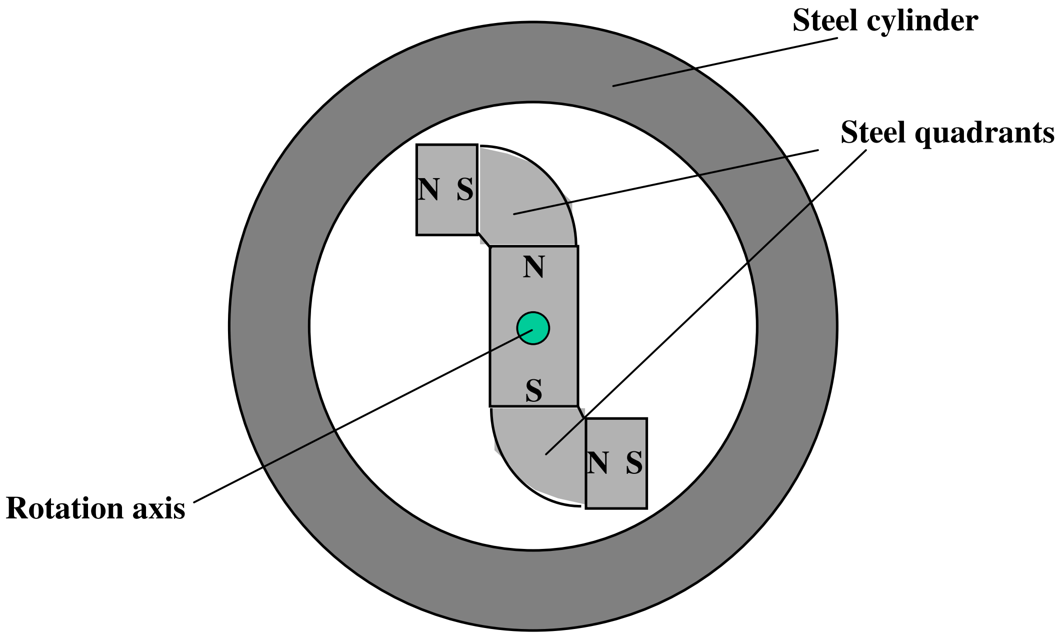
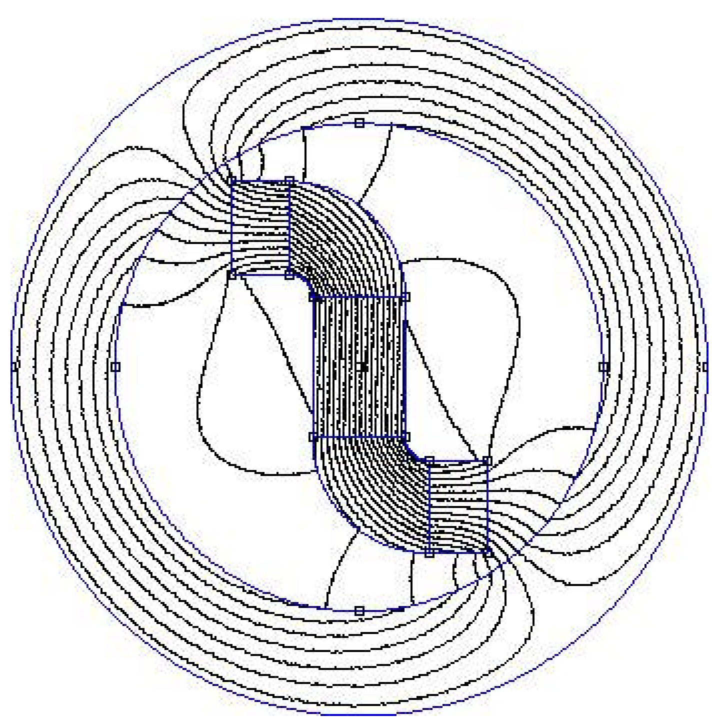
Possible Free-running Motor

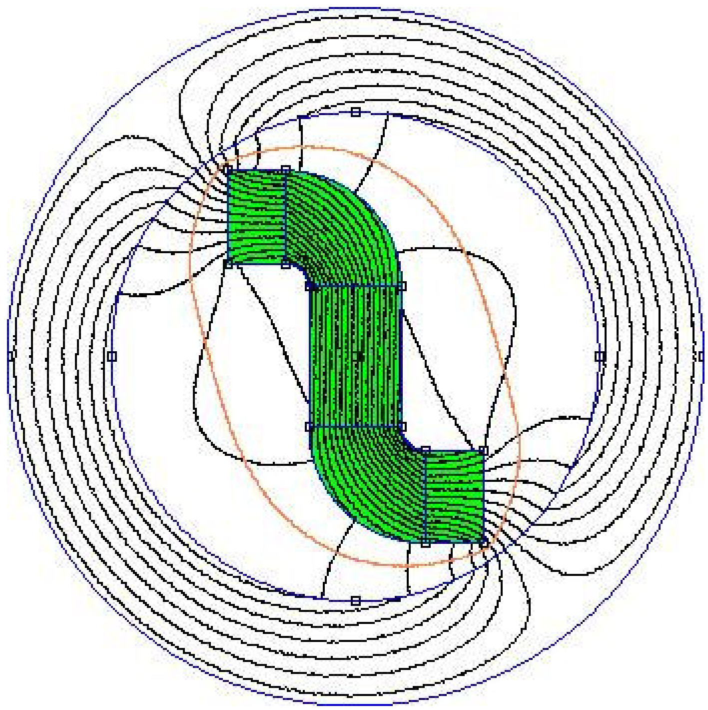
U shaped magnets have been around for a long time often referred to as horseshoe magnets. S shaped magnets are rare, probably because they are considered of little use. Here I am proposing an experiment using an S shaped magnet that can be constructed from three bar magnets, two quadrant shaped steel pieces and a steel cylinder. If someone could build this device it may lead to a free running motor, and even if it doesn't it will solve a problem concerning how to calculate torque using the Maxwell stress tensor. More on that later, but first here is a view of the experiment.



