INTEGRATED's
Field Analysis Program Improved Vacuum Feedthrough Device

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About the Author

David Lancisi has been designing electric motors, actuators, magnetic bearings, and other magnetic devices for over 30 years. He earned a graduate degree from the University of New Hampshire in 1987 working with the well-known department chair Charles Taft, an expert in the field of electromagnetic design, and has been designing motors and actuators for many different applications since then. He spent 7 years designing motors and actuators for disk drives, another 5 years in the cardiac assist industry designing implantable medical devices, and the last 19 years designing custom solutions for many different customers in the semiconductor, medical, military, communications, and aerospace industries. David Lancisi is currently working with an engineering consulting firm focusing on all types of magnetic devices and has been using Integrated Engineering Software's (INTEGRATED) AMPERES™ 3-dimensional magnetic field solver for more than 22 years.

Introduction

The goal of this study is to design a magnetic feedthrough that will be used to transmit torque to mechanisms in vacuum chambers. It is typically not desirable to place motors directly in the vacuum space, due to outgassing and cleanliness requirements of semiconductor processing. The outgassing of motor varnishes and adhesives creates contamination that can adversely affect the vacuum processes. These types of devices are also used to transmit torque from dry to wet environments as can be seen from the multitude of pump mechanisms currently available in the market.

A current design already existed for this application, however the coupling torque was insufficient to drive the mechanisms required to increase overall system throughput. The goal of this project was to make some simple modifications to increase the coupling torque by a factor of two, while not changing any of the mechanical envelope.

Magnetic Model

As mentioned above, the current design of a magnetic coupler previously existed. This was modeled in AMPERES™ and the geometry can be seen below in Figures 1. & 2. The original design had an array of magnets on the outer shell of the assembly. On the rotor, there was a series of teeth machined into the magnetic iron. The attraction force created between the two created the coupling torque through a metallic (stainless steel) barrier to maintain vacuum in the chamber.

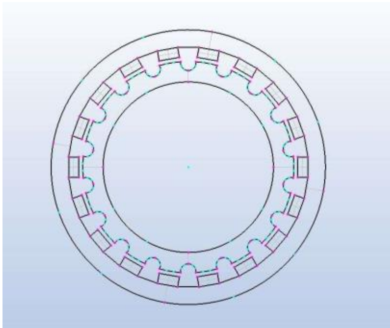

Figure 1

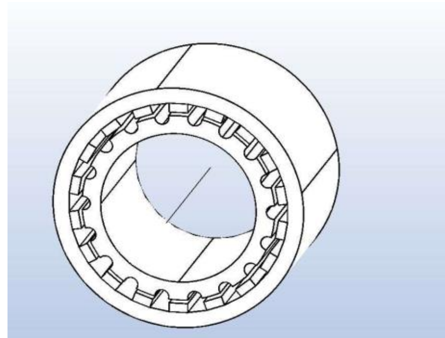

Figure 2

After 3D simulation using INTEGRATED's AMPERES™, the coupling torque of the device was quickly determined using parametric analysis functions. The rotor was rotated through one complete magnetic cycle and solved for the torque at each position. This can be seen in Fig 3. Fig 4 shows the associated flux plots.

