Magnetic compression at General Fusion - experiment and simulation with neutral fluid

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The magnetic compression experiment at General Fusion was a repetitive non-destructive test to study plasma physics applicable to Magnetic Target Fusion compression. A spheromak compact torus (CT) is formed with a co-axial gun into a containment region with an hour-glass shaped inner flux conserver, and an insulating outer wall. External coil currents keep the CT off the outer wall (levitation) and then rapidly compress it inwards. The optimal external coil configuration greatly improved both the levitated CT lifetime and the rate of shots with good compressional flux conservation. As confirmed by spectrometer data, the improved levitation field profile reduced plasma impurity levels by suppressing the interaction between plasma and the insulating outer wall during the formation process. Significant field and density compression factors were routinely observed. Matching the decay rate of the levitation currents to that of the CT currents resulted in a reduced level of MHD activity and a higher frequency of long-lived CTs. We developed an energy and toroidal flux conserving finite element axisymmetric MHD code to study CT formation and compression. The Braginskii MHD equations with anisotropic heat conduction were implemented. The code also has the capability to start magnetic compression from a Grad-Shafranov equilibrium. There are simulated diagnostics for B probes, q-profile, interferometers, and Ion-Doppler measurements. To simulate plasma / insulating wall interaction, we couple the vacuum field solution in the insulating region to the full MHD solution in the remainder of the domain. A plasma-neutral model including ionization, recombination, charge-exchange reactions, and a neutral particle source, was implemented, primarily in order to reduce viscous heating of the ions during formation. We see good agreement between simulated and experimental results.