

ONE OF POSSIBLE APPROACHES TO CONTROL OF MULTIVARIABLE CONTROL LOOP

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Abstract: This paper deals with description of one of possible approaches to control of MIMO control loops with utilisation of the so called binding members and correction members. The designed method of control combinations classical way to ensure of autonomy of control loop via binding members and the use of the method of SISO branched control loops with measurement of dominant disturbance variables to ensure of invariance of control loop by means of correction members. Simulation verification of this method was carried out for three-variable control loop of a steam turbine. *Copyright © 2007 IFAC*

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1. INTRODUCTION

At large numbers of controlled object (steam boilers, turbines, air-conditioning plants, distillation columns, etc.) several variables have to be controlled at the same time. In this case there is not larger member of independent SISO control loop. These control loops are complex with several controlled variables where separate variables are not mutually independent. Mutual coupling of controlled variables is usually given by simultaneous action of each of input (manipulated and disturbance) variables of controlled plant to all controlled variables. These control loops are called MIMO control loops and they are a complex of mutually influencing simpler control loops (Balátě, 2004).

2. CONTROL LOOP OF MIMO SYSTEM

We will consider MIMO control loop with measurement of disturbance (see Fig. 1) where $G_S(s)$, $G_{SV}(s)$, $G_R(s)$ a $G_{KC}(s)$ are transfer matrixes of a controlled plant, disturbance variables, controller and correction members. Signal $Y(s)$ [$n \times 1$] is a vector of controlled variables, $W(s)$ is a vector of setpoints, $U(s)$ [$n \times 1$] is a vector of manipulated variables and $V(s)$ [$m \times 1$] is a vector of disturbance variables.

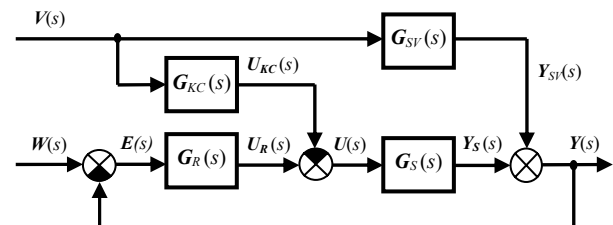


Fig. 1. MIMO control loop with measurement of disturbance

Transfer matrixes of controlled plant and transfer matrix of disturbance variables are considered in forms

$$G_S(s) = \frac{Y_S(s)}{U(s)} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ S_{n1} & S_{n2} & \cdots & S_{nm} \end{bmatrix} \quad (1a)$$

$$G_{SV}(s) = \frac{Y_{SV}(s)}{V(s)} = \begin{bmatrix} S_{V11} & S_{V12} & \cdots & S_{V1m} \\ S_{V21} & S_{V22} & \cdots & S_{V2m} \\ \vdots & \vdots & \cdots & \vdots \\ S_{Vn1} & S_{Vn2} & \cdots & S_{Vnm} \end{bmatrix} \quad (1b)$$

Transfer matrixes of controller and transfer matrix of correction member are considered in forms

$$\mathbf{G}_R(s) = \frac{\mathbf{U}_R(s)}{\mathbf{E}(s)} = \begin{bmatrix} R_{11} & R_{12} & \dots & R_{1n} \\ R_{21} & R_{22} & \dots & R_{2n} \\ \vdots & \vdots & \dots & \vdots \\ R_{n1} & R_{n2} & \dots & R_{nm} \end{bmatrix} \quad (2a)$$

$$\mathbf{G}_{KC}(s) = \frac{\mathbf{U}_{KC}(s)}{\mathbf{V}(s)} = \begin{bmatrix} KC_{11} & 0 & \dots & 0 \\ 0 & KC_{22} & \dots & 0 \\ \vdots & \vdots & \dots & \vdots \\ 0 & 0 & \dots & KC_{mm} \end{bmatrix} \quad (2b)$$

2.1 Autonomy and invariance

Beside stability and quality of control it is often required at synthesis of MIMO control loop that one control variable causes a change of only one corresponding (proper) controlled variable. Such control loop is called autonomous. Elimination of influence of measurable disturbance variables on controlled variables can also be a further requirement. Such control loop is called invariant. Control loop at which the influence of disturbances on controlled variables is completely eliminated are called absolutely invariant. Control loop at which the influence of disturbance variables is eliminated only partially (e.g. only in stabilized state) are called approximately invariant. They are often called also invariant up to ε where ε is an error caused by incomplete elimination of influence of disturbances (Balátě, 2004).

