Numerical Investigation of Free Convection Heat Transfer in Storage Tanks with Different Aspect Ratios

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Abstract:

The impact of aspect ratios (A_1=L/H and A_2=L/W) on heat transfer by free convection in storage tanks containing high-viscosity fluids was examined numerically. Numerical analyses were performed for free convection heat transfer in the tank for 6 different aspect ratios at Rayleigh (Ra) numbers of 10^4, 10^5, 10^6, and 10^7. A grid independence test was performed for a tank with aspect ratios of A_1=2 and A_2=2. Grids were generated according to the dimensions of the tanks with different aspect ratios. The governing equations were solved by the finite volume method. The mean Nusselt numbers (Nu_m) on the hot and cold walls of tanks with different aspect ratios were calculated for Ra numbers in the $10^4 \leq Ra \leq 10^7$ range. Steady flow patterns in the storage tank were obtained for different Ra numbers and aspect ratios. The mean Nusselt number on the hot wall has its minimum value in the tank with A_1=1 and A_2=1 at all Ra numbers. The percentage difference between the minimum and maximum Nu_m obtained on the hot wall at $Ra=10^4$ is 15%, and this rate gradually decreases with increasing Ra. The Ra number is an important parameter in the aspect ratio selection of the tank. It was concluded that the aspect ratio of the tank and the Ra number affect the free convection heat transfer in the storage tank.

Keywords:

Storage tank, numerical analysis, aspect ratio, free convection.