Influence of Mechanical Material Properties of Cement And Rock Formations on Wellbore Cement Stresses in a Geothermal Well

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Abstract

The main purposes of primary cementing operations in any geothermal well is to support casing strings, prevent corrosion or influx of geothermal fluids and provide zonal insolation. Cement sheaths in the well have to maintain structural integrity and provide good bonding between casing and surrounding rock formations. Current wellbore cement design guidelines by API for geothermal wells are based solemnly on strength requirements, which imply that geothermal cements must have a compressive strength of minimum 6.9 MPa (with permeability less than 0.1 mD) throughout 12-month downhole exposure (API Task Group, 1985). This approach was questioned by many recent studies, which concluded that high compressive strength of cements in either petroleum or geothermal wells does not guarantee perfect zonal insolation (Thiercelin et al. 1997; Bosma et al., 1999; Philippacopoulos et al., 2001). Such studies emphasised also that wellbore cement design should take into account variety of other material properties of casing material, cement as well as surrounding rock formations. New Zealand Code of Practise from 2015 is a basis for design of any deep geothermal well, however as it is focused exclusively on casing selection and assessment of casing stresses during well's lifecycle, it lacks standardization for wellbore cement design.

Conventionally used cement blend in geothermal wells around the world, especially in high enthalpy reservoirs, include API class G or H Portland cement with high silica flour content in order to control the strength retrogression (i.e. compressive strength decrease and permeability increase) which for Portland cement takes place under exposure to temperatures of 110°C. Other additives to wellbore cement might include retarders, accelerators, fluid loss agents, friction reducers or defoamers, depending on the casing section being cemented and reservoir conditions. In this study, existing theoretical analytical models for determining casing-cement-rock interaction are applied to show influence of mechanical material properties of cement and rock formations on the resultant stresses in the wellbore cement under defined reservoir conditions of geothermal well. The other aim is to prove inadequacy of current wellbore cement design methods in geothermal industry. Effect of temperature, uniform and isotropic far-field stresses as well as internal well pressure were also evaluated. Geometrical model of casing-cement-rock interaction was based on conventional casing program of high-temperature geothermal wells. It is highly recommended that the wellbore cement design of future geothermal wells be based on results from stress analysis as carried out in this research, than on limited requirement of compressive strength alone.