In order to ensure autonomy and invariance of control loop we start from a command transfer matrix $\mathbf{G}_W(s)$ and disturbance transfer matrix $\mathbf{G}_V(s)$, therefore

$$\mathbf{G}_W(s) = [\mathbf{I} + \mathbf{G}_S(s)\mathbf{G}_R(s)]^{-1} \mathbf{G}_S(s)\mathbf{G}_R(s) \quad (3)$$

$$\mathbf{G}_V(s) = [\mathbf{I} + \mathbf{G}_S(s)\mathbf{G}_R(s)]^{-1} [\mathbf{G}_{SV}(s) - \mathbf{G}_S(s)\mathbf{G}_{KC}(s)] \quad (4)$$

Autonomy

It results from the equation (3) that the control loop is autonomous if it is ensured that the matrix $\mathbf{G}_S(s)\mathbf{G}_R(s)$ is diagonal. On the base of this condition it is possible to derive the following relation

$$\frac{R_{kl}}{R_{ml}} = \frac{S_{lk}}{S_{lm}} \quad k, l, m = \langle 1, \dots, n \rangle, S_{lm} \neq 0 \quad (5)$$

s_{ij} - algebraic supplements of separate elements of a transfer matrix of controlled plant $\mathbf{G}_S(s)$

R_{ij} - separate members of a transfer matrix of controller $\mathbf{G}_R(s)$

Diagonal (main) controllers R_{11}, R_{22}, R_{33} etc. are usually known already from the first design of conception of control. The above mentioned relation (5) is therefore used for calculation of all remaining members of matrix controller i.e. for calculation of transfers of binding members, which are aside-from diagonal elements of transfer matrix of controller $\mathbf{G}_R(s)$.

Invariance

For ensuring absolute invariance it is necessary that the disturbance transfer matrix $\mathbf{G}_V(s)$ (4) is zero. This is possible if the following relation is valid

$$\mathbf{G}_{KC}(s) = \mathbf{G}_S^{-1}(s)\mathbf{G}_{SV}(s) \quad (6)$$

At design of correction members, the task of which is to eliminate the influence of disturbance variable on control loop, internal couplings are omitted at MIMO control loop and thus n SISO branched control loops with measuring of a disturbance variable are gained. Connection of all these SISO control loops is the same and they differ only in separate transfers of controlled plants, controllers, correction members and disturbance variables (Balátě, 2004). Common connection of these control loops is presented on the following Fig. 2.

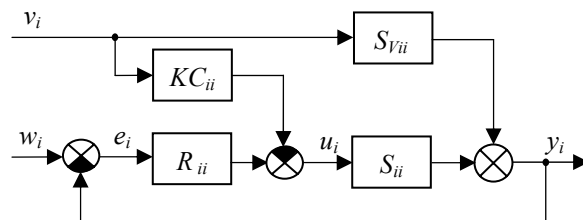


Fig. 2. Block diagram of SISO control loop with measuring of disturbance variable v_i

Correction members KC are determined on the base of the condition (6) i.e. from the condition of invariance. The invariance of the control loop is ensured, according to the above mentioned method, by using analogy of SISO branched control loops with measuring of disturbance variable v_i . Transfer of correction members KC are gained by using the equation (6) in the following form

$$KC_{ii} = \frac{S_{Vii}}{S_{ii}} \quad i = \langle 1, \dots, n \rangle, S_{ii} \neq 0 \quad (7)$$

S_{Vii} - separate members of transfer matrix of disturbance variables $\mathbf{G}_{SV}(s)$

S_{ii} - separate members of transfer matrix of controlled plant $\mathbf{G}_S(s)$

