# Asymmetry and Energy in Magnetic Systems


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Document Number: STRN-TRST-APR-0010-0001

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# 1.0 Overview

This document provides an overview of tests conducted on asymmetric permanent magnetic arrangements in closed loop trajectories.

An asymmetric permanent magnetic arrangement is defined as one in which the relative motion of the magnets is asymmetric with respect to each other's direction of magnetization as demonstrated in the two Figures below.

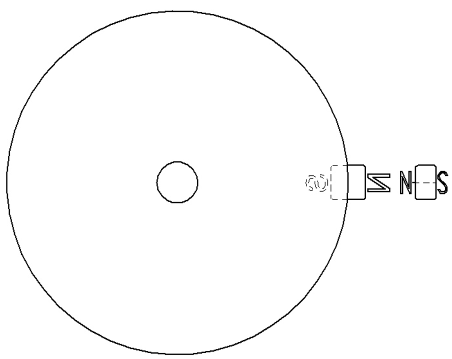


*Figure 1 – Symmetric Magnetic Arrangement*

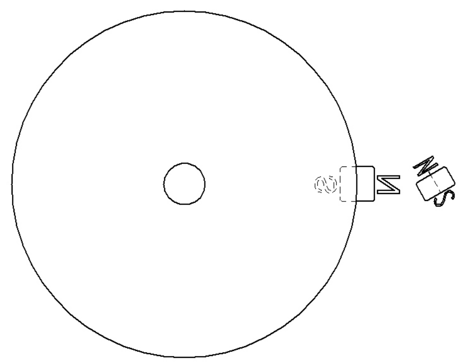


*Figure 2 – Asymmetric Magnetic Arrangement*

Such asymmetric arrangements are a common/unifying feature of companies/individuals claiming to observe energy gains in permanent magnet systems, including such claims made by Steorn Limited.

This document sets out to demonstrate that such asymmetry in itself does not lead to unexpected energy results, but that a combination of asymmetry and non-linear MH relationships does indeed lead to unexpected energy results.

An interaction with a linear MH relationship is defined as one where the MH operating positions of the materials used *are not* caused to move outside of the linear portion of their MH curves, as shown in Figure 3, below.

An interaction with a non-linear MH relationship is defined as one where the MH operating positions of the materials used *are* caused to move outside of the linear portion of their MH curves, as shown in Figure 4, below.

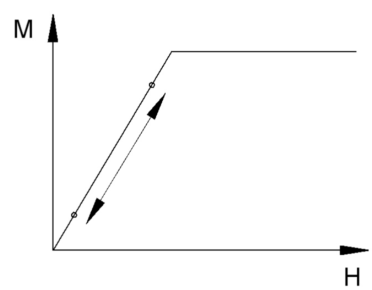


*Figure 3 – Linear MH Movement*

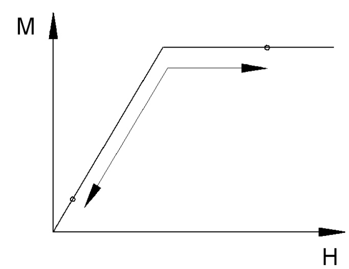


*Figure 4 – Non-linear MH Movement*

## 2.0 Magnetic Arrangements Tested

Two magnetic arrangements are tested. In the first arrangement, two Neodymium Iron Boron magnets are configured as shown in Figure 5.

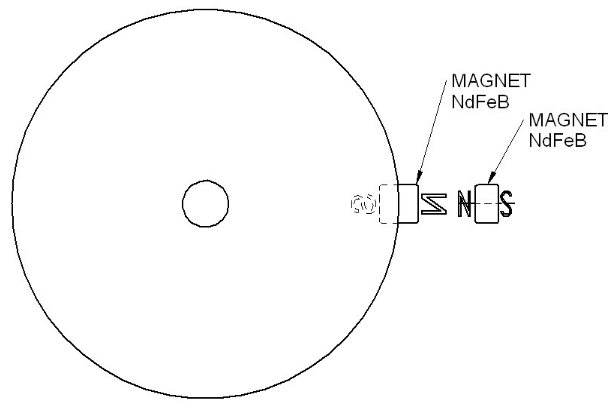


*Figure 5 – Linear MH Arrangement*

The arrangement is such that neither of the two magnets is forced to saturation during the interactions tested. Hence the MH relationship of both magnets is always linear.

