SENSITIVITY ANALYSIS OF SPEED GOVERNORS

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ABSTRACT

Experimental work on the Sensitivity Analysis of Speed Governors is reported. A test rig for mechanical speed governors was assembled. Three types of mechanical governors, namely, Porter, Proell and Hartnell were considered. For the three governor types, speed variation relative to mass at centre sleeve (for a fixed sleeve position) was recorded. The maximum and minimum speeds for each type of speed governor were identified. Sensitivity value for each governor was computed and sensitivity ranking was done for them.

KEY WORDS: Speed Governors, Sensitivity Analysis, Ranking.

1 INTRODUCTION

The dashpot-type isochronous governor (which may be modified by droop) is the standard hydraulic governor in current use for prime movers. This governor is designed to give proportional-plus-integral (actually, rate-responsive) control. The governor has the advantages of giving constant speed control where desired; it can be adjusted to compensate for a low value of damping in the engine system to be controlled, and it has a dashpot including a needle valve whereby one of the governor constants can be varied readily. Disadvantages of hydraulic governors in common use are the poor adjustability of control parameters; too small needle valve openings for normal applications; sensitivity of the dashpot to variations in the viscosity of dashpot oil causing corresponding variations in control parameters; floating (receiving or proportioned pistons that can and do stick; and the relative non-interchangeability of the governors from one type of engine to another. In the new governor described in the paper the foregoing problems and others not mentioned are all solved with the aid of a technique for hydraulic addition. In contrast to current governors, governor parameters including governor time lag can be adjusted independently. Load control can be introduced to the governor without the

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need of an extra servomotor. Nonlinearities are incorporated to improve performance. This governor is a radical departure from existing units greatly increasing the flexibility and reliability of the speed governor.[1]

The place of road safety in Kenyan legislative history since independence in 1963 as a way of illustrating the analytic value of speed for the anthropology of the state is considered . Road safety, a highly visible public concern in Kenya since the 1960s, offers us a way to rethink the temporal dangers and uncertainties of automotive travel under global capitalism, but also to go further in seeking out historical continuities in Kenya's post-colonial aspirations for safer and more efficient roads. This focus on road safety takes us from Africanization, in the 1960s and 1970s, to the regulatory reforms of the 1990s and 2000s in the guise of neo-liberalism. From the vociferous complaints and debates of Kenyan politicians about imported Peugeots being dangerous to drive on Kenya's rough and sparsely tarmacked roads in 1964, to the much publicized traffic crackdown of 2003, the so-called ‘Michuki Rules’, road safety is a field of study ideally suited to the analysis of infrastructural power and its transformations and continuities over a four-decade period. What is of analytic interest here is the new value of speed in an East African region that has aggressively embraced automobility as a vehicle for enhancing state sovereignty in a globalized economy.[2]

In similar vein, researched and documented paper is hereby so presented as to be realizable in the form of a practical solution for the impending traffic problem presently observed in cities all over the world in countries like India, Bangladesh, Pakistan, Sri Lanka, Turkey and few other South East Asian and African countries where due to large population and inadequate infrastructure, road safety enforcement and traffic regulation is very difficult. The paper puts forth a theory which proposes that any given city, town, village can be divided into physical zones which are classified according to different speed ranges. A transmitter is placed at all exit and entry points of the interface of any two zones that transmits a message signal at carrier frequency, indicating the upper limit value of the zones' speed range into which the vehicle is entering at that moment, to the receiver which gives the message as an input to a pre-programmed MICROCONTROLLER embedded within the automobile which compares the speed of the vehicle measured by a sensor at the hind wheel transaxle shaft with the zones' maximum allowable speed and automatically regulates the speed of the vehicle by controlling the fuel flow by sending pulse signals to a solenoid valve and thus keeping the speed of the vehicle in constant check. The volume of fuel flow can be varied by varying the Â¿duty cycleÂ¿ of the pulse input to the solenoid valve. The entire system is a low cost variable electronic speed governor, small in size and easy to assemble onto an existing vehicle without disturbing its present arrangement.[3