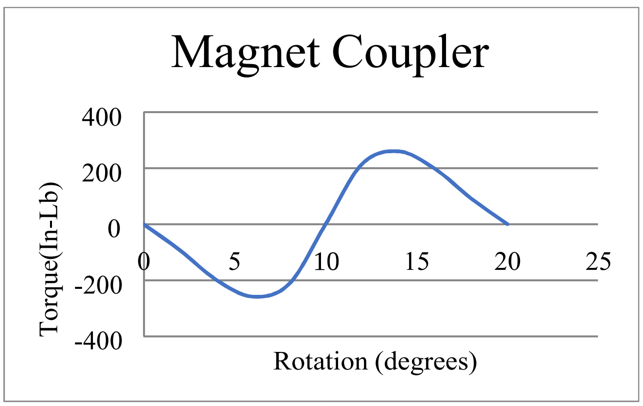

Figure 3

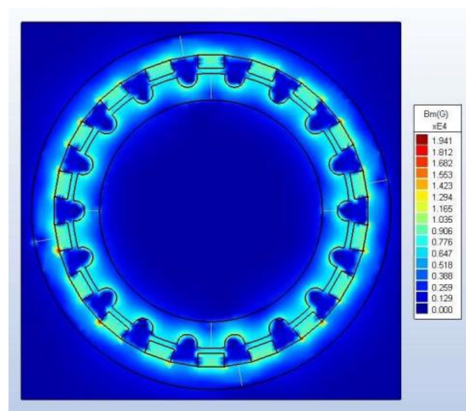

Figure 4

From here, it can be seen that the amount of peak torque that the coupler can tolerate is about 250 in-lbs before it slips. The desire is to increase the coupling torque without a change to the mechanical size.

The next option was to increase the magnet strength from 32 MGOe to 50 MGOe and evaluate the resultant torque. This was a very simple exercise in AMPERES by simply changing the magnet properties and rerunning the parametric simulation. It can be seen in Fig 5 below, the additional torque developed by the magnet change was not significant enough to

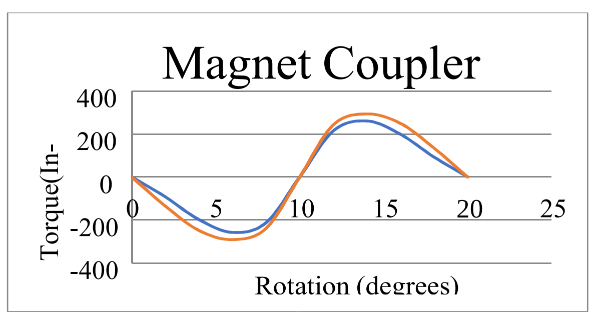

Figure 5

satisfy the end use requirements. The torque increased from about 260 in-lbs to ~300 in-lbs.

The next option to investigate was to remove the teeth on the rotor and replace them with magnets. This option also would preserve the overall shape while hopefully creating a much stronger field interaction between the rotor and stator.

This geometric model can be seen below in Fig 6 and 7.

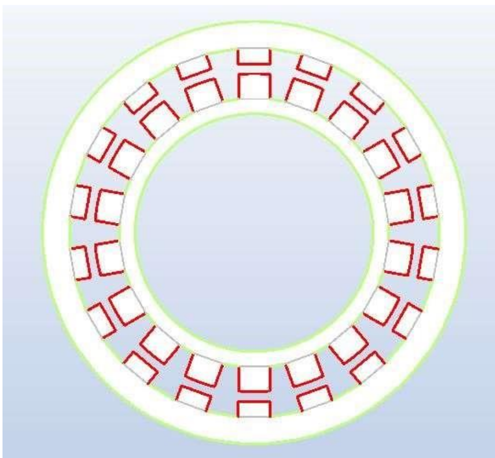

Figure 6

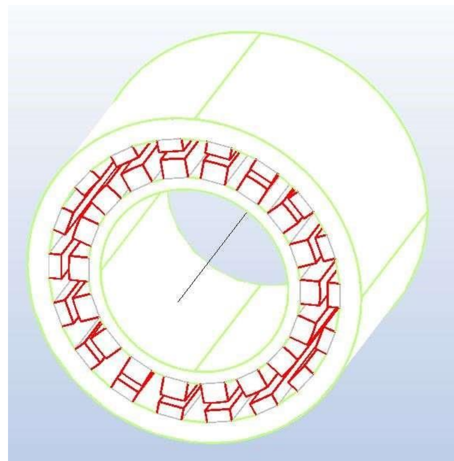

Figure 7

After 3D simulation again using INTEGRATED's AMPERES™, the coupling torque of the device was quickly determined using the parametric analysis functions. The rotor was rotated through one complete magnetic cycle and solved for the torque at each position. This can be seen in Fig 8. Figures 9 & 10 show the associated flux plots.

