adjusted by screwing a nut up or down on the sleeve.

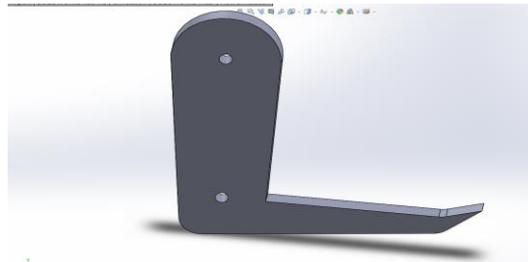
Based on the reference paper (K Kiran Kumar, Improve the Sensitivity of Hartnell Governor with in Alteration Speeds by Introducing Ball Bearing between Sleeve and Spindle to Reduce the Friction, IJIRSET, volume 9, issue 4). I take dimension of hartnell governor (model no-----) then design each part and modify the assembly.



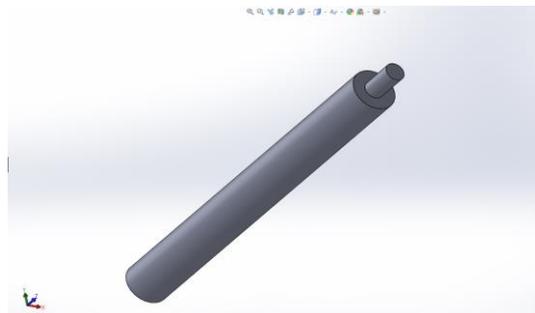
A.PARTS OF HARTNELL GOVERNOR



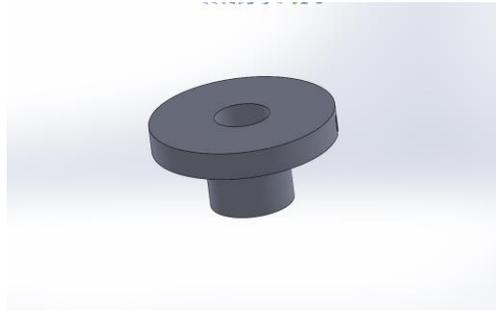
Frame



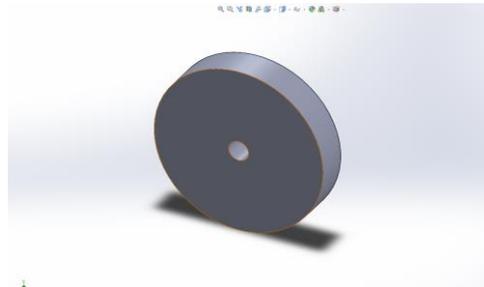
Bell crank lever



Spindle

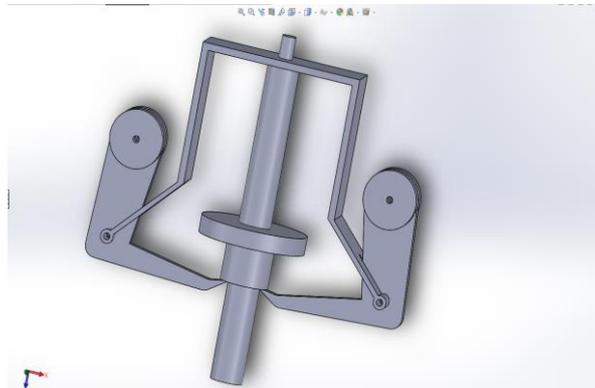


Sleeve



Fly ball

B.ASSEMBLY OF HORTNELL GOVERNOR



Hartnell governor before modification



Hartnell governor after modification



II. EXPERIMENTAL RESULTS AND CALCULATION OF HARTNELL GOVERNOR

By conducting experiment on hartnell governor in our dynamics lab, performed the experiment at different speeds to run the governor and taken the values.

Based on experimental values we calculate the stiffness of governor (K), maximum and minimum centrifugal forces, sensitivity and maximum spring force.