2.2 MIMO control loops synthesis

In practice the possible approximate solution of MIMO control loop is applied from analysis of MIMO control loop and really used control

schemes in particular technological equipments (Balátě, 2004). One of the possible methods of solution of MIMO control loops synthesis is described in the following part of this paper. Generally it is possible to divide this solution into three parts

- design of **main (diagonal) controllers** by any synthesis method of SISO control loops, i.e. design of parameters of main controllers for n SISO control loops ($R_{11}, R_{22}, \dots, R_{nn}$),
- ensuring autonomy of control loop by means of **binding members** of transfer matrix of controller $G_R(s)$,
- ensuring invariance control loop by means of correction members KC by using n SISO control loops with measuring of disturbance variables.

3. SIMULATION EXAMPLE

3.1 MIMO controlled plant

Steam turbine is a typical example of MIMO controlled plant. In this case is considered the turbine with two controlled withdrawals which drives electric generator supplying determined part of electric network (it means the turbine operates without phasing into power network). Here, the turbine represent three-variable control loop. The scheme of three-variable control loop of steam turbine is presented on the Fig 3.

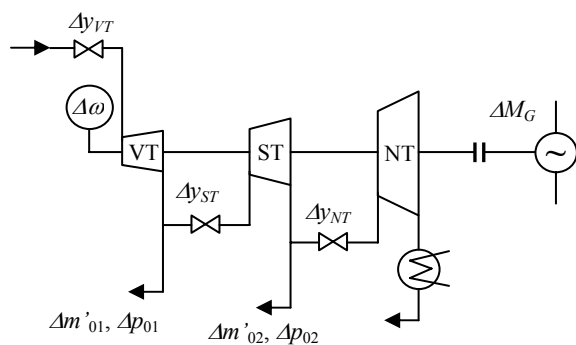


Fig. 3. Three-variable control loop of steam turbine

Denominations on Fig. 3 mean: ΔM_G - change of electric load of turbo-generator, $\Delta m'_{01}$, $\Delta m'_{02}$ - change of mass flow of withdrawn steam, $\Delta \omega$ - change of angular speed of turbo-generator, Δp_{01} , Δp_{02} - change of steam pressure in corresponding withdrawals, Δy_{VT} , Δy_{ST} , Δy_{NT} - change of opening position of control valves of high-pressure, medium-pressure and low-pressure part of turbine.

Controlled variables are $\Delta \omega$, Δp_{01} , Δp_{02} , manipulated variables are Δy_{VT} , Δy_{ST} , Δy_{NT} and disturbance variables are ΔM_G , $\Delta m'_{01}$, $\Delta m'_{02}$.

3.2 Mathematical model of three-variable control loop

Resulting differential equations for creating mathematical model of the controlled plant were gained already after deriving and using linearization from the project OTROKOVICE elaborated by the firm ALSTOM Power (ALSTOM Power, 1998).

The first equation is equation of moment balance which is in the form

$$518.4\Delta\dot{\omega} = -63.3\Delta\omega + 656.9\Delta p_{01} + 4611.7\Delta p_{02} + 1007.3\Delta y_{VT} + 200.6\Delta y_{ST} + 121.5\Delta y_{NT} - \Delta M_G \quad (8)$$

second and third equations are equations of flow through flow spaces which are in the form

$$1.865\Delta\dot{p}_{01} = -1.610\Delta p_{01} + 0.167\Delta p_{02} + 1.523\Delta y_{VT} - 0.361\Delta y_{ST} - \Delta m'_{01} \quad (9)$$

$$13.45\Delta\dot{p}_{02} = 1.563\Delta p_{01} - 10.517\Delta p_{02} + 0.361\Delta y_{ST} - 0.222\Delta y_{NT} - \Delta m'_{02} \quad (10)$$

