Gears are critical mechanical components in power transmission systems, where dimensional accuracy, surface hardness, and fatigue resistance are essential for reliable operation. To meet these requirements, gears manufactured from medium- or low-alloy steels typically undergo austenitisation followed by quenching, often combined with surface hardening treatments. The quenching stage plays a decisive role in determining the final microstructure, hardness distribution, residual stress state, and the extent of distortion.

The geometry of a gear introduces several challenges during quenching. Variations in section thickness between the gear rim, teeth, and hub lead to non-uniform cooling rates, while the presence of sharp curvatures at the tooth root and tip enhances local heat transfer. As a result, the quenching process is inherently transient and strongly non-linear, involving temperature-dependent material properties, boiling heat transfer regimes, and phase transformations in the steel.

In this exercise consider a non-linear transient for simulating the quenching of AISI 4140 steel gear. Start from a suitable austenitization temperature and then quench the gear in oil @ 60°C (see slide 22 lesson 1).