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MECHATRONIC MODEL OF WEAVING LOOM

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Summary: *It is necessary for the mathematical description of solved object to include all its subsystems (mechanical, electrical, hydraulical, control, etc.) to construct mechatronic system. This model was used for solving mechanisms of weaving loom to check all the possible working states of machine runs. With regard to the aims of this work program systems I-DEAS 12 NX, MSC-ADAMS, MSC-EASY5 were used.*

1. Introduction

This paper proposes methodology aim at the deriving of mechatronic model parameters for shedding mechanism with separated drive for the purpose of mathematic simulation of the various conditions and requirements during weaving process.

The final mathematics model should respect flexibility of selected members, friction and clearances in kinematic joints and dynamic excitation derived on the basis of mathematical description of driver and control.

2. Simulation model of shedding and slay mechanisms of weaving machine VEGA

Mathematical models of slay and shedding mechanisms with separated drivers (Fig.1) were created using software I-DEAS 12NX, MSC.Adams and MSC.EASY5. Driver of the shedding device is realized synchronous servomotor - slave, the slay mechanism is driven by asynchronous motor – master. Links of slay and shedding mechanisms and their matrices of inertia, centers of masses and kinematic linkages were defined in sw I-DEAS.

The mathematical model of the shedding mechanism driver appeared from mathematical equations of synchronous motor with vectors control and the control loop with cascade structure was used and solved in sw EASY5. The control of the servo is given by request of equivalent values of rotations at cam shaft of slay φ^* and shaft N° 2 of shedding mechanism φ (Fig. 1). The simulation model was solved in sw ADAMS as problem of the dynamic analysis of spatial system of 36 rigid bodies with 11 cylindrical, 20 rotational, 8 spherical, 4 translational joints and 4 flexible spur belts.

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Cam contour of shedding mechanism was defined by cam curve

$$\eta'(\xi) = -|\eta'|_{Max} \sin^{2m+1} \pi\xi \,. \tag{1}$$

The rotor excitation of asynchronous motor is given by two ways: dynamically using Kloss's equation for the speed-torque characteristic or kinematic excitation by course of angular velocity from measurement at the real machine. The rotor excitation of synchronous motor TGT4-0750 was realized driving moment using model at sw EASY 5.

Initial conditions are given position of heald shafts in alignment. The model has 10 degrees of freedom (exhaustively in Ondrášek et al., 2007)

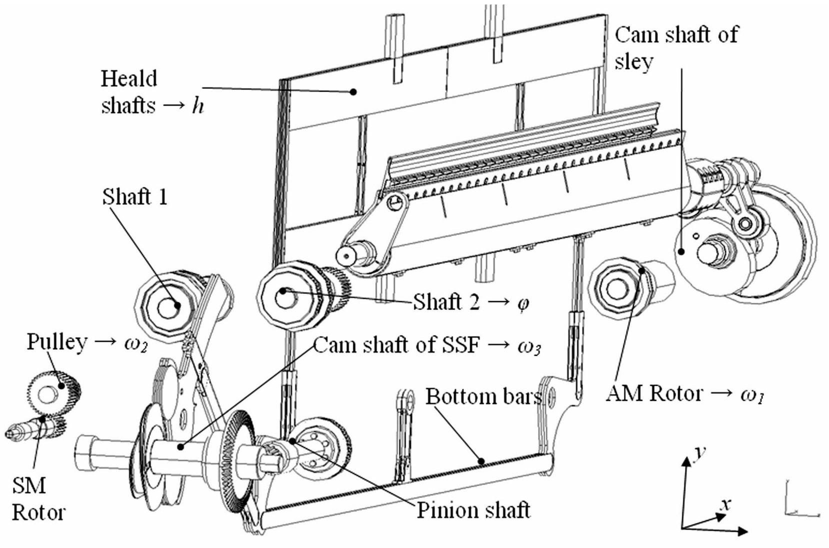

Fig. 1: Model of the shedding and sley mechanism with 2 heald shafts.

3. Mathematical model of synchronous motor with permanent magnets in complex form and in ordinary rotational coordinate system

3.1. Control block diagram of synchronous motor

The mathematical model of drive and control setting up in sw EASY 5 uses the image transmission for solving to system of equations in rotational coordinate system *d*, *q*:

$$U_d = R_s I_d + L_d \frac{dI_d}{dt} - \omega L_q I_q \tag{2}$$

$$U_q = R_s I_q + L_q \frac{dI_q}{dt} + \omega\left(L_d I_d + \psi_m\right) \tag{3}$$

$$M = \frac{3}{2} p_p \left[\psi_m I_q + \left(L_d - L_q\right) I_d I_q\right] \tag{4}$$

where ω is electrical angular velocity of rotor and also rotational coordinate system *d*, *q*, equations (2) and (3) are voltage equations and (4) is expression of the moment of motor.

