The high-pressure gas atomization is considered a superior powder manufacturing process due to its controllability over powder size distribution. To optimize the powder size and yield, it is essential to understand the physics of high-pressure gas atomization. To gain understanding of the atomization characteristics and the effect of gas pressure, melt and atomizing gas properties, and melt flow on droplet size distribution, a numerical two-phase flow study is performed using Eulerian-Eulerian Volume of Fluid (VOF) interface tracking method. Annular slit, close-coupled gas atomizer is considered to atomize molten aluminum using nitrogen as the atomizing gas. Characteristics of several interfacial instabilities have been identified at different stages of the atomization process. Despite the increment in the rate of atomization with the increasing gas pressure, deformation characteristics and the breakup mechanisms remain unchanged. However, it is found that the rate of the evolution and the effectiveness of the atomization process increases with the gas pressure. Secondary atomized droplets are identified by discriminating the droplets based on the droplet aspect ratio and their axial location. The current grid resolution is found to be sufficient for capturing the characteristics of both primary and secondary atomization. Cumulative volume obtained from the numerical simulations at low gas pressures display similar trends to the experimental results. Three melts (aluminum, yttrium, and steel) are used to investigate the effects of the molten metal properties on atomization. In general, similar flow characteristics have been identified in all the three melts irrespective of their differences in the thermophysical properties. It is found that the rate of atomization process decreases with increasing melt density, and the yield of the atomized powder is seen to increase. The melt flow rate can also significantly change the flow characteristics and interfacial instability.