In the second arrangement the Neodymium Iron Boron magnet rotor is supplemented with a soft ferrite magnet as shown in Figure 6.

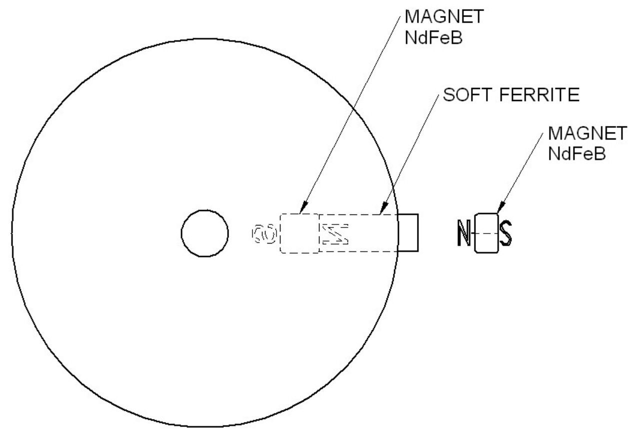


*Figure 6 – Non-linear MH Arrangement*

The net effect of this rotor configuration is to cause the ferrite to be saturated in the absence of the stator's magnetic field.

Because the stator magnetization is in repulsion to the rotor magnetization, at certain parts of the magnetic interactions the strength of the stator's magnetic field is such as to cause the ferrite to move from saturation to the linear part of its MH curve.

Hence the substantive difference between the two arrangements is that in the first arrangement all the MH movements are linear and in the second arrangement non-linear MH movements can be expected.

For the purpose of this document the first arrangement is titled linear MH arrangement and the second arrangement is titled non-linear MH arrangement.

# 3.0 Experiments and Tests Conducted

A test is defined as a rotation of the rotor with the stator magnet in a fixed position during the rotation. The net energy cost of that rotation is the key test result.

The experimental results shown in this section are produced by the Magnetic Torque Measurement System, details of which may be found in the document "*Magnetic Torque Measurement System*" document number *STRN-TMTH-APR-0008-0002*.


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## Experiment 1: Symmetric Linear MH

The first experiment involves various tests of the first arrangement with the stator magnet at a different radial distance from the rotor for each test, as shown below.

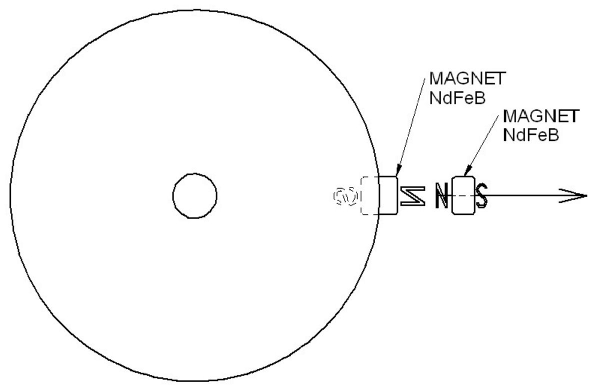


*Figure 7 – Symmetric Linear MH Experiment*

This experiment tests the effect of varying the air gap, and hence varying field strength on a linear MH arrangement in a symmetrical configuration.


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## Experiment 2: Asymmetric Linear MH

The second experiment involves various tests of the first arrangement with the stator at different tangential positions, as shown below.