S.no	Height (h)	Speed		Radius		Centrifugal force		Stiffness (K)	Sensitivity (S)
		N _{max}	N _{min}	R _{max}	R _{min}	F _{C max}	F _{C min}		
1	6	220	200	168.91	165	85.99	69.48	3.59	0.095
2	10	231	200	170.82	165	95.52	69.48	3.84	0.1438
3	14	240	200	174.13	165	105.59	69.48	4.06	0.1818
4	19	263	200	177.39	165	129.15	69.48	4.09	0.2721
5	24	271	200	180.65	165	139.67	69.48	3.81	0.3014
6	29	285	200	183.91	165	157.26	69.48	3.94	0.3505

Experimental values table.

Model calculations are shown below. Based on that calculations graph is drawn.

Calculations:

$$H = b/a (R_{max} - R_{min})$$

$$6 = 115/75 (R_{max} - 165)$$

$$R_{max} = 168.91 \text{ mm}$$

$$\omega_{min} = 2\pi N_{min} / 60 = 2\pi * 200 / 60 = 20.94 \text{ rad/sec}$$

$$\omega_{max} = 2\pi N_{max} / 60 = 2\pi * 220 / 60$$

$$\omega_{max} = 23.03 \text{ rad/sec}$$

$$F_{C min} = m r \omega^2 = 0.96 * 165 * 10^{-3} * 20.94^2 = 69.45 \text{ rad/sec}$$

$$F_{C max} = m r \omega^2 = 0.96 * 168.9 * 10^{-3} * 23.03^2 = 85.99 \text{ N}$$

$$\text{Stiffness (K)} = 2 * (a/b)^2 * (F_{C max} - F_{C min}) / (R_{max} - R_{min}) = 2 * (75/115)^2 * (85.99 - 69.45) / (168.91 - 165) = 3.59 \text{ N/m}$$

$$\text{Sensitivity (S)} = 2 * (N_1 - N_2) / (N_1 + N_2) = 2 * (220 - 200) / (220 + 200) = 0.095, M = 3 \text{ kg}, K = 3.888 \text{ N/mm}$$
 (average value from the table), $m = 0.96 \text{ kg}$

Maximum friction force (f) = 15N (from the reference paper)

From the table at maximum speed: $N_2 = 285 \text{ rpm}$

$N_1 = 200 \text{ rpm}, F_{C1} = 68.49 \text{ N}, F_{C max} =$

$157.26 \text{ N}, a = 75 \text{ mm}, b = 115 \text{ mm}$

h at 285 rpm is 29mm.

At maximum speed (285 rpm) $h = 29 \text{ mm}$

Maximum spring force $F_{S2} :$



$$F_{S2} - F_{S1} = hs, F_{S2} - F_{S1} = 29 * 3.888, F_{S2} - 46.196 = 29 * 3.888, F_{S2} = 158.948, F_1 a = \frac{1}{2} (Mg + F_{S1} + f)b; 69.48 * 75 = \frac{1}{2} (3 * 9.81 + F_{S1} + 15) * 15;$$

$$F_{S1} = 46.196 \text{ N.}$$

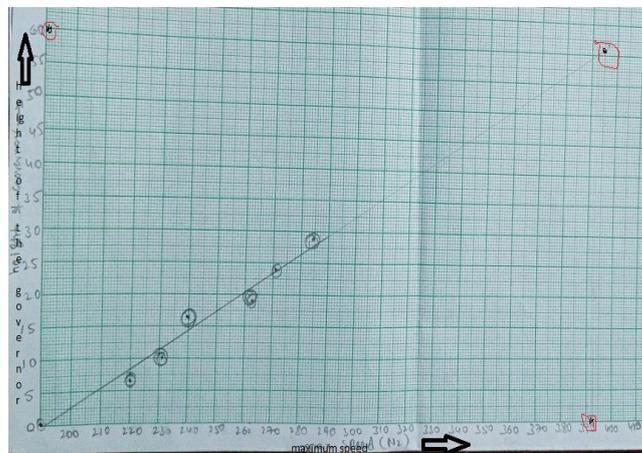
At maximum height of the hartnell governor (60 mm):

Graph drawn Based on experimental values to get the maximum speed, because at maximum speed governor is subjected to maximum stress.

Along x-axis: maximum speeds at different heights of governor

Y-axis: heights of governor at different speeds.

