Design & Validation Of E-Rpm Adjustment Assembly For Mechanical Governor System

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Abstract: This paper detailing the problem of speed fluctuation of IDI engine Rpm i.e. hunting and dipping. It is due to E-RPM adjustment assembly for mechanical centrifugal flyweight governor system. E-RPM adjustment assembly works mainly for high speed adjustment &idle speed adjustment. In mechanical centrifugal flyweight governor system of IDI engine, issue at idle rpm hunting and dipping issue was reported in field.New designs of plunger type stopper cover with compressed coil spring are proposed for E-RPM adjustment assembly for mechanical centrifugal fly-weight governor system. 3D-Modeling of new design is done on Seimen's NX. Kinematic simulation was done with the help of Altair's (Motion-View & Motion-Solver). Based on the results from MBD, the prototype is made and tested in engine. As per the test results from engine testing, with new design there is no hunting and dipping problem is reported at idle rpm.

Keywords: Diesel (IDI) engine, Engine speed governor, speed adjustment assembly, Compressive Spring, MBD, Motion-View, Motion-Solve, Hunting, Dipping **Abbreviations:** IDI (Indirect Injection); MBD-(Model Base Design) ; E-RPM- (Engine RPM) ; FIP- (Fuel Injection Pump), etc.

1. INTRODUCTION

In mechanical centrifugal flyweight governors two forces oppose each other. One of these forces is tension spring (or springs) which may vary either by an adjusting device or by movement of the manual throttle. The engine produces the other applicable force for governor. Weights, attached to the governor drive shaft, are rotated, and centrifugal force is generated, when the engine drives the shaft. The centrifugal force varies with the speed of the engine and counter balance the fuel flow. (Fig.1)

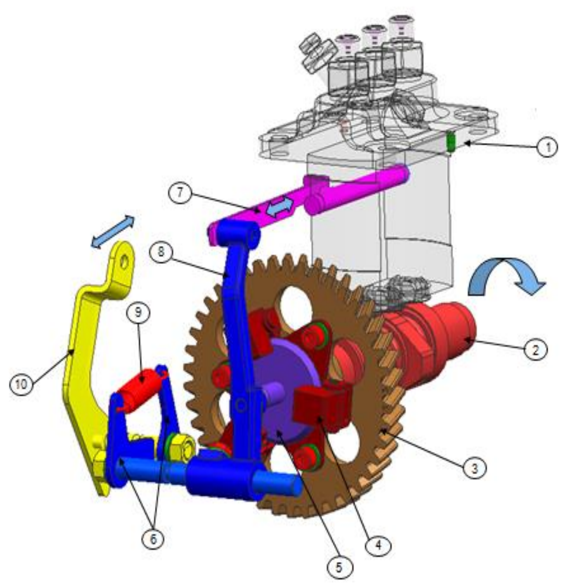

Fig 1. *Mechanical Governor Working System*

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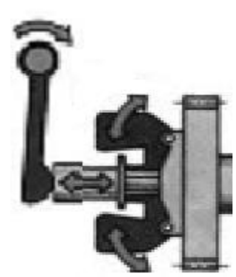
2. GOVERNOR MECHANISME OPERATION

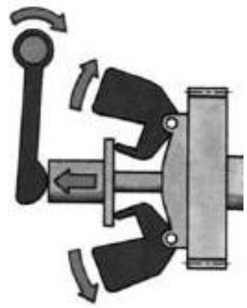
The governor is acting directly having the main input variable as pump drives shaft rotational speed. The Mechanical centrifugal governor system work on a half of engine's speed (N=n/2)

1) Fuel Injection Pump (Cassette Type)
2) Cam Shaft (Fuel Injection Pump)
3) Fuel Injection Pump Cam Gear.
4) Flyweight (Flyweight centrifugal force is acting upon the sliding sleeve)
5) Sliding Sleeve
6) Governor Spring Holding Link
7) Fuel Control Rod(Slide towards Max and Min. Fueling side).
8) Control Link (Which is balanced by the tension force of the control spring system consisting of a main)
9) Governor Spring (the spring applies a restraining force on the flyweight mechanism to raise engine speed.
10) Throttle Lever

Operation of the governor keeps the engine speed constant as the centrifugal force acting on the governor weights balances with the tension of the governor spring .As the engine speed increases the governor weights will open, forcing the end of the sliding sleeve against the control link. The Control link then moves against the governor spring tension and moves the fuel injection pump control rack, through the fuel control rod, in the direction that decreases the amount of fuel delivered by the injection pump. The Governing control System has a feedback and therefore, maintains a chosen engine speed, regardless of engine load variation.



