Temperature – Deformation relations in shape memory alloys

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Biography

Adiguzel graduated from Department of Physics, Ankara University, Turkey in 1974 and received PhD- degree from Dicle University, Diyarbakir-Turkey. He has studied at Surrey University, Guildford, UK, as a post doctoral research scientist in 1986-1987, and studied on shape memory alloys. He worked as research assistant, 1975-80, at Dicle University and shifted to Firat University, Elazig, Turkey in 1980. He became professor in 1996, and he has been retired on November 28, 2019, due to the age limit of 67, following academic life of 45 years. Dr. Adiguzel served his directorate of Graduate School of Natural and Applied Sciences, Firat University, in 1999-2004. He received a certificate awarded to him and his experimental group in recognition of significant contribution of 2 patterns to the Powder Diffraction File – Release 2000.

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Heat treatment, homogenization and phase transformations have great importance in the processing of materials as a tool in industry and other field. Shape memory effect is a temperature dependent phenomenon exhibited by certain alloy systems called shape memory alloys which take place in the class of smart and functional materials, due to the response to the variation of temperature and external conditions. These alloys have dual characteristics called thermoelasticity and superelasticity. Thermoelasticity is governed by thermal and stress induced martensitic transformations on cooling and stressing, and performed thermally on heating and cooling after first cooling and stressing processes. Superelasticity is governed by stress induced transformation by stressing and releasing materials at a constant temperature in parent phase region.

Shape memory alloys can be plastically deformed with external stress in the low temperature product phase condition and recover the original shape on heating, and cycle between original and deformed shapes on cooling and heating, respectively. The origin of this phenomenon lies in the fact that the material changes its internal crystalline structure with changing temperature. Shape memory effect involves a crystallographic phase transformation, martensitic transformation, on cooling and reverse austenitic transformation on heating.

Thermal induced martensite occurs along with lattice twinning and ordered parent phase structures turn into twinned martensite structures by means of lattice invariant shears, and these structures turn into detwinned martensitic structures by means of stres induced transformation. Lattice Twinning occurs in two opposite directions, <110 > -type directions on the {110}-type plane of austenite matrix in self-accommodating manner and consists of lattice twins.

The twinning occurs with internal stresses, while detwinning occurs with the external stresses. Twinning and detwinning processes can be considered as elementary processes activated during the transformations. Temperature has great importance in the thermomechanical behavior of shape memory alloys. Shape memory effect is performed in a temperature interval after first cooling and stressing processe, whereas superelasticity is performed mechanically in a constant temperature in parent phase region, just over the austenite finish temperature. Deformation at different temperature exhibits different behavior beyond shape memory effect and superelasticity. Copper based alloys exhibit this property in metastable beta-phase region, which has bcc based structures at high temperature parent phase