From the graph:



Maximum height gover (h) = 60mm

Maximum speed at that height = 392 rpm

At maximum height

$$N_1 = 285 \text{ rpm}, N_2 = 392 \text{ rpm}, R_1 = 165 \text{ mm}, F_{C1} = mr_1\omega_1^2 = 0.96 * 165 * (2\pi 285/60)^2, F_{C1} = 69.48 \text{ N}, h = b/a (R_2 - R_1); 60 = 115/75 (R_2 - 69.48), R_2 = 108.61 \text{ mm}, F_{C2} = mr_2\omega_2^2 = 0.96 * 108.61 * 10^{-3} * (2\pi 392/60)^2, F_{C2} = 175.7 \text{ N}, F_{S2} - F_{S1} = hs, F_{S2} - 46.196 = 60 * 3.888, F_{S2} = 279.476 \text{ N}$$

At maximum speed (392 rpm)

$$h = 60 \text{ mm}, N_2 = 392 \text{ rpm}, F_{C1} = 69.48 \text{ N}, F_{C2} = 175.7 \text{ N}, F_{S1} = 46.196 \text{ N}, F_{S2} = 158.948 \text{ N}, M = 3 \text{ kg}, m = 0.96 \text{ kg}, f = 15 \text{ N}$$

Data Required For Dynamic Analysis:

Maximum centrifugal force acting on governor = 175.7 N.

Mass of each fly ball = 0.96 kg

Mass of the sleeve = 3 kg

Maximum spring force (at 60 mm governor height) = 158.948 N

Maximum frictional force = 15 N

Dynamic Analysis of Hartnell Governor before and After Modification:

The values of maximum spring force, centrifugal force, sleeve and fly ball mass are applied on both (before and after modifications) assemblies.

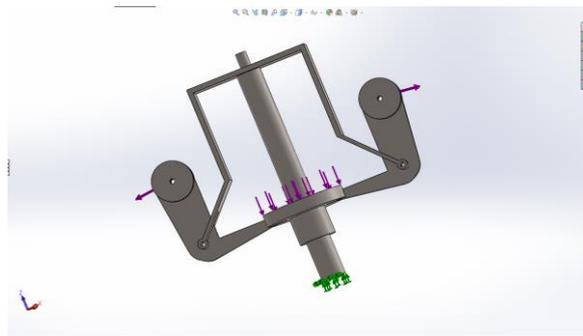
Both assemblies is constrained as shown below.

Material properties:

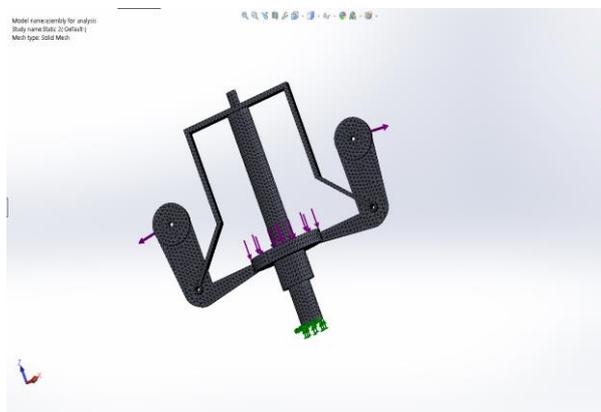
The material of governor is Stainless Steel

For Stainless Steel

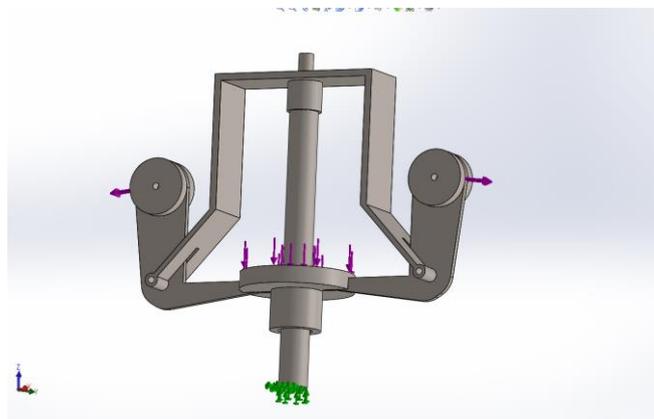
Yield strength:	1.72339e+008 N/m²
Tensile strength:	5.13613e+008 N/m²
Elastic modulus:	2e+011 N/m²
Poisson's ratio:	0.28
Mass density:	7800 kg/m³
Shear modulus:	7.7e+010 N/m²
Thermal expansion coefficient:	1.1e-005 /Kelvin



