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MAGNETIC TECHNOLOGIES

Flux Density Enhancement

Using Shaped Field Magnets

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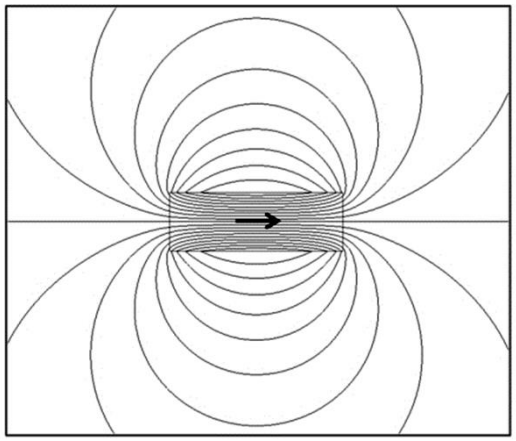
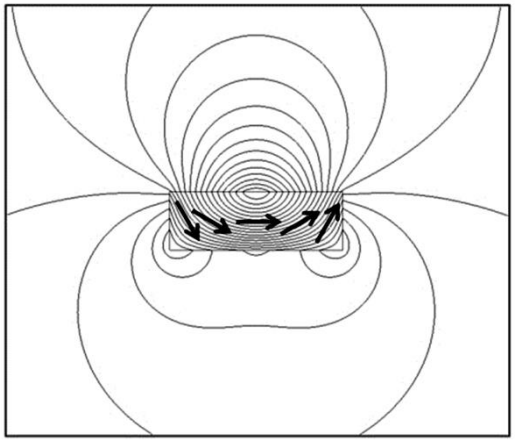
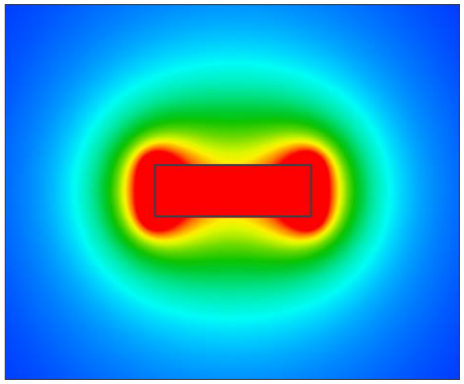
Shaped Field Magnets (SFM)

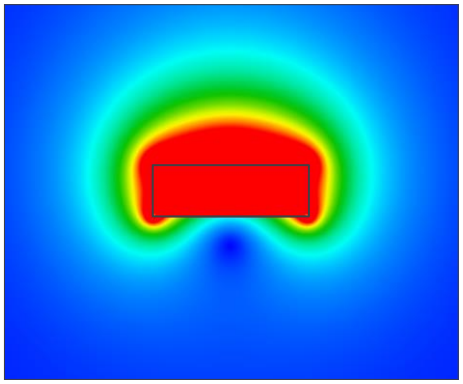


Traditional Magnets



Shaped Field Magnets





Patent applied for process imparts a domain orientation pattern into the structure of the magnet.

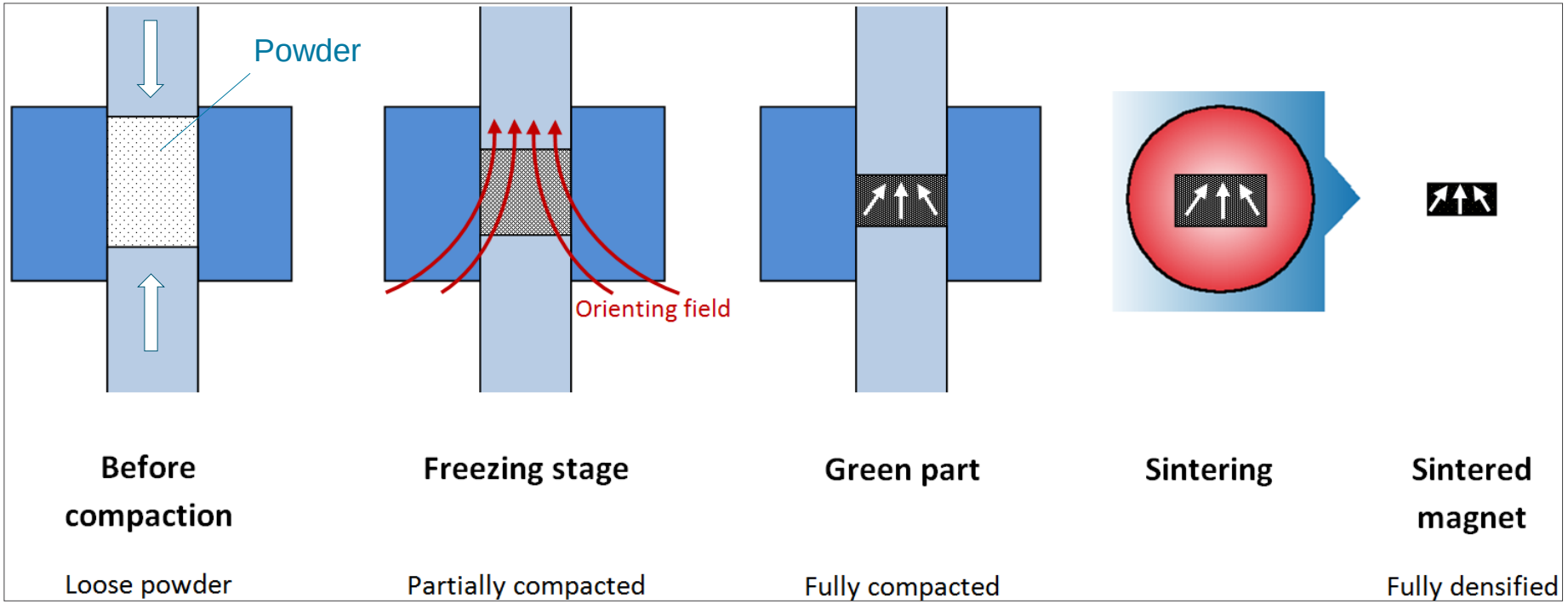
Shaping the field redirects the magnet's force to where it is needed.