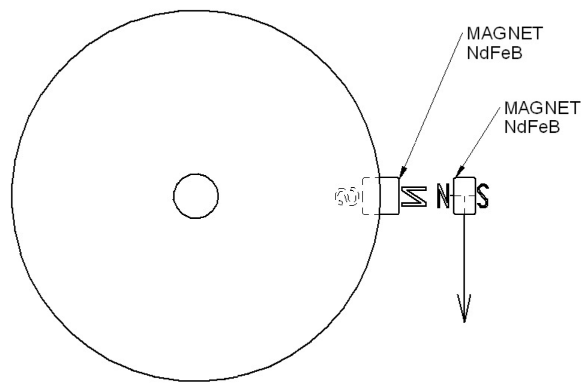


*Figure 8 – Asymmetric Linear MH Experiment*

This experiment tests the effect of varying the air gap and varying asymmetry on a linear MH arrangement.


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## Experiment 3: Symmetric Non-linear MH

The third experiment involves various tests of the second arrangement with the stator magnet at a different radial distance from the rotor for each test, as shown below.

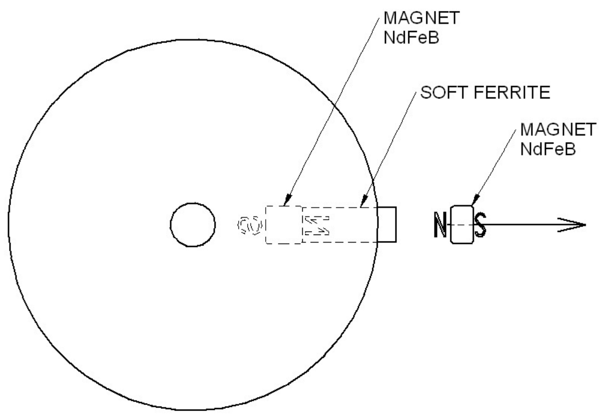



*Figure 9 – Symmetric Non-linear MH Experiment*

This experiment tests the effect of varying the air gap, and hence varying field strength on a non-linear MH arrangement in a symmetrical configuration.

## Experiment 4: Asymmetric Non-linear MH

The fourth experiment involves various tests of the second arrangement with the stator at different tangential positions, as shown below.