The control block diagram of synchronous motor with permanent magnets assembled according to equations (2) ÷ (4) is in Fig. 2.

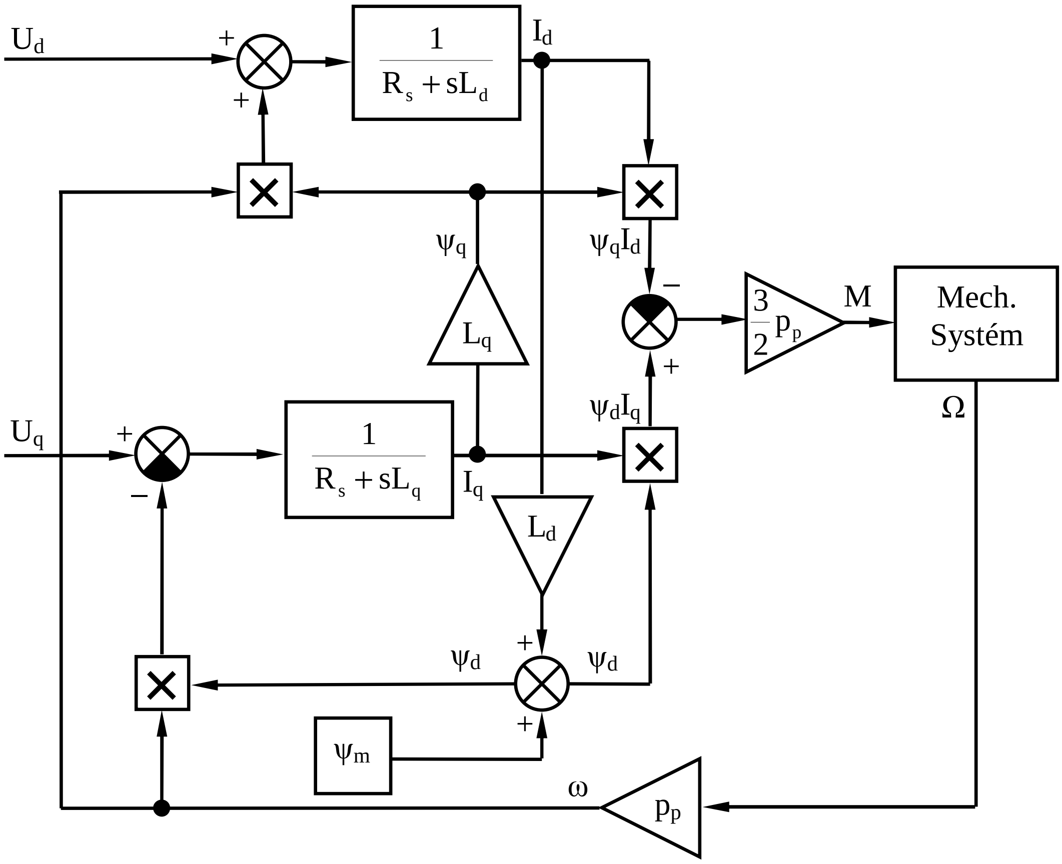

Fig. 2: Control block diagram of synchronous motor with permanent magnets.

3.2. Control structure of driver with synchronous motor in rotational coordinates

The motion of the shedding mechanism is bond with motion of slay mechanism through velocity and positional back coupling in control scheme. Required value of angular revolving φ of shedding mechanism shaft 2 is cam shaft rotation φ*. The cascade control loop with current, power-speed and position back couplings is in Fig. 3.

