5–10 October 2025
Kap Europa, Messe Frankfurt

24. International Forging Congress
Forging a **Sustainable** Future.

EUROFORGE IFC
24. INTERNATIONAL FORGING CONGRESS 2025

Scientific line:

New materials in forging

Title: Effect of Hot Deformation on Microstructure and Porosity of Additively Manufactured 7050 Al Alloy

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Abstract:

7050 aluminum alloy is Al-Zn-Mg-Cu ultrahigh-strength aluminum alloy, with high specific strength, yield ratio and plastic deformation capacity, widely used in the aerospace field. Wire arc additive manufacturing(WAAM) technology has advantages of high manufacturing efficiency and low cost, especially suitable for large size aluminum alloy components manufacturing. Therefore, the additive manufacturing technology of 7050 Al alloy has been widely concerned. However, the lack of comprehensive properties of as-deposited microstructure composed of coarse columnar grains and pores has become an important bottleneck restricting its application. In this paper, large plastic deformation is introduced by hot compression and the effect of deformation temperature and deformation amount on microstructure and porosity of as-deposited 7050 Al alloy is studied systematically. The cylindrical specimens used in the hot compression experiment are taken from the single wall of WAAM 7050 Al alloy. The deformation temperature range is 390~540 °C, the deformation amounts are 20%, 40% and 60%, and the strain rate is 0.01 s-1. In the results, only slip deformation occurs at 420 °C and below. Local dynamic recrystallization occurs at columnar grain boundaries at 450 °C. Complete dynamic recrystallization occurs at 480 °C with the average grain size of about 60 μm, which proves that the as-deposited grains are refined effectively and the layered microstructure is completely eliminated. The microstructure is overburned at 510 °C and above, and the specimens are crushed. The η eutectic phases (Mg(Zn,Cu,Al)2) distributed along grain boundaries are broken and the deformation heat accelerates its dissolution, thus effectively thinning the η eutectic phases. As the deformation amount increases from 20% to 60%, the deformation preferentially occurs from the interlayer of columnar grains and gradually extends to the whole columnar grain layers. The deformation in different layers doesn't occur at the same time. The annihilation degree of porosities in the as-deposited microstructure is determined by the deformation amount. The spherical pores are first compressed to ellipsoid, and then further compressed until completely closed. The shear stress on the left and right sides of pores causes the initial grain boundaries in this region to break and rotate preferentially. With the deformation amount increasing, obvious orientation rotation also occurs in the original grains for deformation coordination. The pores are basically annihilated completely at 60% deformation amount with porosity of less than 0.1%. This study provides a theoretical basis for the development of additive manufacturing + large plastic deformation technology.