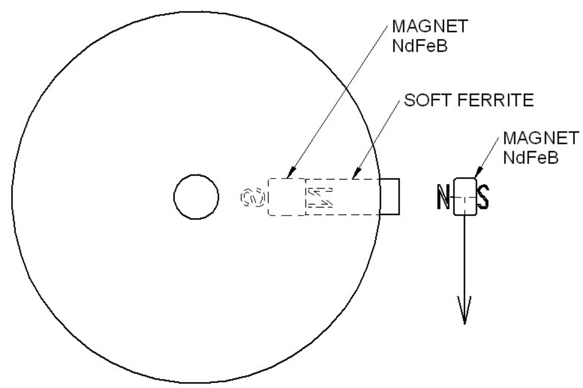


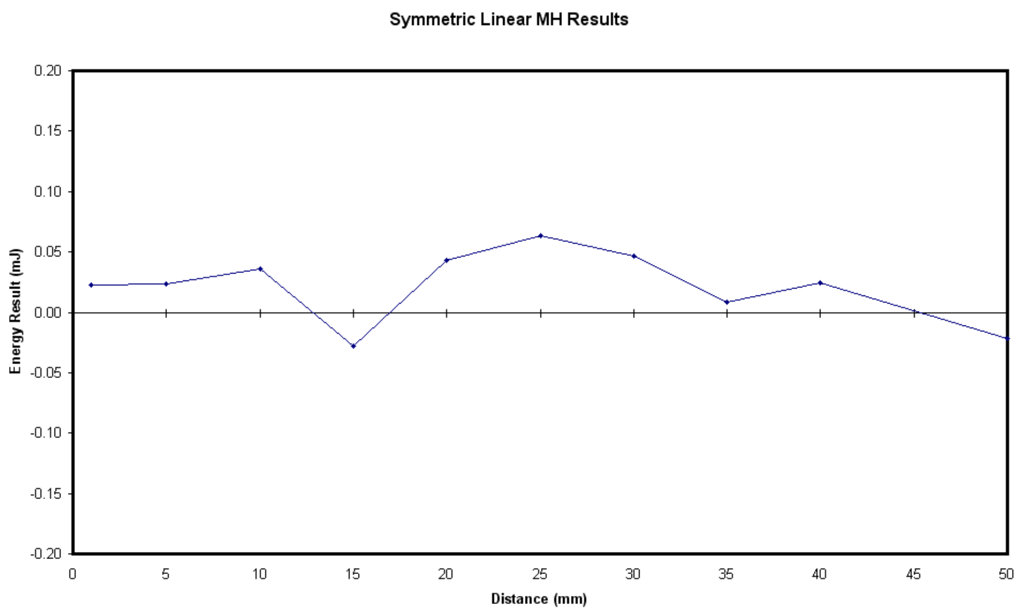

*Figure 10 – Asymmetric Non-linear MH Experiment*

This experiment tests the effect of varying the air gap and varying asymmetry on a non-linear MH arrangement.

# 4.0 Test Results

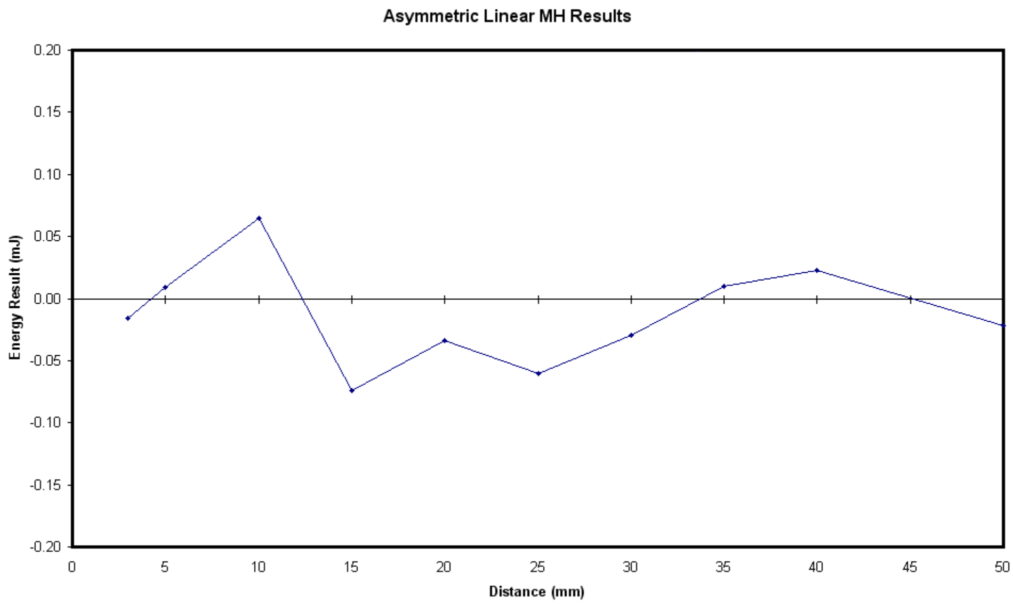
The calibrated uncertainty of the test system used to produce the results shown in this section is 0.09 mJ, further details on this uncertainty figure may be found in Section 5 of this document.

Experiment 1: Symmetric Linear MH




The tests performed demonstrate that a symmetrical magnetic arrangement with a linear material MH response shows a zero energy result regardless of the level of the air gap.

