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THE STRESS-STRAIN STATE OF THE REACTORS IN THE PROCESS OF TITANIUM TETRACHLORIDE REDUCTION

This article is devoted to the numerical simulation by finite element method of stress-strain state of the reactors in the process of titanium tetrachloride reduction. The report examines the deformation mechanisms that lead to a change in shape of the lateral wall of the reactor under the influence of an inhomogeneous temperature field and the possible technological solutions to eliminate them.

Global titanium sponge manufacturers face a serious problem – distortion of reactors during the process of producing titanium sponge by magnesium-thermal method. Under the influence of such process reactors are early removed from service and production costs are increased. Solving this problem can significantly improve the efficiency of the titanium industry enterprises.

Analysis of reactors in stress-strained state was carried out with regard to operating conditions and physical and mechanical properties of materials. Deformation of reactors is caused by variety of negative factors: uneven heating of reactors in furnace; effect of gauge argon steam pressure p_o = 0,03 MPa on a side wall in reduction reaction zone; act of axial strain on flange by reactor vessel and reacting mass $P = 10^4 \ldots 10^5$ N depending on the type of reactor.

The character of strain and hogging of reactors shows the necessity of consideration of nonlinear processes (plastic flow and fluidity) when constructing their physical-mathematical model.

The solution was carried out by finite element method. For this purpose, based on drawings of actual retorts, its axially symmetric geometric model using CAD module of Comsol Multiphysics application suite. For calculation was used Nonlinear Structural Materials module, which allows to simulate deformation behavior of model, to determine elastic and plastic deformation zones, to predict collapse of reactors during recovery period producing titanium sponge. Based on find dependence, at $\Delta T > T_{crit} = 60\ ^\circ C$, reactor walls in the process of titanium tetrachloride reduction undergo plastic deformation, maximum value of which can reach $\varepsilon_{max}^{pl} = 5{,}5\ \%$.

Conclusions

1. Simulation of the process showed, that reactor wall deformation is caused mainly by thermal expansion of the material under the effect of an inhomogeneous temperature field.

2. Minimum overheating temperature $\Delta T_{crit} = 60\ ^\circ C$ of reactor walls in reaction zone, which leads to plastic deformation, was determined.

3. The fundamental capability to control plastic deformation by controlling and changing temperature gradient $\partial T/\partial z$ was shown.

4. Following materials requirements for reactors, that eliminate plastic deformation at operating temperature of 950 ° C were determined: linear expansion coefficient $\alpha \leq 20 \cdot 10^{-6}\ K^{-1}$, yield strength $\sigma_{0.2} \geq 120$ MPa, tensile strength $\sigma_B \geq 210$ MPa.

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