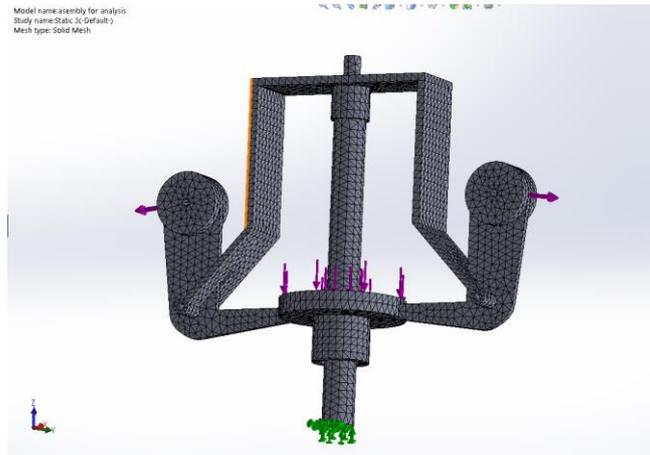
Maximum Forces on governor (with out bearing)



After meshing (without bearing)



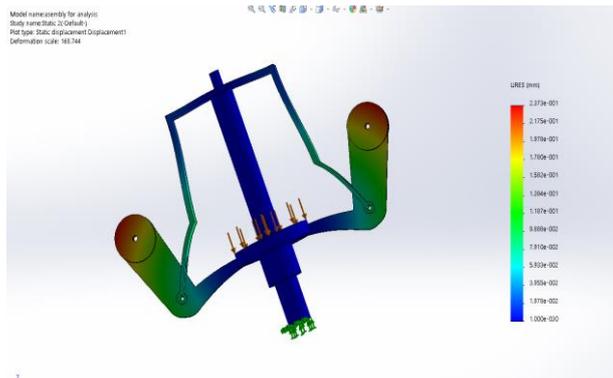
Maximum Forces on governor (with bearing)



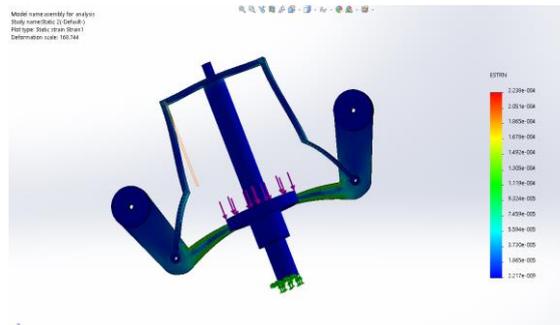
After meshing (with bearing)

III.RESULTS

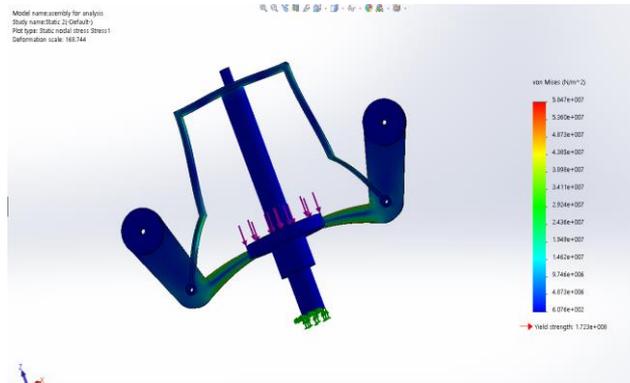
Results are found by using solid work soft ware 15 version. We got the stress, strain and displacement values as shown below.



