

Simulation of permanent magnetic objects in a customized fashion

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In this application note, Dr. K.M. Prasad, Senior R & D Engineer from Integrated Engineering Software discusses the magnetization of a virgin magnetic material into a permanent magnet in IES's magnetic solver AMPERES.

In the model, a piece of a virgin magnetic material in the desired shape was exposed to highly impressed magnetic fields produced by the magnetic chargers. Different regions were exposed to different impressed magnetic fields simultaneously, to get a customized pattern of magnetic orientation. Images show a semicircular ring magnetized in 6 alternatively reversing magnetization directions oriented along its axis. The angular stretch of each magnetization portion is 30° . Accordingly, a magnetic charger having 6 sets of coils with alternatingly changing senses of current flow is modeled. The virgin piece of semicircular magnetic ring was sandwiched between the charger plates, and appropriate material was assigned to the model. This model was discretized and solved by selecting a command "**Magnetize**" in AMPERES. Once magnetization was done, the geometry related to the magnetic charger was deleted and the appropriate permanent magnetic material property was assigned to the semicircular disk. This model was solved by hitting "**Run Solver**" in AMPERES to determine the magnetic fields produced by the magnetized ring.

This simulation involved two important actions. First, the material to be magnetized was divided into many smaller volumes because the higher the number of divisions, the better was the accuracy. However, the number should not be more than a required number. In this example, the semicircular ring was divided into 6 equal angular portions and each angular portion was subdivided into 9 smaller volumes. In total the semicircular ring was divided into 54 (=6X9) smaller volumes. The reason for dividing the magnetizing piece into smaller volumes was that AMPERES calculated magnetic flux density vector (**B**) at the geometric center of the each smaller volume and magnetized it in the direction of **B** vector. We also noticed a division of 24 (=6X4) smaller volumes produced the same results as 54 smaller volumes. Second, the smaller volumes to be magnetized were defined with the help of the, "**To be Magnetized**" command in the "**Permanent Magnet**" menu in **AMPERES**.

It is important to note that the magnetic material property of the virgin piece is different from that of the permanently magnetized piece. For the virgin piece, the magnetic material can be a linear material with a constant relative permeability or a nonlinear material specified by a nonlinear B-H curve confined to the first quadrant only. After the magnetization is done in AMPERES the material for the magnetized piece should be replaced with a permanent magnetic material, specified by a linear or a nonlinear second quadrant demagnetization curve as per simulation needs.

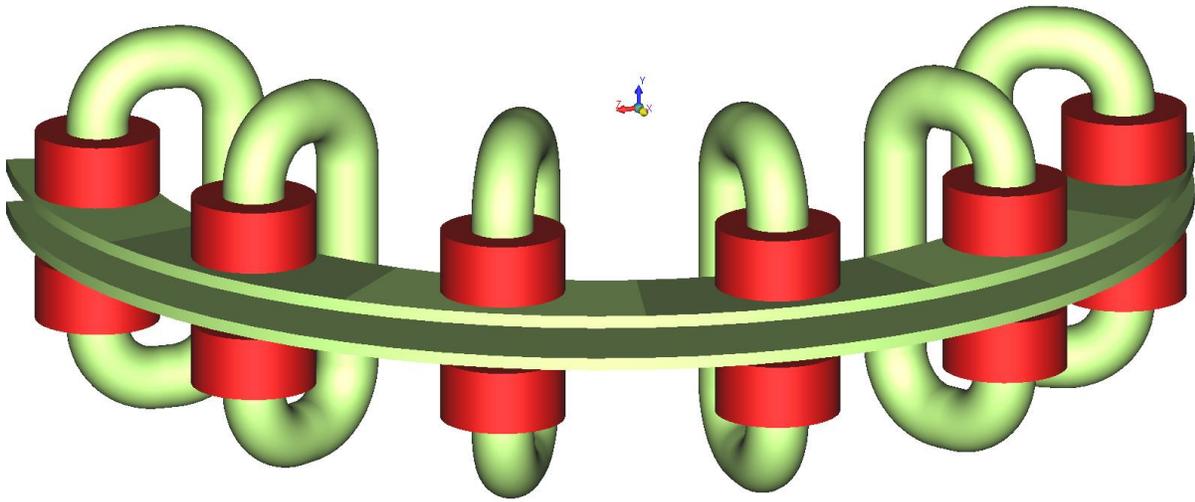


Fig. 1: Magnetizing Charger.