It is possible to re-write the above presented differential equations into better-arranged form by introducing relative values (with regard to starting stable state-operational, i.e. to calculated point) at which relation of values can be generally written in the form $\varphi_X = \Delta X / (X)_0$. Then differential equations are given by following relations

$$325710.7\dot{\varphi}_\omega = -39771.4\varphi_\omega + 9196.6\varphi_{p_{01}} + 7148.1\varphi_{p_{02}} + 19289.8\varphi_{y_{VT}} + 12015.9\varphi_{y_{ST}} + 8480.7\varphi_{y_{NT}} - 39789\varphi_{M_G} \quad (11)$$

$$26.110\dot{\varphi}_{p_{01}} = -22.540\varphi_{p_{01}} + 0.259\varphi_{p_{02}} + 29.165\varphi_{y_{VT}} - 21.624\varphi_{y_{ST}} - 6.94\varphi_{m'_{01}} \quad (12)$$

$$20.848\dot{\varphi}_{p_{02}} = 21.882\varphi_{p_{01}} - 16.301\varphi_{p_{02}} + 21.624\varphi_{y_{ST}} - 15.496\varphi_{y_{NT}} - 6.94\varphi_{m'_{02}} \quad (13)$$

Three algebraic equations are gained by using the sentence about differentiation of the original, out of which after arrangement it is possible to put together transfer matrix of the controlled plant and disturbance variables. The Laplace transform of an output (controlled) variable is given by the following relation

$$Y(s) = G_S(s)U(s) + G_{SV}(s)V(s) \quad (14)$$

after substitution we receive

$$\begin{bmatrix} \varphi_\omega \\ \varphi_{p_{01}} \\ \varphi_{p_{02}} \end{bmatrix} = G_S(s) \begin{bmatrix} \varphi_{y_{VT}} \\ \varphi_{y_{ST}} \\ \varphi_{y_{NT}} \end{bmatrix} + G_{SV}(s) \begin{bmatrix} \varphi_{M_G} \\ \varphi_{m'_{01}} \\ \varphi_{m'_{02}} \end{bmatrix} \quad (15)$$

where

$$\mathbf{G}_S(s) = \begin{bmatrix} \frac{0.73s^2 + 1.59s + 1.11}{12.3s^3 + 21.8s^2 + 10.7s + 1} & \frac{0.46s^2 + 0.74s + 0.09}{12.3s^3 + 21.8s^2 + 10.7s + 1} & \frac{0.32s^2 + 0.33s + 0.04}{12.3s^3 + 21.8s^2 + 10.7s + 1} \\ \frac{1.68s + 1.31}{1.51s^2 + 2.48s + 1} & \frac{-1.246s - 0.9589}{1.51s^2 + 2.48s + 1} & \frac{-0.01}{1.51s^2 + 2.48s + 1} \\ \frac{1.51s^2 + 2.48s + 1}{1.51s^2 + 2.48s + 1} & \frac{1.51s^2 + 2.48s + 1}{1.51s^2 + 2.48s + 1} & \frac{1.51s^2 + 2.48s + 1}{1.51s^2 + 2.48s + 1} \end{bmatrix} \quad (16)$$

$$\mathbf{G}_{SV}(s) = \begin{bmatrix} \frac{-1.51s^2 - 2.48s - 1}{12.3s^3 + 21.8s^2 + 10.7s + 1} & \frac{-0.09s - 0.15}{12.3s^3 + 21.8s^2 + 10.7s + 1} & \frac{-0.09s - 0.08}{12.3s^3 + 21.8s^2 + 10.7s + 1} \\ 0 & \frac{-0.40s - 0.31}{1.51s^2 + 2.48s + 1} & \frac{-0.005}{1.51s^2 + 2.48s + 1} \\ 0 & \frac{-0.42}{1.51s^2 + 2.48s + 1} & \frac{-0.50s - 0.43}{1.51s^2 + 2.48s + 1} \end{bmatrix} \quad (17)$$

Step response of transfer matrix of the controlled plant $\mathbf{G}_S(s)$ and of transfer matrix of disturbance variables $\mathbf{G}_{SV}(s)$ are presented on the following figures (see Fig. 4 and Fig. 5).

