

Analysis of Casing Connections Subjected to Thermal Cycle Loading

Jueren Xie and Gang Tao

C-FER Technologies, Edmonton, Alberta, Canada

Production of heavy oil and bitumen, which is increasing around the world as conventional oil resources are depleted, often uses thermal well technologies such as Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD). Casing connections are one of the most critical components in thermal wells. Historically, the literature shows that over 80% of reported uphole casing failures experienced in thermal wells occurred at connections. Typical connection failure mechanisms include structural damages, such as parting, thread rupture, and shoulder plasticity, and serviceability damages, such as leakage. One of the critical load conditions causing casing and casing connection failures is the thermal cycle loading, with high peak temperatures typically in excess of 200°C, which can cause the well casing and casing connections to deform plastically.

There are generally three types of connections used in intermediate or production casing of thermal wells: API (American Petroleum Institute) round, API buttress and proprietary premium connections. This paper presents finite element analysis of these three types of casing connections subjected to thermal cycle loading. Based on analysis results, this paper demonstrates that the premium connection, which has a metal-to-metal seal region, is the most suitable of these three connection designs for the use in thermal wells, in terms of structural integrity and sealability. This paper also presents recommendations for casing connection design for successful service in thermal well applications.

Keywords: Casing, Connection, Cyclic Steam Stimulation (CSS), Sealing, Steam Assisted Gravity Drainage (SAGD), Strength, Structural Integrity, Thermal Cycles, Thermal Wells.

1. Introduction

Thermal well technologies, such as Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD), have been widely used in the production of heavy oil and bitumen. Their use continues to increase as the worldwide production of oil continues to evolve from depleting conventional light oil to more viscous heavy oil and bitumen resources. In the CSS recovery process, high pressure, high temperature steam (330°C-350°C) is injected into the reservoir, followed by a soaking period to allow the thermal energy of the injected steam to disperse into the reservoir, heat the oil and thereby significantly reduce its viscosity, and the heated oil is then produced to the surface from the same well. The SAGD process typically utilizes two parallel horizontal wells positioned above one another and spaced several meters apart. High temperature steam (200°C -275°C) is continuously injected into the upper injection well to heat the reservoir. The hot fluids produced (oil, condensate and formation water) then drain into the lower production well by gravity and are produced to surface by natural steam lift or various artificial lift