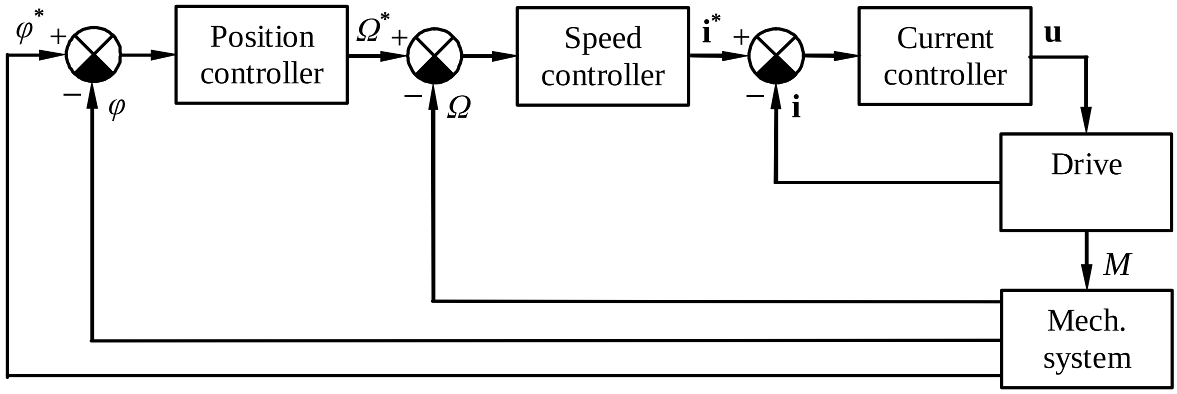

Fig. 3: Cascade control loop with current, power-speed and position feedback.

4. Verification of simulation model

Measurements of kinematic values at chosen parts of the weaving machine VEGA-220 working in range of speed $\omega^* = 350 \div 650$ rpm were realized for reason of verification of simulation model. The servomotor TGT4-0750 electric quantities – currents, voltages and power were measured at the same time.

4.1. Measurements of kinematic quantities

Kinematic quantities as rotor speed of the asynchronous motor ω_1, speed of the shedding mechanisms belt pulley at synchronous motor ω_2 and speed of shedding mechanism cam shaft ω_3 were measured using incremental angular velocity sensors (Fig. 1). The heald shafts stroke h was measured by piezoelectric sensors of acceleration (Fig. 6). The comparison of the measured and calculated courses of angular velocities servomotors Ω for speeds 450 rpm and 600 rpm are shown in Fig. 4 and 5. It is simulation of kinematic excitations of asynchronous motor with resistance in joints.

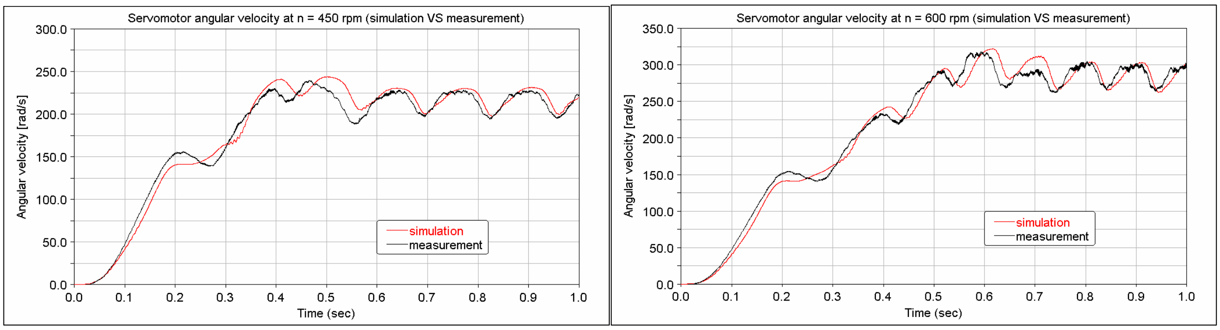

Fig. 4, 5: Comparison of computed and measured angular velocities *Ω(t)* of servomotors for speeds 450 rpm and 600 rpm.

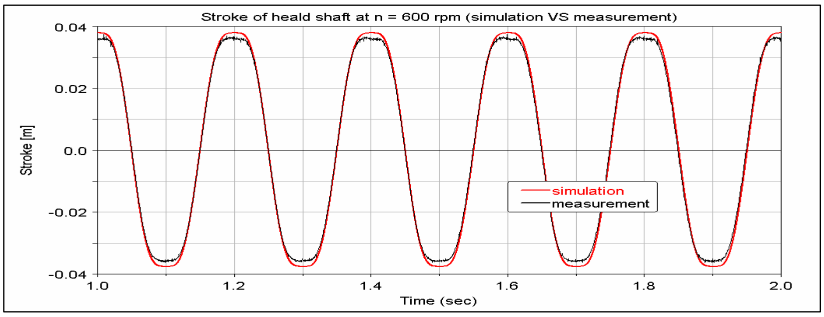

Fig. 6: Comparison of computed and measured heald shaft stroke *h(t)* for speed 600 rpm.

4.2. Measurements of electric quantities

The measurements of electric quantities of servomotor as currents $i_U(t)$, $i_V(t)$, $i_W(t)$, voltages $u_U(t)$, $u_V(t)$, $u_W(t)$ and power $P(t)$ of servomotor were realized at the same time. The comparison of chosen courses measured quantities are shown in following figures.