## Experiment 2: Asymmetric Linear MH




The tests performed demonstrate that an asymmetrical magnetic arrangement with a linear material MH response shows a zero energy result regardless of the level of asymmetry.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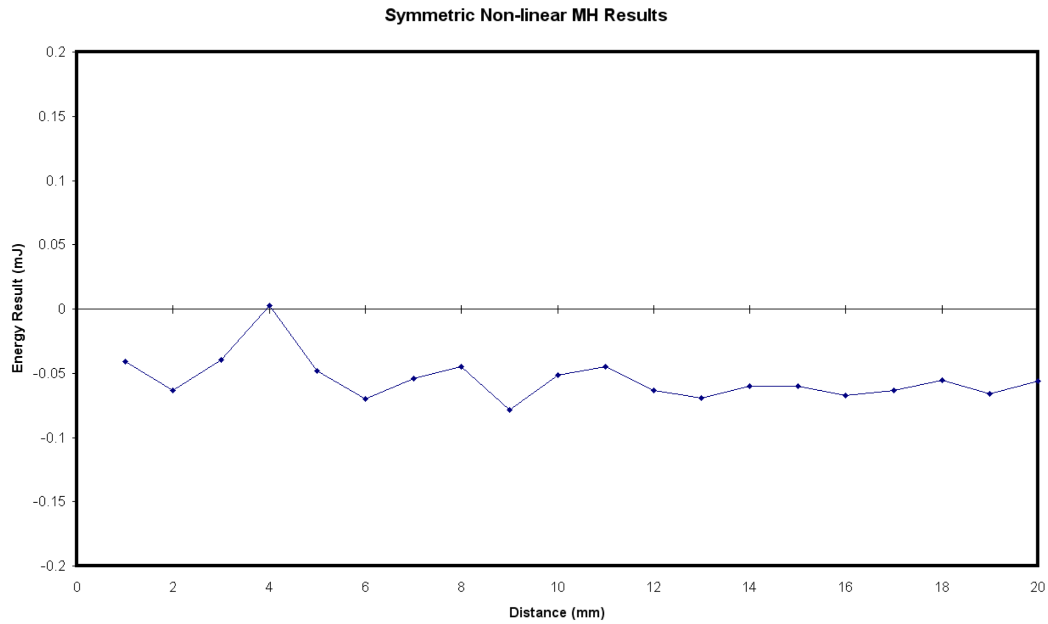
## Experiment 3: Symmetric Non-linear MH




The tests performed demonstrate that a symmetrical magnetic arrangement with non-linear material MH response shows a zero energy result regardless of the air gap.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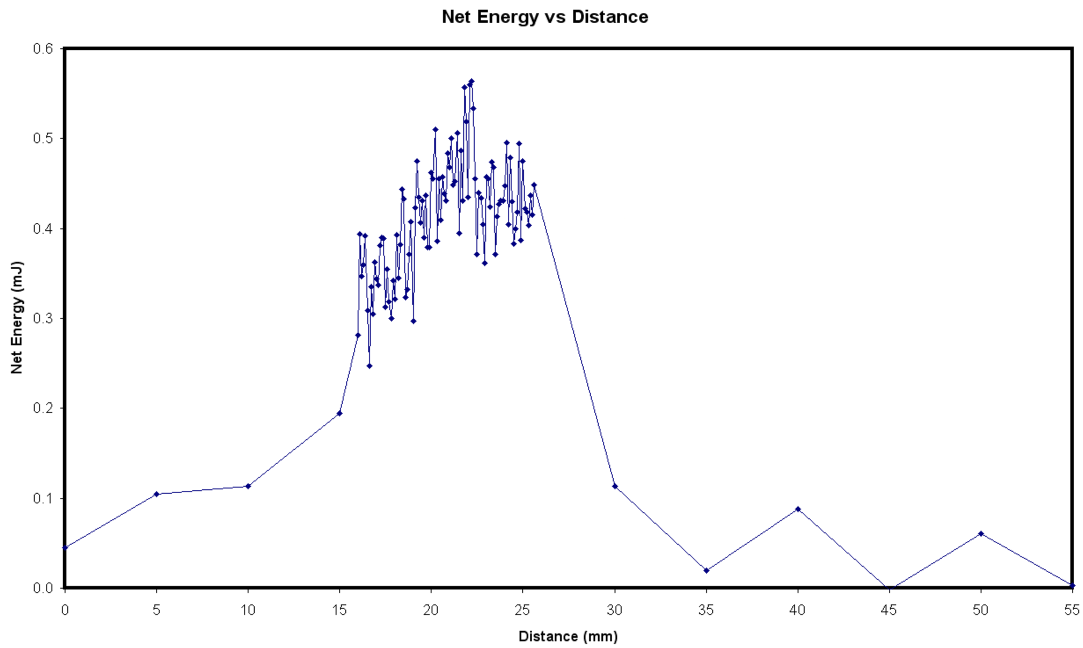
## Experiment 4: Asymmetric Non-linear MH