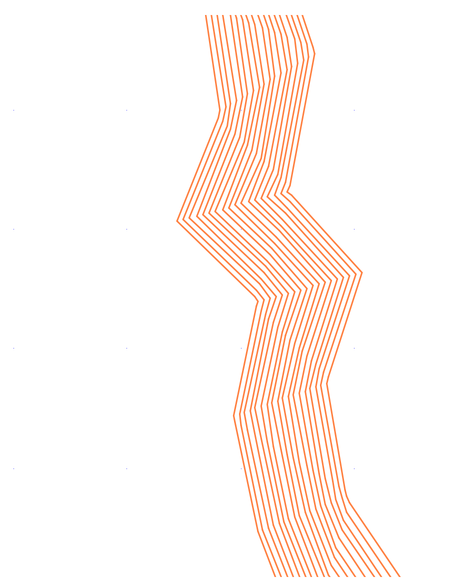
This has been simulated in FEMM and the plot is very much what you would expect.



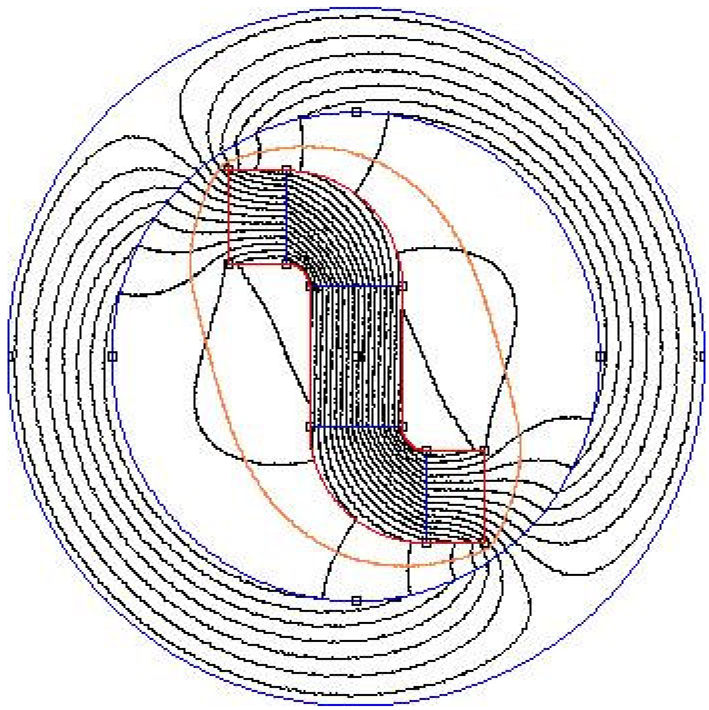
The interesting thing about the FEMM simulation is that it predicts a torque. Now you can obtain the torque by two different methods, both of which use the Maxwell stress tensor. The method recommended in the FEMM manual uses a stress tensor contour that is drawn around the object under consideration, you simply select the block whereupon it turns green, then select the torque integral function. FEMM draws its own stress tensor contour as shown orange in this image.



In fact FEMM draws a number of contours around the object as shown in the expanded image below, and integrates around them all. The black dots show the grid size used that in this case was 0.1mm.



The second method available uses the Maxwell stress tensor as integrated around the outline of the object. You use the line selection command then select the object outline adding adjacent sections bit by bit going around the object in a CW direction until you get back to the starting point. The line turns red, then you select the torque integral function. The next image shows that red outline contour *and* the FEMM generated block contour



The CW direction for selecting the line contour is important because the material boundary is a discontinuity for the magnetic H field used in the tensor calculation, so FEMM uses a contour line slightly to one side of the delineated boundary, and that CW direction ensures that the contour is in the air space outside the object, and not within the object (this is all explained in the manual).

This particular simulation yields a problem between the two methods. The Block selection with the FEMM contour well away from the body gives a torque of 1.032×10^{-5} Nm, while the object outline contour gives 2.261×10^{-2} Nm. That is a huge discrepancy! So which one is likely to be correct? The FEMM manual clearly says the block integral and recommends caution in using the line integral. But study of various texts on the use of the Maxwell's stress tensor for determining surface forces all state it should be done on the air side *and in the immediate vicinity* of the boundary. ***The FEMM block integral contour is not in the immediate vicinity of the boundary***. So there is a good chance that the higher value of 2.261×10^{-2} Nm is correct. That is a significant torque value, at 1000rpm that yields 2.36 watts of free power. The FEMM simulation has a cylinder of 60mm outer diameter and the problem depth was set to 10mm. The magnets were NdFeB 32 MGOe. So that 2.6 watts of free power comes from a motor that is about 60mm diameter and 10mm long.