Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

CFD of Idealized Flows Through ICDs up to Choked Conditions

Jean-Luc Olsen[1], Carlos F. Lange[1]
[1]Department of Mechanical Engineering, University of Alberta, Edmonton, Canada

Abstract

Inflow control devices (ICDs) are used widely in Alberta to increase the oil yield and decrease both the economic and environmental costs of steam assisted drainage (SAGD) based oil extraction. An ideal ICD is highly fluid selective: it creates pressure drop primarily through mechanisms that are sensitive to the fluid properties unique to undesired fluids, while creating little pressure drop through mechanisms strongly dependent on the fluid properties of desired fluids. One goal of our research group is to develop better criteria for comparing ICD designs that capture the ICD's ability to be fluid selective towards allowing viscous bitumen while restricting water and steam which tend to flow at higher velocities.

Previous work has focused on normal SAGD operating conditions, which are incompressible flows of bitumen and water. Also previously explored were the validation of modeling techniques and the development of best modelling practices for achieving convergence for steady state compressible flows of ideal gases in the compressible flow regime up to choked conditions. The current stage of the project is using CFD to investigate choking of an ideal gas approximation of steam through various ICD geometries and developing a mathematical model for the relation between mass flow rate and overall pressure drop. Steady state, total energy, and SST turbulence models are being used by ANSYS CFX to simulate the flows.

This paper presents performance curves from multiple ICD geometries and qualitatively discusses the mechanisms for pressure changes, losses, and recovery and their effects on the mass flow rate in relation to the downstream pressure. The differences in geometry are shown to have effects on both the maximum choked flow rate and the downstream pressure at which choking begins to occur. Analysis shows that pressure changes can be divided into two groups, losses before the choke point and changes after the choke point. Losses before the choke point are seen to decrease the maximum flow rate possible through the ICD and decrease the pressure at which full choking occurs. Changes in pressure after the choke point between the ICD and the outlet shift the pressure at which choking occurs without affecting the maximum mass flow rate.

Word count: 356