

Design and control of shape memory alloy based systems

Unit-1: Smart materials, smart structures - integrated sensing, controlling and actuating techniques, piezoelectric materials, properties, fundamental mechanisms of piezoelectric materials, governing equations, poling, Curie temperature, piezoelectricity, self sensing, design of sensors and actuators, smart structure design issues, pyroelectric, electrostrictive and magnetostrictive materials, applications.

Unit-2: Shape memory alloy, properties, phenomena and mechanisms of temperature controlled shape memory effect, superelasticity, critical temperatures, mechanical properties of shape memory alloy (SMA) at different phases and temperatures, self sensing - force feedback and resistance feedback, MSMA and SMP, design of SMA based systems - mechanism of SMA for different configurations, design of sensors and actuators, smart structure design issues.

Unit-3: SMA modelling, heat transfer equation, heating and cooling time, hysteresis time constants, safe heating current, force relations, modelling the effects of temperature and stress, overview of thermo mechanical constitutive models for SMA, FEM simulation tools - ANSYS, ABAQUS and COMSOL Multiphysics.

Unit-4: Control design for shape memory alloy systems - linear and non-linear control, sliding mode based controls, robust and adaptive controls, modulation techniques and its application to control of SMA based systems - pulse width modulation (PWM), pulse width pulse frequency (PWPF) modulation, intelligent control method (Fuzzy logic and Neural network), predictive control.

Unit-5: Shape memory material based applications in instrumentation and control, automotive, robotic, aerospace, avionics, biomedical and civil engineering, SMA for micro scale applications.

REFERENCE BOOKS

1. Clark, R.L., W.R. Saunders, G.P. Gibbs, "Adaptive Structures," John Wiley and Sons, New York, 1998.
2. Banks, H.T., R.C. Smith, Y. Wang, "Smart Material Structures," Masson S.A., Paris, 1996.
3. Guran, A. and Inman (Eds), "Smart Structures, Nonlinear Dynamics and Control," Prentice Hall PTR, Upper Saddle River, NJ, 1995.
4. Janocha, H. (Ed), "Adaptronics and Smart Structures," Springer-Verlag, Berlin, 1999.

Fremont, M. and S. Miyazaki, "Shape Memory Alloys," Springer, New York, 1996.

Otsuka, K and C.M. Wayman, "Shape Memory Materials," Cambridge University Press, 1998.

Gandhi, M.V. and B. S. Thompson, "Smart Materials and Structures," Chapman & Hall, 1992.

Culshaw, "Smart Structures and Materials", Artech House, 1996.

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"Journal of Smart Materials and Structures," Institute of Physics.

"Journal of Intelligent Material Systems and Structures," Technomic Publishing Co, INC

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"Smart Materials Bulletin," Elsevier Science Ltd.

"Annual International Symposium on Smart Structures and Materials," Organized by SPIE (The International Society of Optical Engineering).

"Annual Symposium on Adaptive Structures and material Systems," in ASME International Mechanical Engineering Congress & Exposition.