Recalling that an accident is unexpected, unusual, unintended and identifiable external event which occurs at any place and at any time, the major concern faced by the government and traffic officials is over speeding at limited speed zones like hospitals, schools or residential places leading to causalities and more deaths on the roads. Hence the speed of the vehicles is to be regulated and confined to the limits as prescribed by the traffic regulations. A solution in the form of providing E-speed governor fitted with a wireless communication system consisting of a Rx which receives the information regarding the speed regulation for their zones Iis hereby proposed. The TX will be made highly intelligent and decide when receiver should be made active to regulate the speed and unwarranted honking from the vehicles which can be deactivated in the silent zones..[4] India has the highest number of road accidents in the world. With over 130,000 deaths annually, the country has overtaken China and now has the worst road traffic accident rate worldwide. This has been revealed by the World Health Organization (WHO) in its Global Status Report on Road Safety pointing to speeding as the main contributing factor. This paper studies and details all the approaches for the reduction of accidents adopted by various countries and especially the necessity of speed governors in Indian vehicles and the role of the same in reduction in accidents with other benefits of speed governors with regard to fuel efficiency, noise & pollutant emissions both in Indian and International aspects.[5] Speed control analysis for a turbocharged engine by simulation using block diagram type of modelling and solving the differential equations using both fourth order Runge-Kutta and transfer function methods using various combinations of proportional, integral and differential coefficients in a PID controller with application of various types of oscillating loads is presented. The simulation results show that the governor using PID control provides the best control of engine speed and the optimum values of these coefficients are different for different operating conditions having different amplitude and frequency of load fluctuations. The Runge-Kutta method is found to give more accurate results but takes more computer time.[6] 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.[7] A general-purpose engine speed control system with an electronic governor in order to improve the current system with a mechanical governor, which shows unstable characteristics as a result of a change in mechanical friction or the A/F ratio (air–fuel ratio) is presented. The control system above has the problems that the feedback signal is only the crank angle because of cost, and the controlled object is a general-purpose engine, which is strongly nonlinear. In order to overcome these problems, a system model is presented for dynamic estimation of the amount of air flow, and a robust controller is designed. In concrete terms, the proposed system includes a robust sliding-mode controller using the feedback signal of only the crank angle, with a genetic algorithm applied to the controller design. Simulations and experiments performed using Matlab/Simulink show the effectiveness of our proposal. This paper describes the development of a new approach for speed governors of small hydropower plants (SHPs) employing servo-pneumatic positioning system (pneutronic system). Aiming at cost reduction, easy maintenance, and obtaining an environmentally friendly product, a pneumatic system is designed for the control of wicked gates in Francis turbines to replace the conventional approach using a hydraulic system. The positioning system development is based on the non-linear modelling of the pneumatic valve and cylinder and includes a PID controller with dead zone compensation. Using a test bench corresponding to a 400 kW power plant, the model is validated and the performance requirements, according to international standards, are fully satisfied. Results are presented for a speed governor prototype installed on-site in a 35 kW Francis turbine where load rejection and step response tests were carried out. The theoretical and experimental results show that a servo-pneumatic speed governor can be used successfully for SHPs, being restricted to turbines of up to 1 MW considering only the pneumatic component costs.[9]

The work in this research proposes a new method for the design of the load frequency control (LFC) in power systems using H ∞ techniques. The proposed procedure is used to design a robust governor for hydro turbine system. Uncertainties like time variations, neglected dynamics, and nonlinear effect of the water hammer phenomenon are main reasons that inspire us to adopt the proposed method for such application. Mixed sensitivity configuration has been adopted in this design scenario with filters properly designed to reflect stability and performance requirements of the LFC. The uncertainties have been incorporated in the design stage as an additive uncertainty where the hydro turbine plant is approximated and represented as a ratio of polynomials. The new governor is tested in single-machine–infinite-bus (SMIB) system and subjecting different disturbance signals to the system. The proposed governor showed guaranteed internal stability, satisfied both frequency and time domains requirements. Also, it proved a guaranteed stability and performance of the closed-loop system in response to these signals with the existence of system parametric variations. The capability of the designed governor to attenuate the angular velocity oscillations are evaluated in the simulation study.[10]

Speed limiters, also described as speed governors, are devices that interact with a truck engine to only permit the attainment of a pre-programmed maximum speed. For more than a decade, they have been used in Europe and Australia to limit the speed of large trucks and are widely available in the United States of America on late model and new class 8 trucks. Many truck fleets use speed limiters both for their safety contribution and to reduce fuel use and tyre wear, with the speed set at a level optimum for these factors.[11]

The function of the governor is to maintain the speed of an engine within specified limits whenever there is a variation of load. This device can be used in almost all vehicles. The objective of our investigation to identify the stress concentration areas, areas which are most susceptible to failure when governor is rotating about its axis, also the value of these stresses is measured. This analysis is carried out with the help of PRO E. The displacement of the various elements of the SPINDLE from the base is also calculated and the graphs are plotted. Effect of the “WEIGHT OF THE ARMS” is the major area of concern for our study and all the calculations are done considering the weight of the arms. Weight of the arms acts on the centroid of the arms and when the governor assembly rotates, centrifugal force starts acting on the centroid of the arms and tends to deflect the arms, this deflection or bending is to be minimized. In our work, we have done the Stress analysis on a particular configuration of governor assembly and then various materials are suggested on a theoretical basis.[12] Using AMESim to design and tune a patented type of electrohydraulic digital speed governor for KAPLAN hydraulic turbines is considered. Modelling, simulation and experimental identification are shortly presented. The governor contains two connected position loops included in a speed loop or a power loop. The fine-tuning of the electro hydraulic servo systems by AMESim saved time and gets the possibility of a deeper investigation of the main design parameters influence. The actual performance of the prototype (time response, accuracy, static drop, dynamic drop etc.) was found in good agreement with the theoretical prediction.[13]

2 MATERIALS AND METHODS

2.1 MATERIALS

DC Motor 0 – 6000rpm, Gear Box 30:1, Speed Control Unit, Frame to retain chosen governor, Hand Tachometer, Porter Governor, (fixed rotating mass of 1 kg. Centre sleeve mass nominally 0.8 to 1.3kg). Proell Governor (rotating mass – 0.8 kg and 1 kg. centre sleeve mass nominally 0.8 to 1.3 kg). Hartnell Governor (rotating mass 1kg and 1.5 kg). Bell crank arm ratios: 1:1.5 and 1:2.