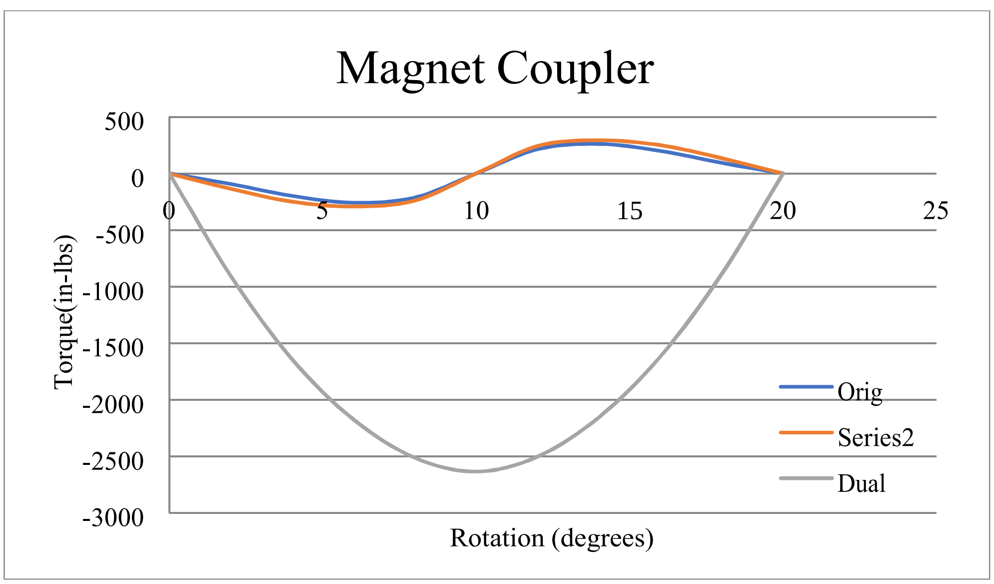

Figure 8

It can be seen that the option of replacing the metal teeth with magnets increased the torque capability of the coupler by a factor of 10. This not only meets and greatly exceeds the design intent, but will only prove beneficial in the long term as the performance requirements of the mechatronic system increase.

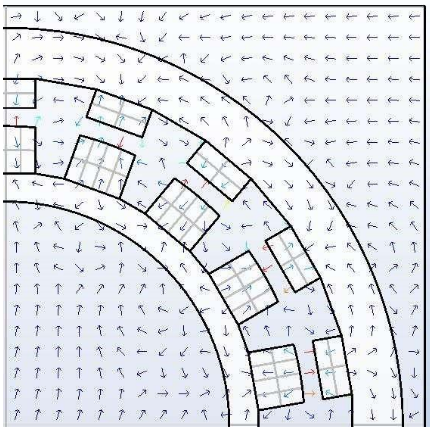

Figure 9

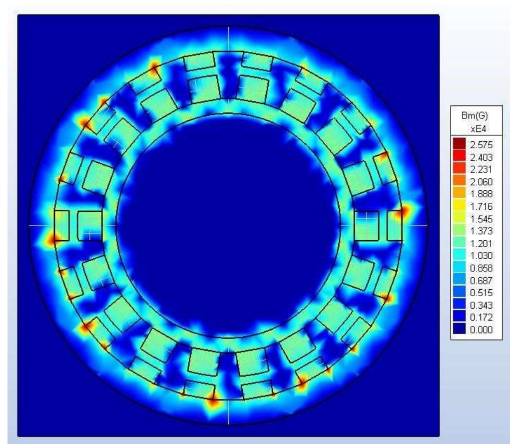

Figure 10

Conclusion

It has been shown that the torque-carrying capability of this device can be increased 10X by simply changing some of the internal components. Through the use of INTEGRATED's AMPERES™, this type of exercise can be done in a matter of hours via simulation, as opposed to fabricating these parts and using trial and error. For applications such as these, AMPERES™ has been used countless times as an extremely valuable simulation tool to create new, industry-leading devices.

Acknowledgement

The author is grateful for the continuous support of INTEGRATED with updated versions of AMPERES™ and extremely helpful tech support personnel. Working with AMPERES™ over the many years has been a great experience and continues to be an important tool for providing our customers with new, leading-edge designs. As it goes with many popular software programs, the updates always prove valuable, especially with geometry generation features. This software has definitely improved through the years, and we look forward to designing many more devices in the future using INTEGRATED's AMPERES™.

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