Advantages:

- Higher applied fields than previously possible
- Field shape is optimized for the application
- Higher-Temp lower remanence materials become competitive
- Increased design freedom around magnets
- Reduced overall system weight

Imparting the Shaped Field - example

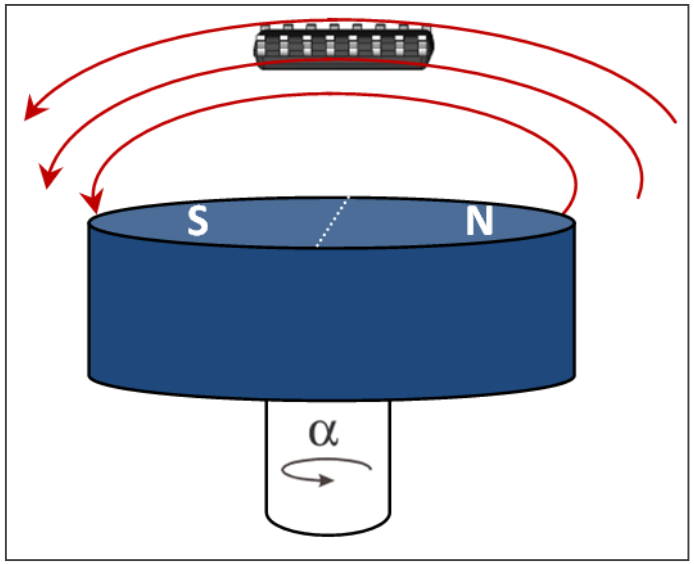
Challenges

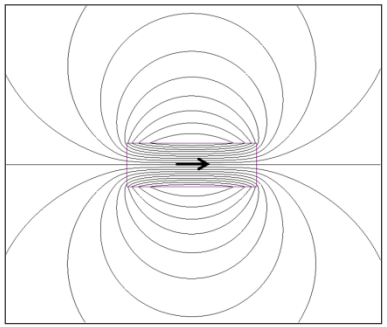


- Substantially more complex tooling.
- Orienting fields change during compaction.

