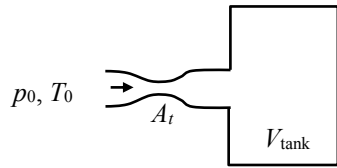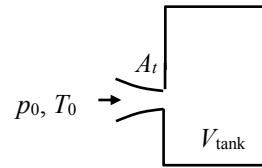Which nozzle will fill the tank faster (or will they fill at the same rate), assuming that the tank is initially evacuated? Justify your answer. The upstream stagnation properties, throat areas, and tank volumes are identical in both cases.

$p_0,\ T_0$ A_t V_{tank}

converging-diverging nozzle

$p_0,\ T_0$ A_t V_{tank}

converging nozzle

SOLUTION:

The converging-diverging nozzle will fill the tank faster. Since the tank is initially evacuated, the flow will start at choked conditions in each case. Hence, the mass flow rate into each tank will be the choked flow mass flow rate (i.e., the maximum mass flow rate), which will be identical in both cases since the throat areas and stagnation properties are identical. However, the converging-diverging nozzle will remain choked for a wider range of back pressure ratios than the converging nozzle. Hence, converging-diverging nozzle will fill the tank more rapidly.

critical back pressure ratio
below which the flow is choked