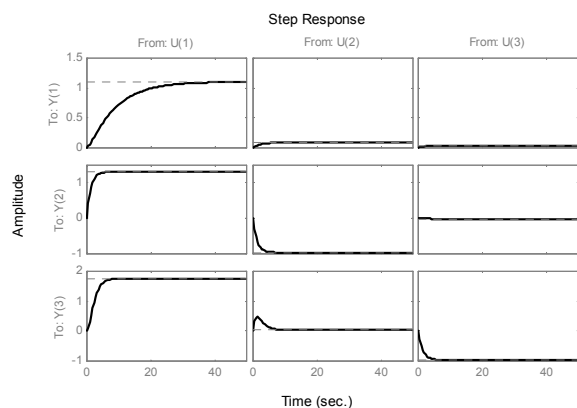


Fig. 4. Step response for transfer matrix of the controlled plant $\mathbf{G}_S(s)$

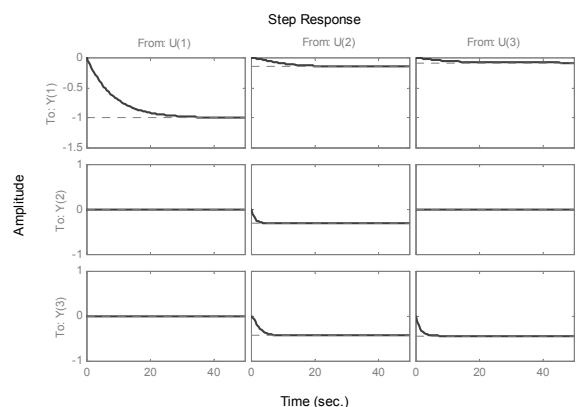


Fig. 5. Step response for transfer matrix of disturbance variables $\mathbf{G}_{SV}(s)$

3.3 Synthesis of three-variable control loop

The principal described in the paragraph 2.2 is used at solution of synthesis of the three-variable control loop. First transfers of main controllers R_{11} , R_{22} , R_{33} are determined for transfer functions S_{11} , S_{22} a S_{33} then autonomy of control loop by using relation (5) is being solved and in the end fulfilment of the condition of invariance (approximate invariance) of control loop is ensured by using equation (7).

At design of parameters of main controllers the following methods were used:

- Ziegler Nichols step response method (Åström and Hägglund, 1995; Balátě, 2004),
- method of desired model (method of dynamics inversion) (Vítečková, 1998; Wagnerová and Minář, 2000),
- polynomial method of synthesis - 1DOF (1 degree of freedom configuration) configuration (Blaha and Dostál, 2002; Prokop, *et al.*, 2006).

For method of desired model it was necessary to arrange transfer functions on main diagonal of transfer matrix of controlled plant $\mathbf{G}_S(s)$ to the form of transfer functions for which the method of desired model was designed, therefore transfer functions S_{11} , S_{22} , S_{33} were arranged to the form

$$S_{11,upr} = \frac{1.106}{9.372s + 1} \quad S_{22,upr} = \frac{-0.959}{1.168s + 1} \quad S_{33,upr} = \frac{-0.966}{1.291s + 1} \quad (18)$$

To calculation of binding members R_{ij} (aside-from diagonal elements of transfer matrix of controller $\mathbf{G}_R(s)$) was used, as mentioned above, equation (5). Then these members were determined from following relations

$$\begin{aligned} R_{12}(s) &= \frac{S_{21}}{S_{22}} R_{22} = \frac{S_{13}S_{32} - S_{12}S_{33}}{S_{11}S_{33} - S_{13}S_{31}} R_{22} \\ R_{13}(s) &= \frac{S_{31}}{S_{33}} R_{33} = \frac{S_{12}S_{23} - S_{13}S_{22}}{S_{11}S_{22} - S_{12}S_{21}} R_{33} \\ R_{21}(s) &= \frac{S_{12}}{S_{11}} R_{11} = \frac{S_{23}S_{31} - S_{21}S_{33}}{S_{22}S_{33} - S_{23}S_{32}} R_{11} \\ R_{23}(s) &= \frac{S_{32}}{S_{33}} R_{33} = \frac{S_{13}S_{21} - S_{11}S_{33}}{S_{11}S_{22} - S_{12}S_{21}} R_{33} \\ R_{31}(s) &= \frac{S_{13}}{S_{11}} R_{11} = \frac{S_{21}S_{32} - S_{22}S_{31}}{S_{22}S_{33} - S_{23}S_{32}} R_{11} \\ R_{32}(s) &= \frac{S_{23}}{S_{22}} R_{22} = \frac{S_{12}S_{31} - S_{11}S_{32}}{S_{11}S_{33} - S_{13}S_{31}} R_{22} \end{aligned} \quad (19)$$

