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Construction of driver controller for hydraulic turbine using remote controller Atmega32 of atmel

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Abstract: *The article mentions the research of controlling hydroelectric turbine governor with automatic equipment. The automatic governor of a turbine is a combination of equipment that is responsible for sensing changes in the speed of rotation and changing the corresponding position of regulating devices including: Induction, the regulating structure, the actuator structure. The results are shown through simulation on the Matlab / Simulink software showing the quality criteria set for the hydroelectric turbine adjustment system. Software built on Atmega32, Computer communication software tested on the model and obtained good results.*
Keywords: *Hydroelectric turbines, Atmega32, Governor.*

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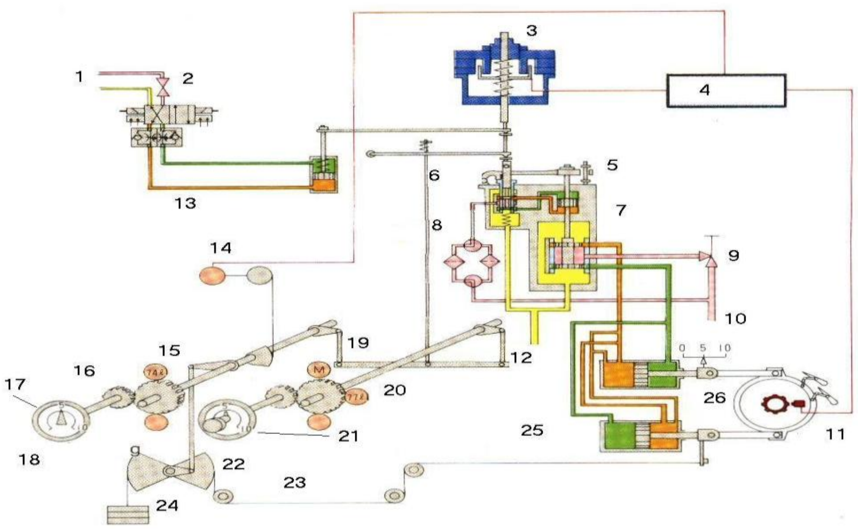
I. Introduction

Hydroelectric turbine is an important equipment in hydropower plants. The speed regulation of hydroelectric turbines determines the technical specifications of the power plant, frequency stability ability of the generator. In fact, there have been many studies on aquatic turbines and hydraulic turbine speeding methods. Building the control system using remote controller Atmega32 with full functions, and research and develop the ability to manage, collect data and control by computer.

Capturing and mastering advanced technologies of governor controller allow people for proactive and easy deployment of applications in practice to bring economic efficiency, flexibility in production, repair and maintenance.

II. Hydroelectric turbine governor.



According to the diagram, the order of notation is as follows:

1. Pressure oil supply hose
2. Magnetic valve for start and stop
3. Converter
4. Turbine regulator

5. Plunger control
6. Valve Pilot
7. Main distribution valve
8. Pull bar
9. Shut off valve
10. Pressure oil supply
11. Measure the turbine speed
12. Pipes
13. Switchgear
14. Frequency converter for feedback
15. Servo motor aperture limiter
16. Limit lock of aperture position
17. Gauges of aperture position
18. Position transducer for aperture position meter
19. Motor for aperture limit
20. Limit lock for the aperture position switch
21. Device measuring the limit position
22. Rolling limit of aperture
23. Mechanical feedback unit
24. Weights
25. Servo motor
26. The direction

III. Calculate the main parameters of the Turbine governor Characteristic parameters:

- Turbine capacity:

$N = 9{,}81\eta QH$

$N = 0{,}9.1489{,}13.30 = 41100$ (kW)

- Number of turns featured:

$$n_s = \frac{n\sqrt{N}}{H\sqrt[4]{H}}$$

$$n_s = \frac{136{,}4\sqrt{41100}}{30\sqrt[4]{30}} = 95{,}371$$

According to Fapurt, where n_s = 95,371 look up the graph of relation between n_s with type of Turbine and head, we are designed as Kap Lan Turbine type with the following parameters :

$n'_{I\,t} = 58$ (v/p) ; $n'_{I\,tt} = 62$ (v/p)

$Q'_{I\ min} =$ 0,1 (m^3/s) ; $Q'_{I\ max} = 0{,}18$ (m^3/s)