2.2 METHODS

The variable alternating current (Variac) on the motor control at this time was set at its zero position. With a selected governor mounted on the Frame to Retain chosen governor, the variac was then turned clockwise, consequently the speed of the motor (DC) increased and this was registered by bringing the tachometer in contact with the motor spindle with special rubber coupling. For the Porter and Proell governors, by continuously turning the Variac in clockwise direction, the speed of the motor and hence that of the governor rotating mass was increased. This made the sleeve position moved higher up as the speed was increased. The mass at centre sleeve was varied by adding balls to the centre mass at the rate of 30 balls. At a particular position of sleeve, the speed for each centre mass was taken. The results so obtained are tabulated in Tables 1,2 and 3. The minimum and maximum speeds for each governor were identified from these tables and were used to compute the Sensitivity of each governor as shown in Table 4. Based on these sensitivity values, these governors were ranked. During the experiment, it was ensured that friction was reduced to minimum. Also, it was ensured that the tachometer reading remained fairly constant before taking final reading. With the method of "no-parallax", it was ensured that the centre sleeve co-incided with a whole number of sleeve position before final reading was taken.

3 RESULTS

TABLE 1: PORTER GOVERNOR

S/NO	NO. OF BALLS ADDED	MASS OF CENTRE SLEEVE (gm)	SPEED (RPMX1/30)	SLEEVE POSITION (cm)
1	30	830	2950	7.0
2	60	860	3450	7.0
3	90	890	3550	7.0
4	120	920	3390	7.0
5	150	950	3450	7.0

SOURCE: Data from Experiment

TABLE 2: PROELL GOVERNOR

S/NO	NO. OF BALLS ADDED	MASS AT CENTRE OF SLEEVE (gm)	SPEED (RPM X1/30)	SLEEVE POSITION (cm)
1	30	830	2050	7.0
2	60	860	2100	7.0
3	90	890	2400	7.0
4	120	920	2300	7.0
5	150	950	2350	7.0

SOURCE: Data from Experiment.

Table 3: HARTNELL GOVERNOR

S/NO.	ROTATING MASS (Kg)	TACHOMETER READING	GOVERNOR ROTATION (RPM)	SLEEVE POSITION (CM)
1	1	2420	80.67	2
2	1.5	1800	60.00	2

SOURCE: Data from Experiment

TABLE 4: SENSITIVITY OFGOVERNORS

S/NO	GOVERNOR TYPE	W_1	W_2	SENSITIVITY = $[2\ (W_2 - W_1)]/(W_1 + W_2)$	SENSITIVITY RANKING
1	PORTER	2950	3550	0.1846	MORE SENSITIVE
2	PROELL	2050	2400	0.1573	LEAST SENSITIVE
3	HARTNELL	2420	1800	0.2938	MOST SENSITIVE

SOURCE: Data from Tables 1,2 and 3.

4 DISCUSSION

Results from Table 1, reveals for Porter governor, speed of 2950 rpm corresponding to a sleeve centre mass of 830 gm rising to a peak of 3550 rpm at a sleeve centre mass of 890 gm, the dropping to a speed of 3450 rpm at a sleeve centre mass of 950 gm. Thus the maximum and minimum speeds for the Porter governor are 3550 and 2950 rpm respectively. These values are tabulated in Table 4 and form the basis for computing the sensitivity of the Porter Governor.

In similar vein, Table 2 data in Table 2 reveals that for the Proell governor, speed of 2050 rpm corresponding to sleeve centre mass of 830 gm rising to a pick of 2400 rpm at 890 gm, then dropping to a speed of 2350 rpm at a sleeve centre mass of 950 gm. Thus the maximum and minimum speeds for the Proell governor are 2400 and 2050 rpm respectively. These values assre tabulated in Table 4 and form the basis for computing the sensitivity of the Proell governor. Also for the Hartnell governor, a maximum speed of 2420 rpm corresponding to rotating mass of 1 kg dropped to 1800 rpm as the rotating mass was increased to 1.5 kg. The maximum and minimum speeds are tabulated in table 4 and therefore form a basis for the calculation of the sensitivity of the Hartnell governor.

Finally, the maximum and minimum values for the respective governors so tabulated in Table 4 were used to compute their respective sensitivities. Clearly the ranking of the sensitivities in Table 4 , reveals that the Proell governor is least sensitive, Porter governor more sensitive Hartnell governor most sensitive.

5 CONCLUSION

Based on the results of Table 4, the following conclusion is drawn: that Hartnell governors are better suited for low speed control; Proell governors are better suited for medium speed control while Porter governors are better suited for high speed control. On the other hand, the sensitivity values for the speed governors show that the Porter governor is more sensitive than the Proell governor. The Hartnell governor is the most sensitive.

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