Computation of effective coefficient of thermal expansion of nodular cast iron

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ABSTRACT

Nodular cast iron is formed by graphite nodules in a metal matrix, in which the as-cast matrix may be ferritic, ferritic-pearlitic or pearlitic. The nodular cast iron is employed in industry because of its good mechanical properties and facility for casting; it is used in several important parts as brake systems, crankshafts, and gears. In some cases the parts are subjected to temperature changes, therefore they may undergo thermal expansions in service conditions. Thermal expansion plays a key role when there are tight tolerances between parts with different Coefficients of Thermal Expansion (CTE). In this paper, the effective CTE (secant) of a nodular cast iron is evaluated using a finite element method. The computational micromechanical model takes into account a three-dimensional Representative Volume Element (RVE), which is formed by graphite nodules embedded in a ferritic-pearlitic matrix[1] in a random distribution. Ferrite is considered as a halo around nodules, and the RVE has periodic boundary condition. The mechanical behaviour of phases has been modelled as linear elastic. This model takes into account volume fraction, CTE, Young's modulus and Poisson's ratio of each phase. In the present work pearlite is considered as a homogeneous micro-constituent and its properties have been calculated using the Rule Of Mixture (ROM). Coefficients of thermal expansion of ferritic, ferritic-pearlitic and pearlitic nodular cast iron have been evaluated using the above mentioned model over a range from ambient temperature up to 600ºC. The results obtained with the computational model were compared with ROM model, n-layered sphere model[2] and experimental measurements[3]. In all cases the results of the present computational model and n-layered sphere model are very close. The CTE of ferritic and pearlitic nodular cast iron: from ambient temperature up to 300ºC the models have the same trends as in the experiments. The error with respect to the experiments is around 5% using both computational model and n-layered sphere model, and around 7% using ROM. From 300ºC up to 600ºC the models do not have the same trends than the experimental results, with the slope of experimental CTE being the smallest. The error, according to experiments, is around 7.5% using both n-layered model and computational model, and around 3% using ROM. The CTE of ferritic-pearlitic nodular cast iron: from 200ºC up to 600ºC the models have the same trends as in the experiments. The error with respect to the experiments is around 5.5% using both computational model and n-layered sphere model. Experimental results and CTE using ROM are very close in above mentioned temperature range.

REFERENCES

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