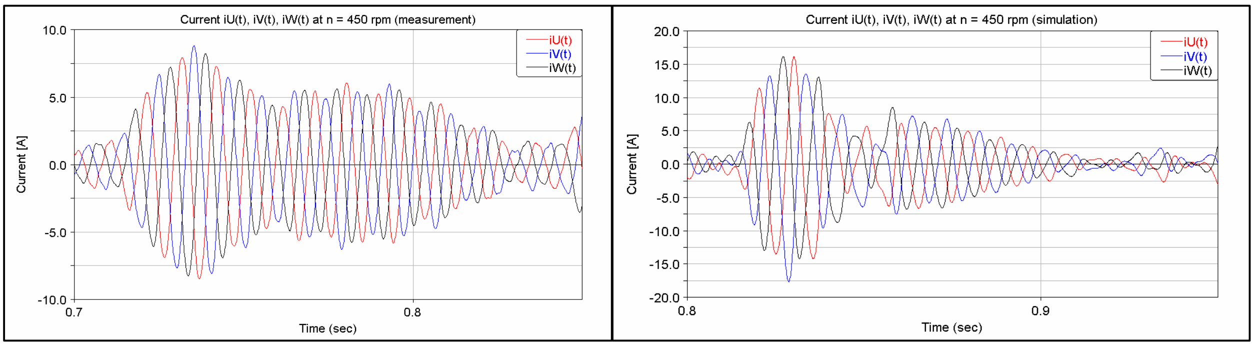

Fig. 7, 8: Comparison of measured and computed courses of currents $i_U(t)$, $i_V(t)$, $i_W(t)$ at servomotors for speed 450 rpm.

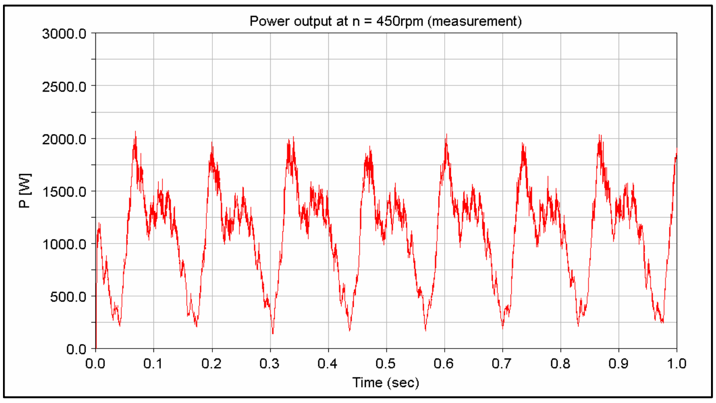

Fig. 9: Measured course of power *P(t)* at servomotors for speed 450 rpm.

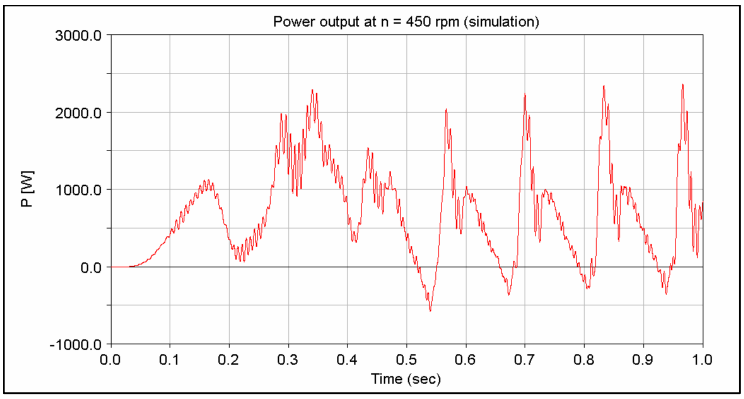

Fig.10: Computed course of power *P(t)* at servomotors for speed 450 rpm in starting up of machine - simulation with kinematic excitation of asynchronous motor.

4.3. Derive parameters of servomotor

Parameters of servomotor TGT4-0750 $R_{2phases}$ and L_{2phase} were measured using instrument Agilent 4263B ($f = 100\ Hz$, $U = 1\ V$). The physical quantities resistance R_{1f}, inductance L_{1f} and magnetic flux ψ_m were calculated according measured values and substituted into numerical model of servomotors (See Tab. 1).

R_{1f}	1,95 Ω
L_{1f}	11,423 mH
ψ_m	0,15 Wb

Tab. 1

5. Conclusions

The simulation model accurately enough describes real machine, i.e. two mechanisms of weaving loom with their drivers and controls. Equivalence of results is evident especially for steady state of the mechanisms.

The time courses of chosen quantities (accelerations, currents, driving moments, powers etc.) are possible to evaluate for arbitrary speeds of loom and to forecast influence of design modifications on behaviour of the machine.

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References

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