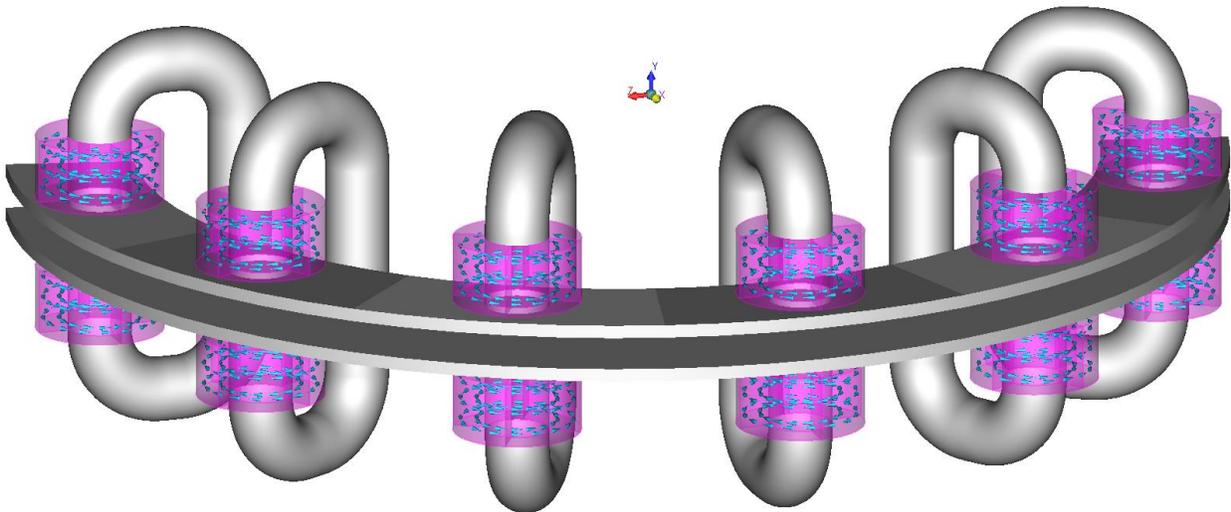


Fig. 2: Current sense.

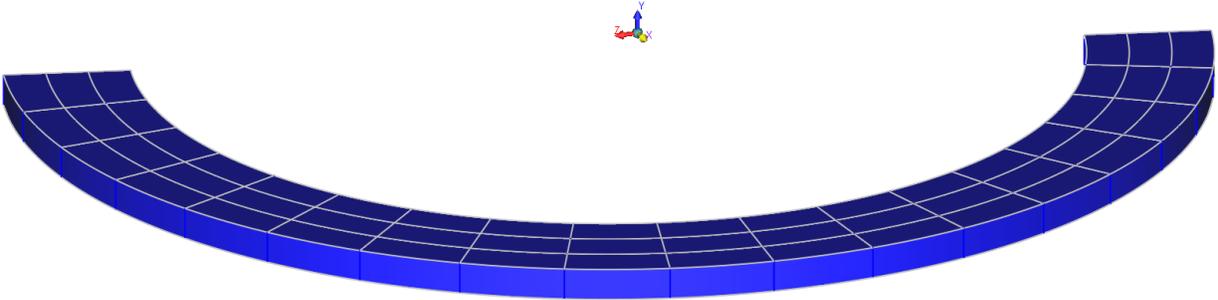


Fig. 3: Semicircular ring to be magnetized.