The tests performed demonstrate that an asymmetrical magnetic arrangement with a non-linear material MH response produces a net energy result that is a clear function of the level of asymmetry.

The test results documented in this section demonstrate that asymmetry with a linear MH relationship always produces a zero energy result. Symmetry with a non-linear MH relationship always produces a zero energy result.

However, the key principle demonstrated in these experiments is that asymmetry with a non-linear MH relationship can produce energy results that are non-zero. The results also show that there is a clear relationship between the level of asymmetry and the energy result.

Note that comparable results are obtained for the same experiments using a dynamic test system and simulations produced by Flux3D.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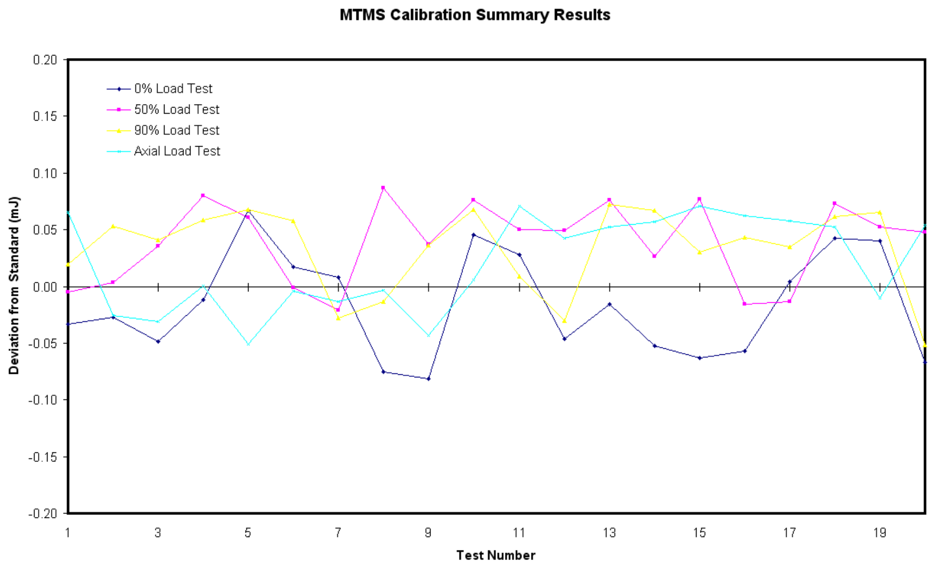
# 5.0 Measurement Uncertainty and Results

Eighty calibration tests were performed on the Magnetic Torque Measurement system as defined in the document "*Magnetic Torque Measurement System*" document number *STRN-TMTH-APR-0008-0002*.

These tests are summarized as 0% Load Calibration Tests, 50% Load Calibration Tests, 90% Load Calibration Tests and Axial Load Calibration Tests. The test data for these tests may be found in the Excel spreadsheets of the same name.




The maximum deviation from standard recorded by the system was 0.0866 mJ, with a two sigma of 0.091 mJ. The maximum energy result recorded during the experiments was 0.564 mJ. This result a factor of 6.2 times the maximum measurement uncertainty.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