To determine of correction members KC_{ii} was used relation (7), hence

$$KC_{11} = \frac{S_{V11}}{S_{11}}, \quad KC_{22} = \frac{S_{V22}}{S_{22}}, \quad KC_{33} = \frac{S_{V33}}{S_{33}} \quad (20)$$

Transfer matrix of controllers $\mathbf{G}_R(s)$

Transfer matrix of controllers $\mathbf{G}_R(s)$ with utilization of chosen methods of synthesis was following

$$\mathbf{G}_R(s) = \begin{bmatrix} \frac{34.28s + 34.18}{s} & \frac{1.35s^2 + 0.56s + 0.05}{s(s + 2.09)} & \frac{0.29s^2 + 0.12s + 0.01}{s(s + 1.06)} \\ \frac{46.24s + 46.10}{s} & \frac{-1.09s - 0.32}{s} & \frac{0.39s^2 + 0.18s + 0.02}{s(s + 1.06)} \\ \frac{64.53s + 64.33}{s} & \frac{-1.53s^2 - 0.22s + 0.07}{s(s + 2.089)} & \frac{-1.22s - 0.35}{s} \end{bmatrix} \quad (21)$$

b) method of desired model

$$G_R(s) = \begin{bmatrix} \frac{0.85s + 0.09}{s} & \frac{0.15s^2 + 0.15s + 0.02}{s(s + 2.09)} & \frac{0.03s^2 + 0.03s + 0.003}{s(s + 1.06)} \\ \frac{1.14s + 0.12}{s} & \frac{-0.12s - 0.10}{s} & \frac{0.04s^2 + 0.04s + 0.006}{s(s + 1.06)} \\ \frac{1.60s + 0.17}{s} & \frac{-0.17s^2 - 0.12s + 0.02}{s(s + 2.09)} & \frac{-0.13s - 0.10}{s} \end{bmatrix} \quad (22)$$

c) polynomial method of synthesis - 1DOF configuration

$$G_d(s) = \begin{bmatrix} \frac{0.61s^3 + 2.39s^2 + 1.72s + 0.23}{s(s^2 + 1.37s + 0.67)} & \frac{0.25s^3 + 0.69s^2 + 0.46s + 0.04}{s(s^2 + 2.88s + 1.65)} & \frac{0.11s^4 + 0.32s^3 + 0.30s^2 + 0.11s + 0.01}{s(s^3 + 2.67s^2 + 2.35s + 0.68)} \\ \frac{0.82s^3 + 3.22s^2 + 2.32s + 0.31}{s(s^2 + 1.37s + 0.67)} & \frac{-0.20s^2 - 0.53s - 0.28}{s(s + 0.78)} & \frac{0.15s^4 + 0.44s^3 + 0.43s^2 + 0.16s + 0.02}{s(s^3 + 2.67s^2 + 2.35s + 0.68)} \\ \frac{1.14s^3 + 4.50s^2 + 3.23s + 0.44}{s(s^2 + 1.37s + 0.67)} & \frac{-0.28s^2 - 0.70s - 0.28s + 0.06}{s(s^2 + 2.88s + 1.65)} & \frac{-0.48s^2 - 0.94s - 0.43}{s(s + 0.90)} \end{bmatrix} \quad (23)$$

Transfer matrix of correction members

Transfer matrix of correction members was given by the following relation (it was the same for all three methods)

$$G_{KC}(s) = \begin{bmatrix} \frac{-2.06s^2 - 3.39s - 1.37}{s^2 + 2.18s + 1.52} & 0 & 0 \\ 0 & \frac{0.32s + 0.25}{s + 0.77} & 0 \\ 0 & 0 & 0.45 \end{bmatrix} \quad (24)$$

Simulating scheme presented on the following figure (see Fig. 6) is utilized in program environment MATLAB/SIMULINK for simulating verification of used procedure.