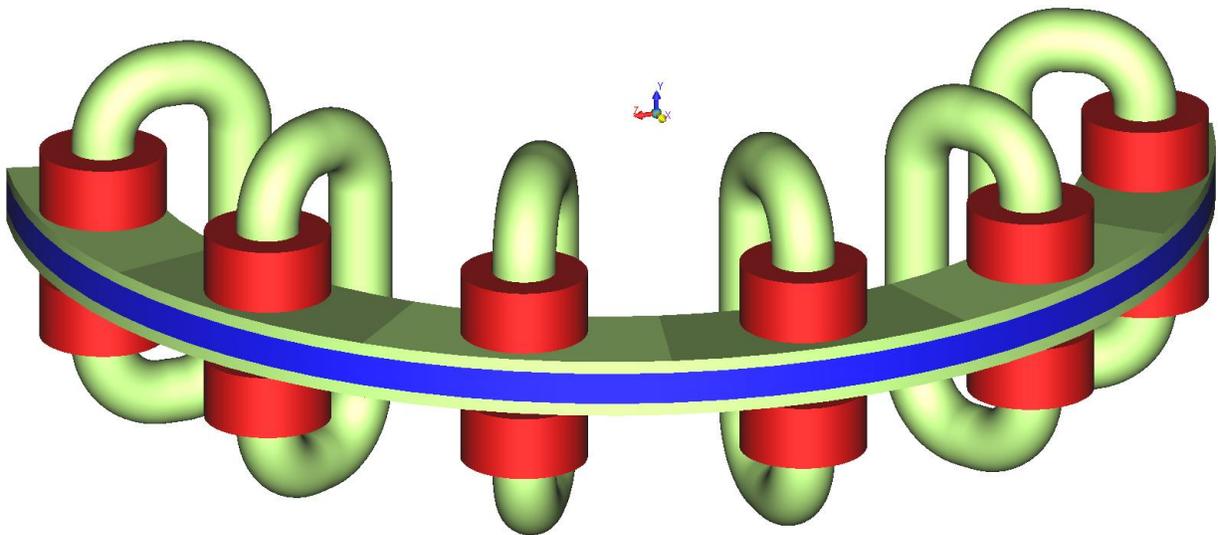


Fig. 4: Semicircular ring sandwiched between the plates the magnetizing charger.

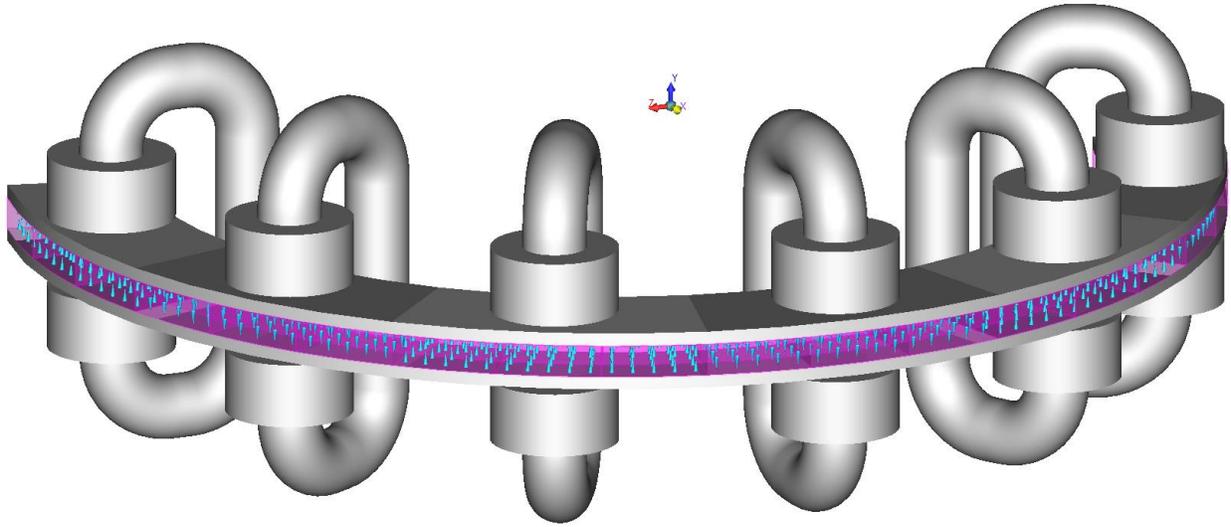


Fig. 5: Semicircular ring after magnetized.

