Internal Duct Cooling (IDC) with rib turbulators is one of the common cooling techniques applied inside the turbine airfoils. It is very important for the gas turbine industry to design and develop an optimized cooling channel that maximizes the amount of heat removed, while simultaneously minimizing the pressure drop for a target overall cooling effectiveness. Angled ribs perform superior to the transverse ribs due to additional secondary flow associated with them. However, they result in a highly non-homogenous heat transfer distribution, which is a manifestation of the complex, turbulent flow field inside the channel. It is very important to comprehend the secondary flow physics to characterize the heat transfer distribution in such angled ribbed channels. Additionally, due to the manufacturing constraint, the gas turbine industry encounters a challenge to make ribs’ edge sharp and results in ribs with rounded edges. Only a handful of literature address round ribs focusing on heat transfer and pressure drops. To the best of our knowledge, no study is performed to understand the aerodynamics associated with the round ribs. The objective of the present study is to provide a fundamental understanding of the flow physics on the heat transfer and pressure drop behavior in 45° ribbed channels both with sharp and rounded edge ribs. An optical non-intrusive technique, Stereo PIV is utilized for the flow investigation. Besides the experiments, numerical studies were also conducted by using LES and different RANS models. The LES results show very good agreement with the experimental data. The RANS results are compared with the experiment as well as LES results to shed light on their prediction capability for such channels. The aerodynamic behavior is correlated with the wall heat transfer distribution and found that the secondary flow vortex has a major influence on the heat transfer characteristics for both types of the ribs.