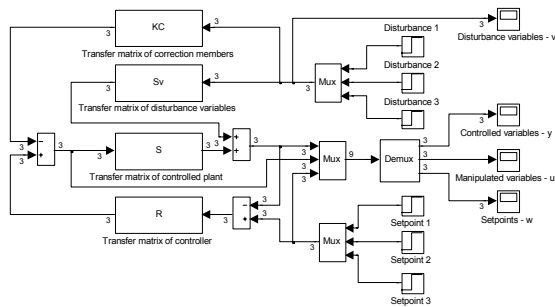


Fig. 6. Simulation scheme of control loop

Simulations of three-variable control loop of a steam turbine with utilization of chosen SISO synthesis methods, which are used at design of parameters of main controllers, are presented on the following figures (see Fig. 7, Fig. 8, Fig. 9). The following parameters were chosen at all simulations:

- vector of time for setpoints (t_{w1}, t_{w2}, t_{w3}): [30 150 270]
- vector of setpoints (w_1, w_2, w_3): [1 1 1]
- vector of time for disturbances (t_{v1}, t_{v2}, t_{v3}): [90 210 330]
- vector of disturbances (v_1, v_2, v_3): [1 1 1]
- total time of simulation (t_S): 400
- time step (k): 0.05

Designation of variables on the figures (see Fig. 7, Fig.8, Fig. 9) corresponds to definite variables existing in the three-variable control loop of steam turbine, i.e.:

controlled variable: $\mathbf{y} = \{y_1 \rightarrow \varphi_{\omega}, y_2 \rightarrow \varphi_{p01}, y_3 \rightarrow \varphi_{p02}\}$

manipulated variable: $\mathbf{u} = \{u_1 \rightarrow \varphi_{y_{TT}}, u_2 \rightarrow \varphi_{y_{ST}}, u_3 \rightarrow \varphi_{y_{NT}}\}$

setpoint: $\mathbf{w} = \{w_1 \rightarrow \varphi_{\omega}, w_2 \rightarrow \varphi_{p01}, w_3 \rightarrow \varphi_{p02}\}$

disturbance: $\mathbf{v} = \{v_1 \rightarrow \varphi_{M_G}, v_2 \rightarrow \varphi_{m'_{01}}, v_3 \rightarrow \varphi_{m'_{02}}\}$

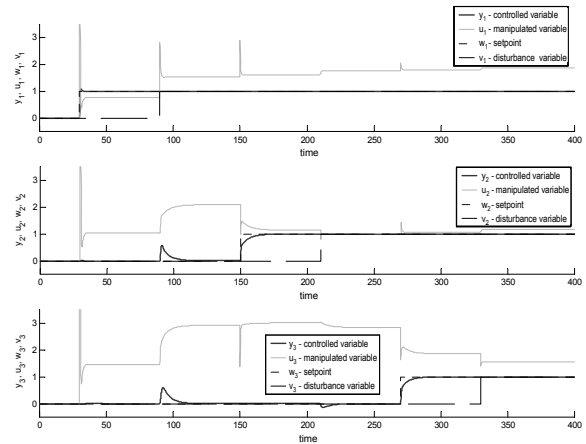


Fig. 7. Simulation of control loop with utilization of Ziegler Nichols step response method

