Ministry of Education and Science of Ukraine
Sumy State University

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ROTOR MACHINERY DYNAMICS

Independent Studies

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Recommended by the Department of Computational Mechanics named after Volodymyr Martsynkovskyy (minutes No. 5 of 21.12.2022).

Contents

Topic 1. The fundamentals of rotor dynamics

A simple conservative single-mass model of rotor dynamics. Direct synchronous precession. A self-balancing phenomenon. Equation of a motion for a single-mass model of the unbalanced rotor. Considering the external friction. Kinematics of rotating rotor's precessions. Equation of rotor dynamics considering the anisotropy of elastic forces. Loss of dynamic stability. Forced oscillations of a balanced horizontal rotor. Kinematics of a horizontal rotor. Equation of rotor dynamics considering the impact of a liquid layer. Influence of the circulating force. Determination of amplitude and phase frequency responses. Dynamic stability of a centrifugal pump's rotor.

The supplementary material for independent studies is presented in Table 1.

Table 1 – The supplementary material for Topic 1, pages

Reference	[1]	[2]	[3]	[4]	[5]
Lectures					
Lect. 1	1–7	–	–	–	–
Lect. 2	19–24	–	–	–	–
Practical trainings					
Pr. tr. 1	62–78	–	–	–	–
Pr. tr. 2	52–61	–	–	–	–
Pr. tr. 3	–	121–133	–	–	–
Pr. tr. 4	–	188–193	–	–	–

Topic 2. Study of rotor dynamics by discrete models of oscillations

The primary dependencies. Self-oscillation of a rotor without contact interaction with the stator. Self-oscillating precession of a rotor under contact with the stator. A mathematical model of self-oscillations for a floating ring considering dry friction. Stability and self-oscillations of a single-mass model considering anisotropy of elastic forces. Influence of internal viscous friction on dynamics of a horizontal rotor. Basic approaches to creating discrete models of rotor dynamics. The traditional discrete multi-mass model. Ways to consider the gyroscopic moment of inertia in rotor dynamics. Influence of the gyroscopic moment of inertia on rotor's critical frequencies. Shape functions of a 2D beam-type finite element. Lagrange equations of the 2nd kind for transverse oscillations of a beam element. Matrix equation of rotor dynamics. Free and forced oscillations of the rotor's finite element model.

The supplementary material for independent studies is presented in Table 2.

Table 2 – The supplementary material for Topic 2, pages

Reference	[1]	[2]	[3]	[4]	[5]
Lectures					
Lect. 3	62–67	186–187	–	–	521–525
Lect. 4	106–116	–	–	65–66	–
Lect. 5	8–18	–	–	–	–
Practical trainings					
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Pr. tr. 6	68–82	194–197	–	–	–
Pr. tr. 7	–	–	–	68–69	–
Pr. tr. 8	25–29	–	4–6	–	–
Pr. tr. 9	31–36	–	6–7	–	–

Topic 3. Fundamentals of balancing rotors for centrifugal machines

Conditions of rotor's dynamic equilibrium. Types of unbalances. Equivalent systems of imbalances. The concept of a rigid rotor. Quality criteria in rotor balancing. Static balancing of a rotor. Dynamic balancing of a rotor. The phenomenon of unbalance for a rotor balanced in two correction planes at low frequency. The decomposition of a synchronous precession for an unbalanced rotor by mode shapes of free oscillations. Rotor balancing by mode shapes. The Den Hartog's approach in rotor balancing.

The supplementary material for independent studies is presented in Table 3.

Table 3 – The supplementary material for Topic 3, pages

Reference	[1]	[2]	[3]	[4]	[5]
Lectures					
Lect. 6	99–101	–	–	–	–
Lect. 7	104–105	–	1–2	–	–
Practical trainings					
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Pr. tr. 11	2–7, 49–51	–	–	–	–
Pr. tr. 12	123–126	–	–	–	–
Pr. tr. 13	126–130	–	3–4	–	–

Topic 4. Parameter identification of mathematical models of rotor dynamics

Simple algebraic models. A generalized algebraic model. Non-algebraic models. A single experiment. A series of experiments. An implicit model. Linear parameter identification. Linear regression formula. Balancing by the calculation model of rotor dynamics. Practical balancing of a flexible rotor on the operating frequency. Application of the linear regression formula for balancing a flexible rotor by the Den Hartog's approach. Application of the linear regression formula for balancing a flexible rotor by mode shapes.

The supplementary material for independent studies is presented in Table 4.

Table 4 – The supplementary material for Topic 4, pages

Reference	[1]	[2]	[3]	[4]	[5]
Lectures					
Lect. 8	36–48, 117–122	–	–	63–68	–
Practical trainings					
Pr. tr. 14	88–93	–	–	–	–
Pr. tr. 15	21–28	–	–	–	–
Pr. tr. 16	82–87	192–193	–	68–72	–

References

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