At Idle Speed Condition



At Maximum Speed Condition

Fig.2 *Flyweight reacts against Throttle control Link*

2.1 Engine at Idle Speed

At Stop Position, the speed control lever is moved into the low idle position and then advanced slightly. The starting spring will then pull the Throttle lever to the excess (Max.) fuel position. At the same time the Control link will move up against the full-load stop. The flyweights then come to rest against the Sliding Sleeve. While the starter is cranking the engine, the injection pump begins supplying excess fuel to the engine. Once the engine starts, the centrifugal force produced by the whirling flyweights overcomes the starting spring tension (even before idle speed is reached). Engine speed increases until the flyweight centrifugal force and the governor main spring are balanced.

2.2 Engine at Maximum Speed

Governor operation at maximum speed is similar to idle speed operation, except that the control link stretches the governor main spring to its maximum length. The fully stretched main spring causes the control link to move against the full-load stop with greater force, and the control link to move into the maximum fuel delivery position. Once full-load maximum speed is reached, governor response will regulate fuel delivery between full-load and high idle to handle any load as long as there is no overload In some cases, If Governor Main Spring would not be able to balance the Centrifugal forces against Spring tensioned forces than governing unbalanced would create the numerous problem in engine governing system such like that (E-Rpm Hunting, Dipping at low Idle and High Idle rpm & Rpm Drop on Load Conditions and have developed a component (is called Plunger Type E-Rpm Control Assembly) to control E-rpm and unbalanced governing system of engine in stable governing system in running conditions.

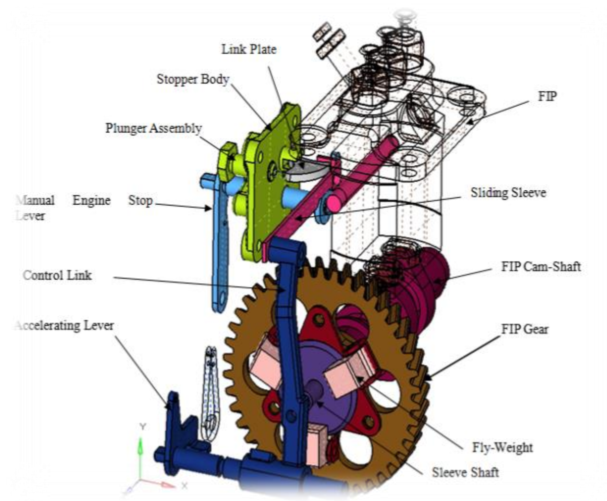


Fig 2. *1D-Model of Stopper with Governor Assembly*

High Speed Adjustment: At High engine speed the Centrifugal flyweight Forces would increase and then it would force governing parts in opposite direction and tension spring try to oppose the centrifugal forces to control the movement of fuel metering unit and if the two forces will not control to each other and varying then high engine rpm related issues (like hunting, dipping). Idle Speed Adjustment: During de-acceleration the centrifugal flyweight forces would decrease and tension spring forces would come to slow down and centrifugal forces shown less effect on governing system and the tension spring forces would directly forces to Fuel control rod and shown in fig 2.1. to reduce the fueling. Governor system would not in stable due to unbalanced forces & some dimensional errors in part components.

3. DEVELOPED NEW CONCEPT DESIGN TO STABLE GOVERNING SYSTEM (AVOID GOVERNING ISSUES)

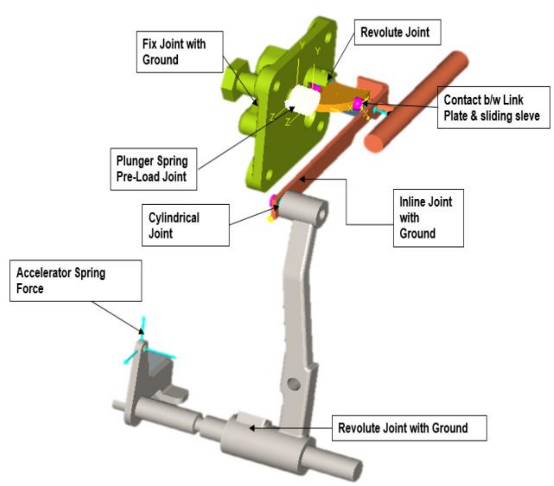


Fig 3. *MBD Model of Stopper with Governor Assembly in Motion-View & Motion-Solver*

This design, we have seen that fuel control rod directly forces on Link Plate. Where we would control or balanced the forces by compressive spring (Plunger spring) in governing system.