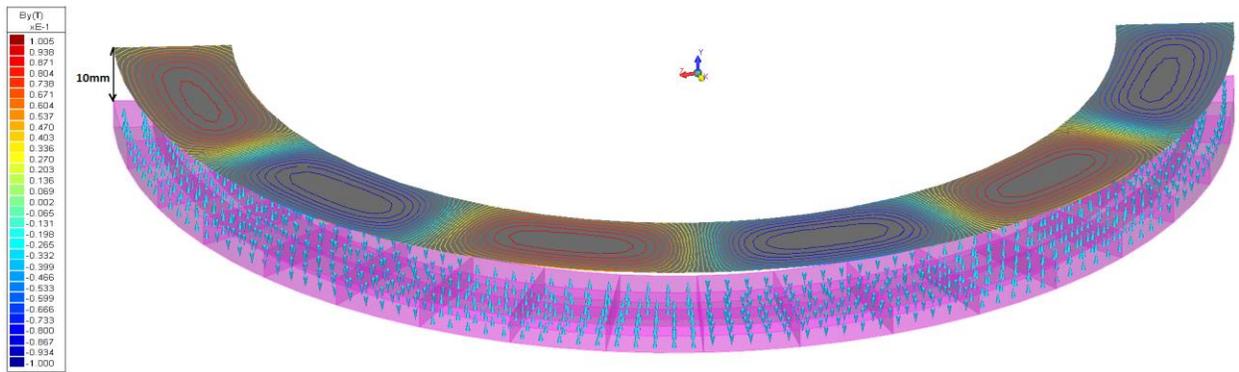


Fig.6: Magnetic charger deleted. Contours of the Y component of magnetic flux density vector B on a surface 10mm above the magnetized semicircular ring.

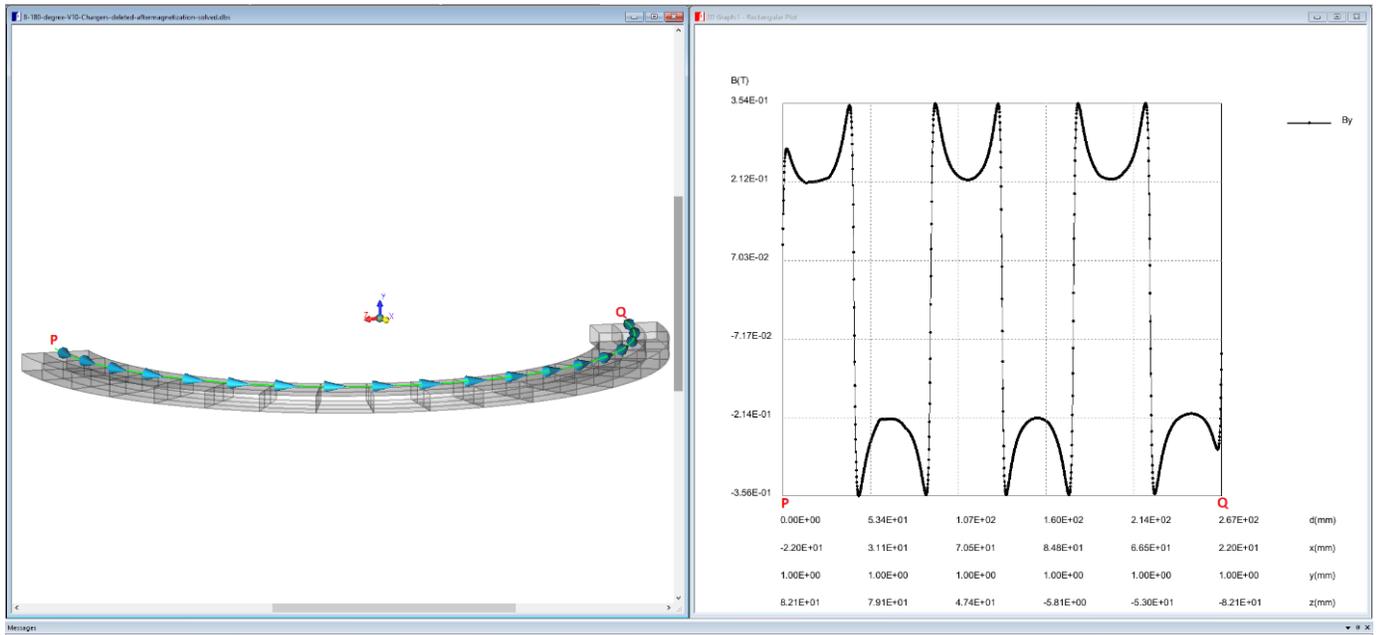


Fig. 7: Variation the Y component of magnetic flux density B along a semicircular arc 1mm above the magnetized ring.