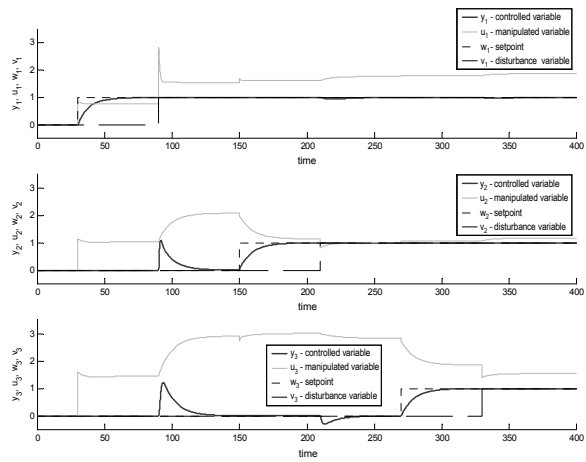


Fig. 8. Simulation of control loop with utilization of method of desired model

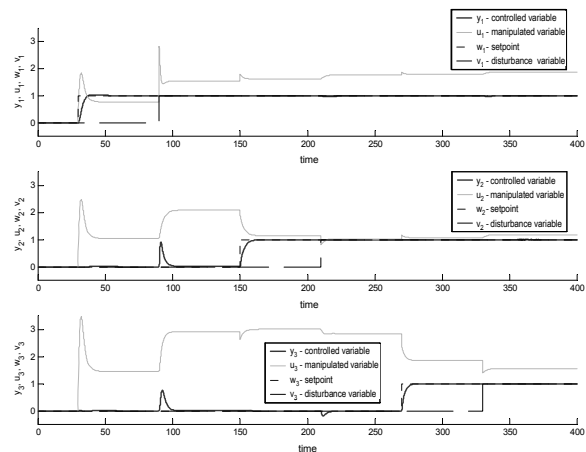


Fig. 9. Simulation of control loop with utilization of polynomial method of synthesis

3.4 Evaluation of simulation experiments

The quadratic criterion (J_K) was used for comparison of used methods of synthesis. Numerical method of integration (method of rectangles) was used for gaining quadratic surface.

$$J_K = \int_0^{\infty} [y(t) - y(\infty)]^2 dt = \int_0^{\infty} [y(t) - w(t)]^2 dt \approx \int_0^{t_r} [y(t) - w(t)]^2 dt \quad (25)$$

where t_r is time of control, $w(t)$ is setpoint, $y(t)$ is controlled variable

Table 1 Quality of control for three-variable control loop

Method of synthesis *)	J_{K1}	J_{K2}	J_{K3}
1	0.118	1.901	2.512
2	4.098	10.24	15.93
3	1.725	3.090	2.793

*) Numbers in the table in the column "Method of synthesis" designate the used method of synthesis, i.e.

- 1 - Ziegler Nichols step response method
- 2 - method of desired model
- 3 - polynomial method of synthesis

Optimal adjustment of control loop is considered here from the point of view of minimal size of quadratic control surface (J_K). However quite different point of view can be rally considered for optimal adjustment. Namely requirements for the shortest time of control and for the smallest overshooting are generally valid for optimal adjustment. However these requirements are antagonistic and therefore the optimal adjustment of controller is always a compromise between them.

It is obvious from the simulation control process presented above (see Fig. 7, Fig. 8, Fig. 9) that the condition of autonomy was fulfilled. Fulfilment of this condition was ensured by means of using binding members R_{ij} (aside-from-diagonal elements of transfer matrix of controller $\mathbf{G}_R(s)$). It is also obvious from the simulation process control that the control loop is invariant or let us say approximately invariant, i.e. that influence of disturbance variables is eliminated only at steady state. Fulfilment of the condition of invariance was ensured by means of correction members KC_{ii} which are considered for elimination of influence of dominant disturbance variables by means of using analogy of SISO branched control loop with measurement of disturbance v .

4. CONCLUSION

It was described one of possible procedure to control of MIMO control loop. Simulation verification of chosen procedure of control is presented on three-variable control loop of steam turbine. At first the method deals with setting-up of main (diagonal) controllers, then determination of binding members for ensuring autonomy and in the end calculation of correction members for ensuring invariance.

The designed method combinations classical way to ensure of autonomy of control loop via binding members and the use of the method of SISO branched control loops with measurement of dominant disturbance variables to ensure of invariance of control loop by means of correction members.

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