From the above parameters we calculate the diameter of Turbine impeller by the formula:

$$D_1^2 = \frac{N_{tt}}{9{,}81.Q_I^{'}.H_{tt}^{3/2}.\eta}$$

$$D_1^2 = \frac{41100}{9{,}81.0{,}14.30^{3/2}.0{,}9316} = 2{,}37$$

$D_1 = 1{,}54$ (m)

Choose $D_1 = 1{,}5$ (m)

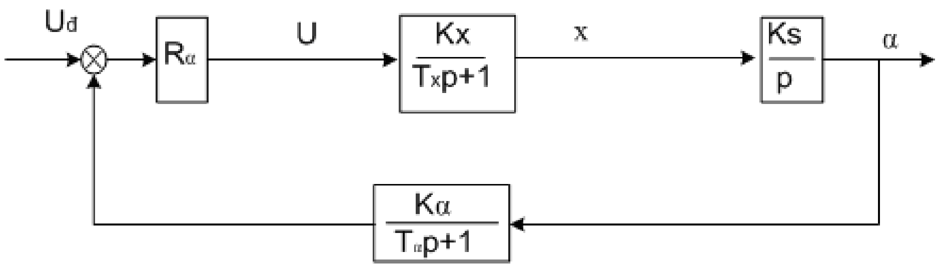
From the selected Turbine type we get the following real Turbine geometry:

$b_0/D_1 = 0{,}1$ --> $b_0 = 0{,}1.D_1 = 0{,}1.1{,}5 = 0{,}15$ (m)

$D_0/D_1 = 1,24$ --> $D_0 = 1,24.D_1 = 1,24.1,5 = 1,86$ (m)

Choose $D_0 = 1,8$ (m)

Turbine governor synthesis



With parameters Tα=0,001; K_s=5; K_x=0,02;

T_x=0,005;K_α=33;

We have an extended object transfer function:

$$S_{o\alpha}(p) = \frac{U_\alpha(p)}{U_d(p)} = \frac{K_x.K_s.K_\alpha}{P(T_xP+1).(T_\alpha P+1)}$$

$$F_{o\alpha}(p) = R_\alpha(p).S_{o\alpha}(p)$$

$$F_\alpha(p) = \frac{F_{o\alpha}(p)}{1+F_{o\alpha}(p)} = \frac{R_\alpha(p).S_{o\alpha}(p)}{1+R_\alpha(P).S_{o\alpha}(p)}$$

Because T_x and Tα are small time constants so applying according to the optimal modular standard, the Tα regulator is an amplification stage Tα =k. We also have :

$$F_\alpha(p) = F_{MC}(p) \rightarrow \frac{R_\alpha(p).S_{o\alpha}(p)}{1+R_\alpha(p).S_{o\alpha}(p)} = F_{MC}(p)$$

$$R_\alpha(p) = \frac{1}{S_{o\alpha}(p)[F_{MC}(p)^{-1}-1]}$$

$$Thay F_{MC}(p) = \frac{1}{2.\tau^2P^2 + 2\tau P + 1}$$

$$\rightarrow R_\alpha(p) = \frac{1}{S_{o\alpha}(p.2)\tau P(1+\tau P)}$$

$$R_\alpha(p) = \frac{P(T_\alpha P+1)(T_\alpha P+1)}{2.\tau P.K_x.K_s.K_\alpha(1+\tau P)}$$

$$\tau = T_x = \frac{T_xP+1}{2T_\alpha.K_x.K_s.K_\alpha} \equiv PD$$

$$K_p = \frac{1}{2T_\alpha.K_x.K_sK_\alpha}$$

$$T_D = T_xK_p$$

$$R_\alpha(p) = K_p + T_D$$

Calculate:

$$T_\Sigma = T_x + T_\alpha = 0,005 + 0,001 = 0,006$$

$$k_1 = K_s * K_x * K_\alpha = 0,002 * 5 * 37 = 0,37$$

$$\Rightarrow k = \frac{1}{2 * 0,006 * 0,37} = 252.5$$

1) *Synthesis of speed regulator loop*

We have a function that conveys the position loop

$$F_{1k}=\frac{1}{2T^2p^2+2Tp+1}\approx\frac{1}{2Tp+1}=\frac{1}{0{,}012p+1}$$

So we have a speed feedback loop

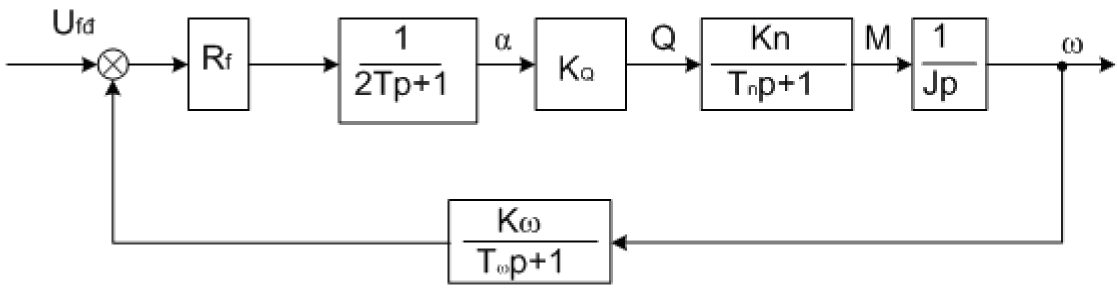


Figure 1: *Speed feedback loop*

We have $S_{o2}(p)=\frac{K_\omega * K_Q * K_n}{J*p*(T_\omega p+1)*(2Tp+1)*(1+T_n p)}$

$\Leftrightarrow S_{o2}(p) = \frac{K}{p(T_\omega p+1)*(2Tp+1)*(1+T_n p)}$

In which:

$$K=\frac{K_\omega.K_Q.K_n}{J}=\frac{0{,}2*520*20{,}62}{1050*10^3}=0{,}002$$

Applying the symmetric optimization standard, we have a speed regulator - a PID controller with the formula.

$$R_f = K_p + Kd.p + \frac{K_i}{p}$$

The symmetric optimization standard function takes:

$$F_{DX}(p)=\frac{1+4T_\sigma p}{1+4T_\sigma p+8T_\sigma^2p^2+8T_\sigma^3p^3}$$

We have :

$F_h(p)= R_f.S_{02} = R_f.\frac{K}{p(T_\omega p+1)*(2Tp+1)*(1+T_n p)}$

=> $F_k(p)=\frac{F_h}{1+F_h}=\frac{R_f.K}{R_f.K+p(T_\omega p+1)(2Tp+1)(T_n p+1)}$

The closed transfer function of the governor applies the optimal modular standard:

$F_k(p)=F_{§X}$

$$=> \frac{R_f.K}{R_f.K+p(T_\omega p+1)(2Tp+1)(T_n p+1)}=\frac{1+4T_\sigma}{1+4T_\sigma+8T_\sigma^2+8T_\sigma^3}$$

$$\Leftrightarrow R_f.K.8T_\sigma^2(1+T_\sigma)=p(T_\omega p+1)(2Tp+1)(T_n+1)(1+4T_\sigma)$$

$$\Leftrightarrow R_f.K.8T_\sigma^2 = p(T_\omega p+1)(2Tp+1)(1+4T_\sigma)$$

$$\Leftrightarrow (K_p + Kd.p + \frac{K_i}{p}).K.8.T_\sigma^2 = p(T_\omega p+1)(2Tp+1)(1+4T_\sigma)$$

Performing the transformation we get the coefficient equation of the property equation:

$$\begin{cases} 8.T_\sigma^2.T_\omega = 8.K_d.K.T_\sigma^2 \\ 8.T^2 + 6T_\sigma.T_\omega = K_p.8.K.T_\sigma^2 \\ 8.K.K_i.T_\sigma^2 = 6.T_\sigma + T_\omega \end{cases}$$

$$\Leftrightarrow \begin{cases} K_d = \frac{T_\omega}{K} = \frac{10^{-3}}{2.10^{-3}} = 0.5 \\ K_p = \frac{8T_\sigma^2+6.T_\sigma.T_\omega}{8.KT_\sigma^2} = \frac{8.(10^{-3})^2+6.10^{-3}.10^{-3}}{8.2.10^{-3}.(10^{-3})^2} = 875 \\ K_i = \frac{6.T_\sigma+T_\omega}{8.K.T_\sigma} = \frac{6.10^{-3}+10^{-3}}{8.2.10^{-3}.10^{-3}} = 437,5 \end{cases}$$