3.1 Results & Discussions

Fuel Control Rod:
Pre-Load as per MBD Simulation for initial position i.e. FIP Lever Travel = Fuel Metering unit travel* Spring Stiffness = N

Compressive spring (Plunger Spring):
As the plunger spring is compressive spring, to apply N of pre-load, the following is Link
Example to set:
Free Length = mm
Set Length = mm
Compressed Length= mm
(Required for N/mm stiff spring)

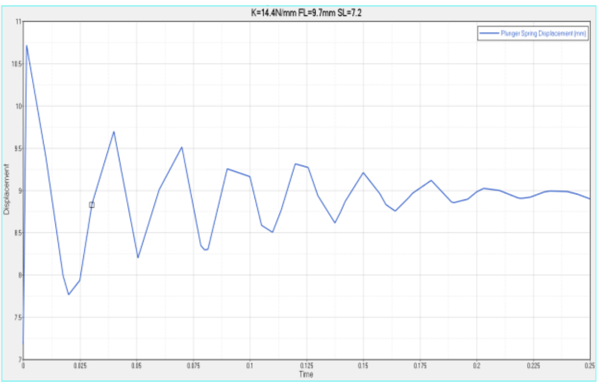
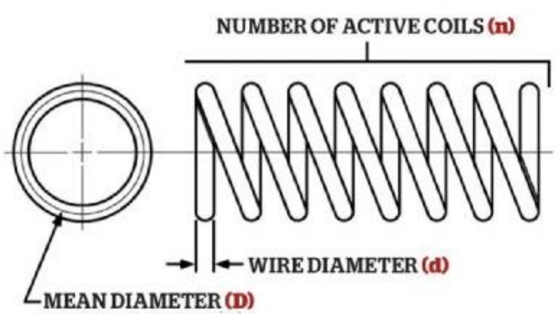


Fig. 3.1 *Compression Spring Result*

Mathematic formula for Compression Spring Rate



$$K = \left[\frac{G \times d}{8 \times C^3 \times N}\right]$$

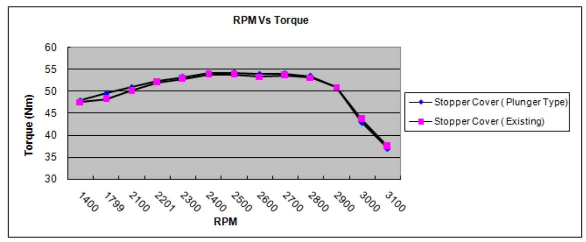
Where,
K = Spring Rate
d = Wire Diameter
N = Number Of Active Coils
G = Modulus of Rigidity
C =Spring Index

Link Profile Plate
Link Profile plate travel distance depends on pre-load (N) and Compressor spring forces (like an intermediate parts)

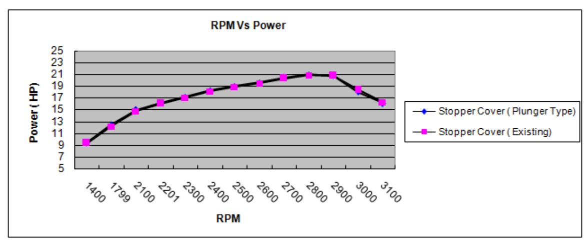
Adjusting Bolt
Adjustments to the engine speed settings are not normally necessary unless the throttle linkage, injection pump, or governor mechanism have been repaired, rebuilt, replaced or are not operating correctly. Since there is no ignition system from which to power an electronic tachometer, a vibration-type tachometer must be used to set engine speed. This engine is equipped with a special damper spring (Fig.) which is designed to prevent engine stalling when the throttle decelerated quickly. Adjustment of this spring is required when adjusting the engine rpm.

4. ENGINE LEVEL PERFORMANCES

4.1 RPM Vs Torque



4.2 RPM Vs Power



4.3 RPM Vs Fuelling

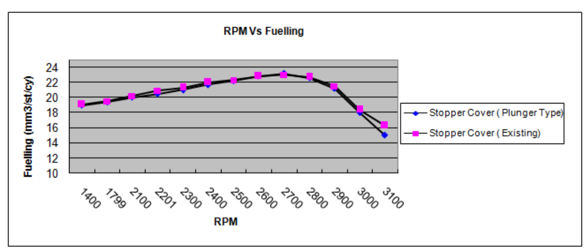


Fig 4. *Performances Comparison of two different type of E (Engine)- Stopper Cover*

5. BENEFITS SUMMARY

1. To avoid field and production related engine rpm setting issues (E-rpm drop, hunting &etc.)
2. To avoid Delay Engine RPM Responses while acceleration and de-acceleration.
3. The model is capable of providing accurate predictions of governor's variable parameters influence on its performance and its characteristics.

6. CONCLUSIONS

With the help of Altair's motion-view and motion-solver, the set-up of Engine stopper assembly with governor was able to establish. Not only established but also resolved up with the problem. Concept design becomes new design of Engine stopper Assembly to avoid governing related issues of engines.

References

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