Residual stresses in as-cast aluminium components: Neutron Diffraction measurements and FE modelling

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A stress relief treatment prior to machining and sawing aluminium DC cast products is required to avoid uncontrolled distortion, crack formation, and significant safety concerns due to the presence of thermally-induced residual stresses created during casting. Numerical models have been developed to compute these residual stresses and yet have only been validated against measured surface distortions. In the present contribution, the variation in residual strains and stresses in the steady state regime of casting have been measured as a function of radial position using neutron diffraction and hole drilling strain gage in two AA6063 grain-refined cylindrical billet sections cast at two casting speeds. A thermo-mechanical finite element model was used to determine the minimum section-length which can be sawed from the billet without significantly relaxing the residual stresses while conforming to the requirements of the neutron diffractometer. The results of the residual stress measurements (neutron diffraction and hole-drilling) compare favourably with the numerical model, in particular the depth at which the axial and hoop stresses change sign. Such results provide insight into the development of residual stresses within castings. In particular, it is shown that stored elastic energy within the as-cast billet varies linearly with the casting speed, at least within the range of speeds that correspond to production conditions.
To conclude, the problematic of the stress generation during quenching of thick aluminium components is evoked as in that particular case, a coupling with solid state phase transformations is present.