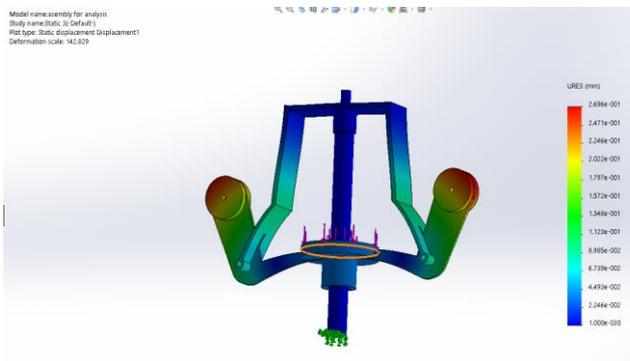
Displacement without bearing



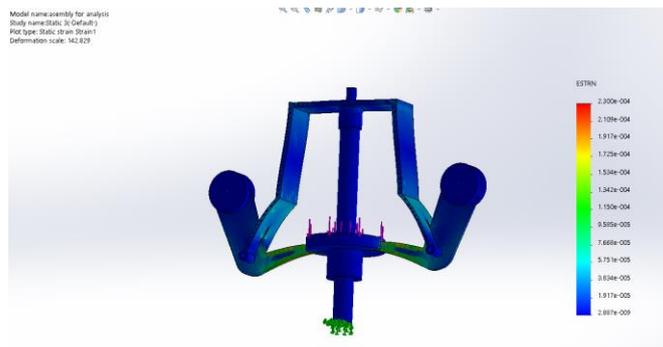
Strain without bearing



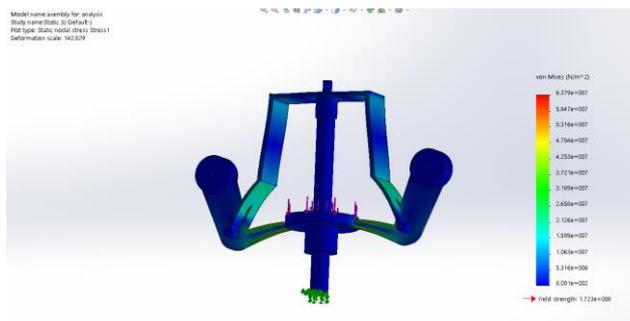
Stress without bearing



Displacement with bearing



Strain with bearing



Stress with bearing



RESULT AND COMPRESSION TABLE

Type	Stress N/ mm ²	F O S
Stress without bearing	58.47	2.94
Stress with bearing	63.79	2.73

In the hartnell governor without bearing and with bearing, the developed stresses are less than yield stress. So the factor of safety is greater than unity which indicates that the design is safe. As a result, in both the assembly, when the governor subjected to maximum loads at maximum speed the developed stresses is less and that stress is less than the yield stress. So the factor of safety is more than unity which indicates that the design is safe.

IV.CONCLUSION

The assembly of the hartnell governor is modified by introduce a ball bearing between sleeve and spindle and 3-D modelling of the parts is done in the Solid Works software. A comparative study has been made between both governors (with and without bearing) and the presently modified governor with respect to Deflection, Strain, stresses and yield strength.

The newly modified governor has reduced the friction and alteration speeds compared to the governor without bearing. The factors of safety for the both are greater than 1 that means design is safe.

The main problem of the governor is insensitive with in alteration of speeds. In this paper, the modification is made to increase the sensitivity of the governor. It concludes that the sensitivity can be increased by decreasing friction between spindle by introduce a small bearing between the sleeve and spindle.

Based on the results modified governor is safe in design from that sensitivity increases with the decreasing of alteration of speeds.

The modified designed are more suitable for domestic generators and diesel power plants because it reduced the alteration speeds and improve sensitivity of governor.

REFERENCES

1. Giri Babu, Experimental Investigation on Watt Governor to Increase Minimum Speed, IJSRP, Volume 5, Issue 2, February 2015.
2. K Kiran Kumar, Improve the Sensitivity of Hartnell Governor with in Alteration Speeds by Introducing Ball Bearing between Sleeve and Spindle to Reduce the Friction, IJIRSET, volume 9, issue 4
3. Experimental Investigation on Watt Governor to Increase Minimum Speed By IJSRP Journal
4. THEORY OF MACHINES, Third Edition by S S RATTAN, with Tata McGraw Hill Education (p) L.t.d.
5. IRJET-DESIGN AND ANALYSIS OF CENTRIFUGAL GOVERNOR: A REVIEW
6. WWW.ANSWERS.COM/TOPIC/GOVER-DE
7. HTTP//EN.WIKIPEDIA.ORG/WIKI/GOVER-DE.