MHD Simulations of Magnetic Compression on Field Reversed Configurations

Yiming Ma[a)], Ping Zhu[a,b)], Bo Rao [a)], Haolong Li [c)]

a) School of Electrical and Electronic Engineering, Huazhong University of Science and Technology, Wuhan, Hubei 430074, China

b) Department of Engineering Physics, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA

c) College of Physics and Optoelectronic Engineering, Shenzhen University, Shenzhen 518060, China

Email: zhup@hust.edu.cn, borao@hust.edu.cn

The magnetic compression has been proved a successful method to heat field reversed configurations (FRCs), but the drastically dynamic behaviors of FRCs make it difficult to understand the physical mechanisms underlying the compression process. The one-dimensional adiabatic model [R. L. Spencer et al., 1983] is a concise and valuable theory to predict the parameters of FRCs during the compression, however, the applicability of the model to the more realistic and dynamic FRC compression process in full 2D or 3D geometry remains to be systematically tested in simulations. In this work, MHD simulations of the magnetic compression on FRCs using the NIMROD code [C. R. Sovinec et al., 2004], and detailed comparisons between numerical results and the theory have been performed. The effects of the assumptions of the theory on the compression process have also been explored. The pressure evolution agrees with the theoretical prediction under different initial conditions. The axial contraction of the FRC can be affected slightly by the initial density profile and the rising rate of the compression magnetic field, but in general the theoretical prediction of the FRC's length is reliable. The evolutions of the density and temperature can be affected significantly by the initial equilibrium profile and the rising rate of the compression magnetic field. Furthermore, during the compression, the radius of the FRC is another parameter that is susceptible to the rising rate of the compression field. The relation $r_s = \sqrt{2} r_o$, as a prerequisite of the theory, holds approximately during the whole compression process, where r_s is the separatrix radius and r_o is the radius of the O-point. Moreover, the detailed profiles of the FRC during the compression have been investigated.