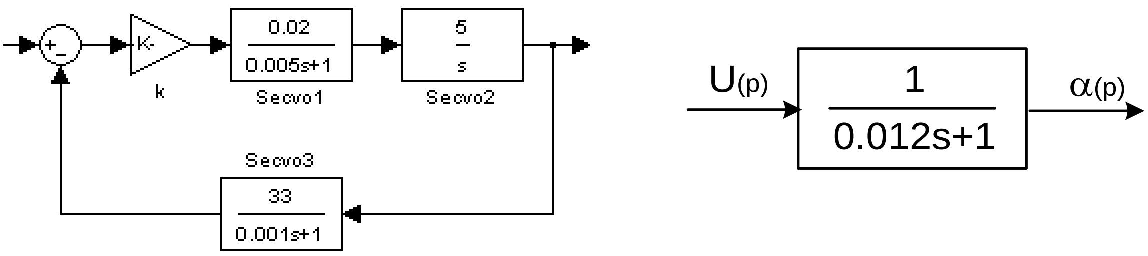
So the speed regulator found has a transfer function:

$$R_f = 875 + \frac{437,5}{p} + 0.5.p$$

IV. Turbine tuning system simulation

Turbine tuning system simulation by Matlab Simulink's software of " **The MathWorks** ".

a. Structure diagram of governor in Simulink



Position control loop *Equivalent transfer function*

Figure 2: *Location controller simulation diagram*

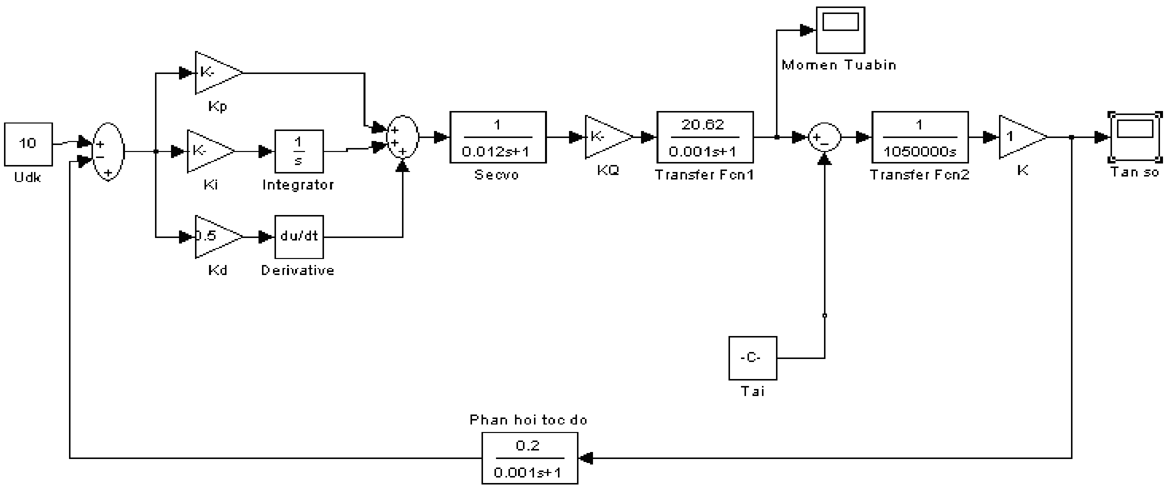


Figure 3: *Simulation results*

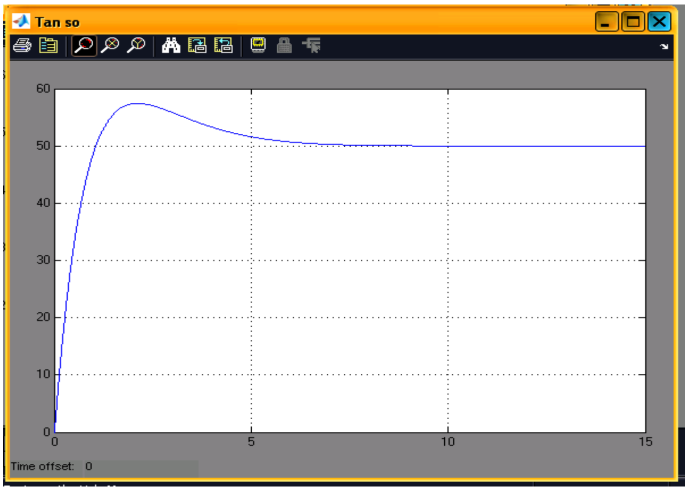


Figure 4: *Simulation results with PID parameters as calculated*

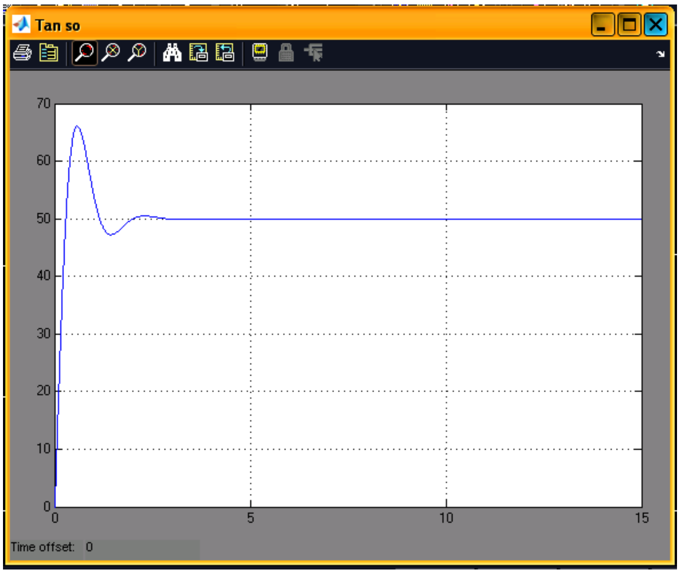


Figure 5: *When increasing the coefficient Kp*

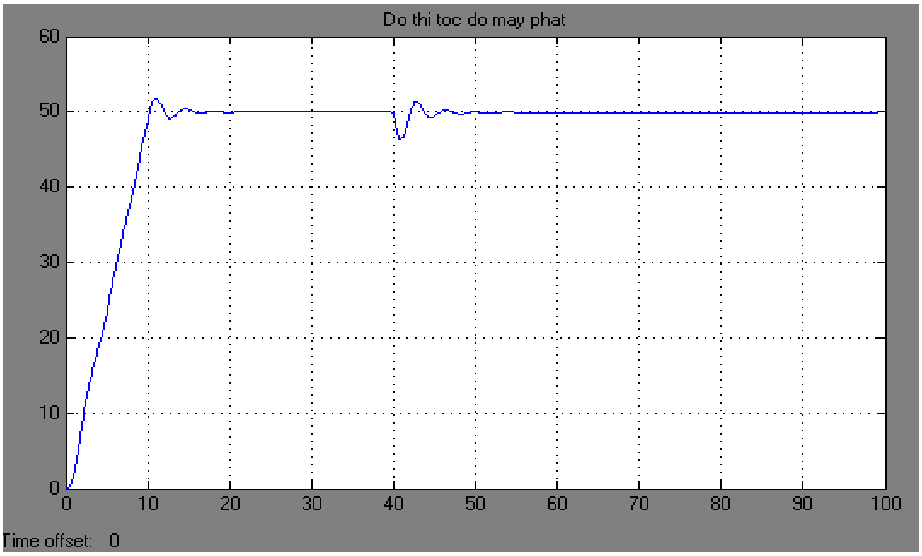


Figure 6: *Graphs of start turbine and feed load after 40 seconds.*

V. Conclusion

The article mentions the research of controlling hydroelectric turbine governor, structure, operation, regulation principles of hydroelectric turbine; Parameter calculation and turbine tuning system simulation; Design the speed control system using Atmel Atmega32 remote controller.

The research have difficulty because the hydroelectric turbine control system is very large, especially the actuator and the turbine system need more support conditions. It is necessary to build a common control system for many units or for the whole hydropower plant and need to pair with other control systems in the hydropower plant.

References

[1]. Hoang Viet Quang (1993), Calculating the stability of the hydroelectric system on the turbine governor and use Microprocessor 8086/8088 to control the hydraulic system according to the program, Master Thesis in Mechanical and Automatic Hydropower, Hanoi University of Technology.

[2]. Truong Cong Tuan, Nguyen Van Dung (2006), Self-study programming Visual Basic 6.0, Culture - Information Publishing House.

[3]. Hydroelectric Department (2003), Hydroelectric station works. Thuy Loi University.

[4]. Vietnam Academy For Water Resources (2006), Note for Irrigation Engineering, Agricultural Publishing House.

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