Study on electrical resistivity enhacement in die-upset Nd-Fe-B magnet by addition of fluoride salt

K. M. Kim[1*], H. W. Kwon[1], J. Y. Kim[2], D. H. Kim[3], J. G. Lee[4] and J. H. Yu[4]
[1]Pukyong National University, Busan, Republic of Korea 48513
[2]Pacific Metals Co., Gumi, Republic of Korea 39382
[3]Stargroup Ind. Co., Daegu City, Republic of Korea 42714
[4]Korea Institute of Materials Science, Changwon, Republic of Korea 51508

Nd-Fe-B-type magnet used in the traction motor of HEV, EV and wind turbine generator is heated up to around 200 °C on service. Due to its high operating temperature, the Nd-Fe-B-type magnet is required to have high room temperature magnetic properties, in particular, high coercivity. Excessive heating of the magnet is due largely to eddy current, which is caused in the magnet by alternating slot field exposing to the magnet during operation. It would be useful if generation of the eddy current could be effectively suppressed by proper technological means. As eddy current is inversely proportional to the electrical resistivity of a material, enhancing the electrical resistivity of magnet can be an effective way for suppressing the eddy current generation, thus preventing excessive heating of the magnet. In this study, enhancement of electrical resistivity of Nd-Fe-B-type die-upset magnet was attempted by addition of fluoride salt using eutectic DyF_3–LiF mixture (eutectic temperature » 700 °C). Commercial melt-spun flakes of Nd-Fe-B-type alloy were mixed with the 76 wt% DyF_3 – 24 wt % LiF salt mixture. The mixture of flake and salt was hot-pressed and then die-upset. The addition of eutectic DyF_3–LiF salt mixture was found to remarkably enhance the electrical resistivity of Nd-Fe-B-type die-upset magnet without severely sacrificing magnetic properties. Enhancement of electrical resistivity by the addition of eutectic DyF_3–LiF salt mixture was more profound with respect to the addition of DyF_3. By adding 5 wt% of DyF_3–LiF salt mixture the electrical resistivity of Nd-Fe-B-type die-upset magnet was enhanced up to ca. 1100 mW.cm compared to ca. 180 mW.cm of the magnet without addition of the eutectic salt mixture. Unlike the single salt of DyF_3, the added DyF_3–LiF salt mixture was liquid during both the hot-pressing and die-upsetting, thus it distributed more uniformly along the interface between the flakes (Fig. 1). The remarkably enhanced electrical resistivity in the die-upset magnet added with DyF_3–LiF salt mixture was attributed to the uniformly distributed insulating salt mixture. Magnetic property of the die-upset magnet added with DyF_3–LiF salt mixture was compared to that of die-upset magnet without salt addition or with addition of single salt of DyF_3, which was solid during whole processing.

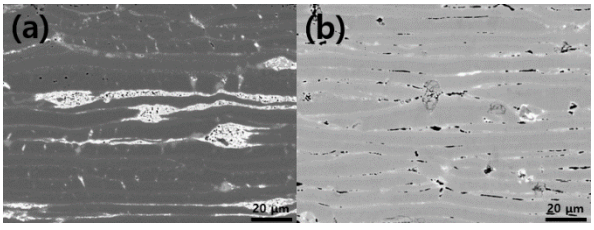

Fig. 1. BSE image of the Nd-Fe-B-type die-upset magnet with addition of (a) DyF_3 single salt and (b) eutectic DyF_3 – LiF salt mixture.