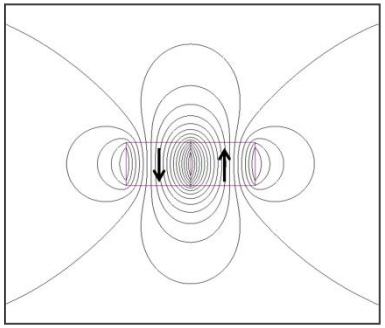
Sensor Magnets

Possible configurations

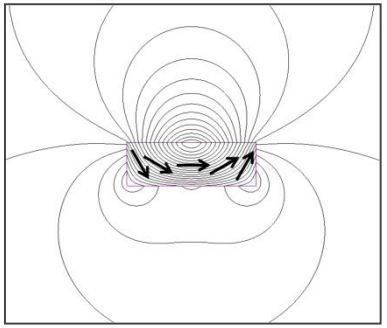




uniform diametric

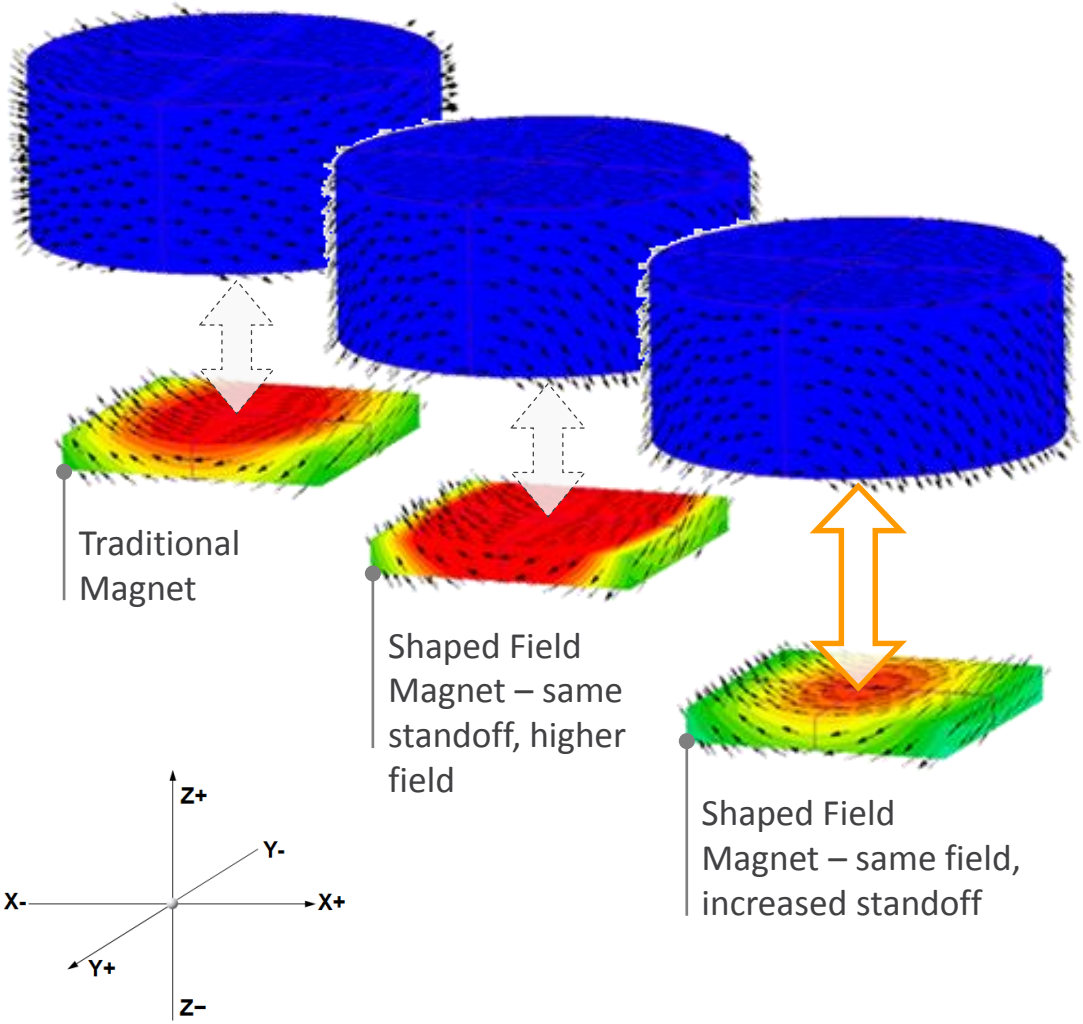


axial 2-pole



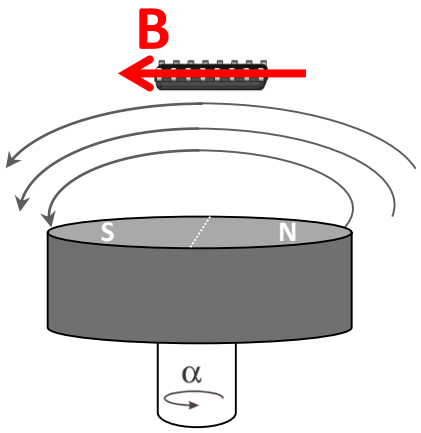
Shaped Field

Sensor Magnet - In-plane



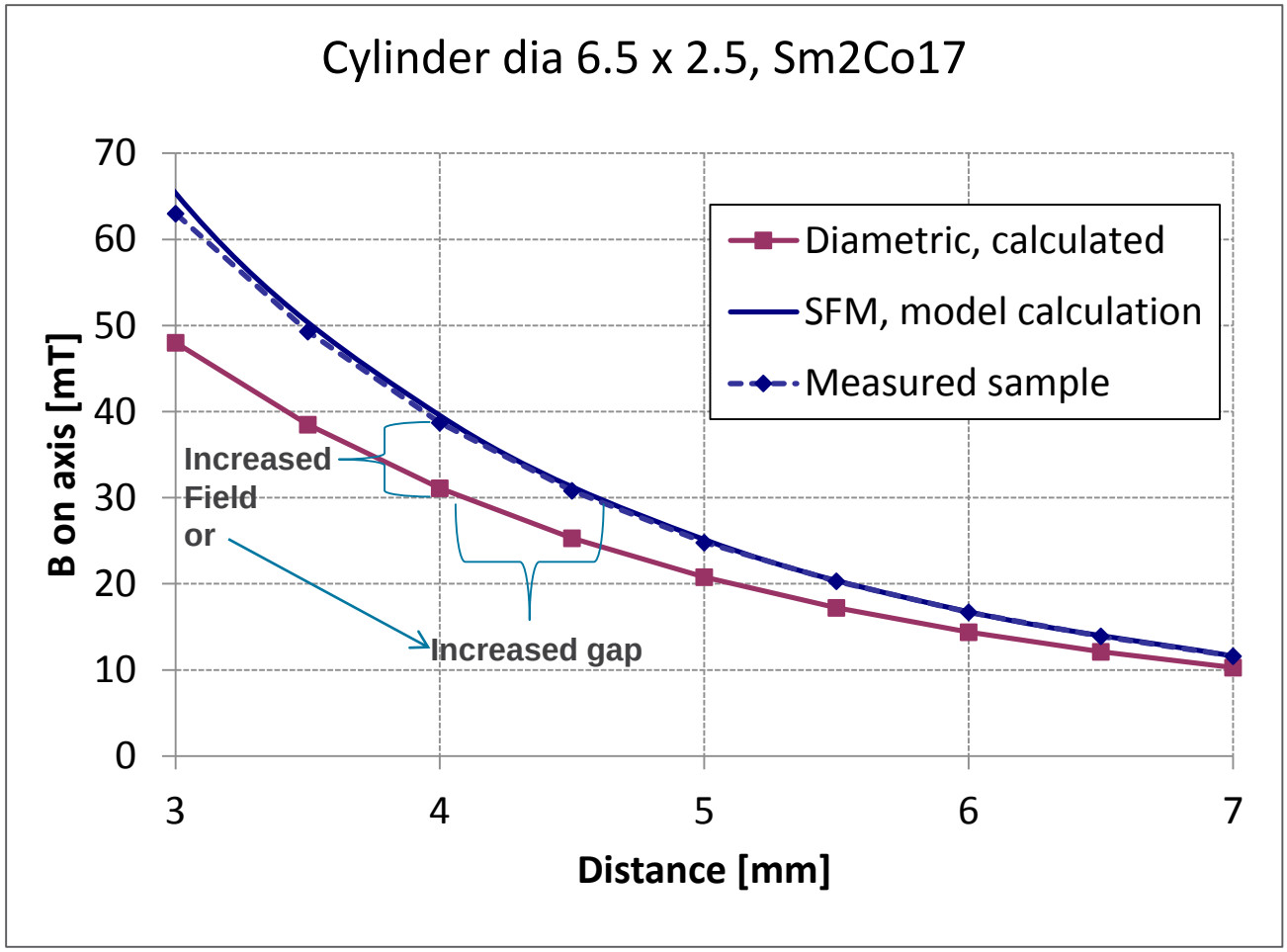
- SFMs improve the **in-plane case (Bx)**
  - For in-plane sensors, field strength is increased 20%
- Increased strength
  - More reliable signals
  - Greater standoff distance
  - More freedom of design

Sensor Magnets - In-plane



"In-plane"

Experimental result



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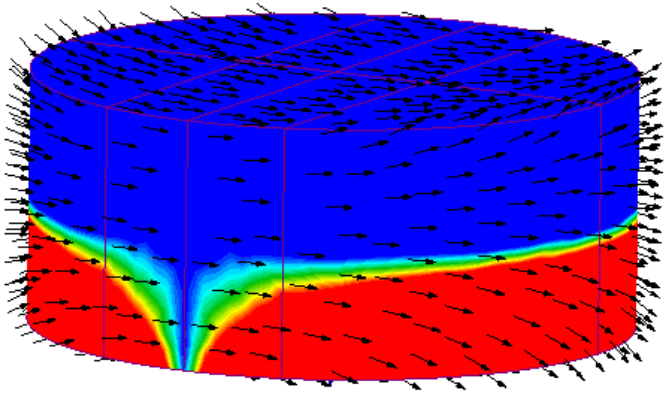
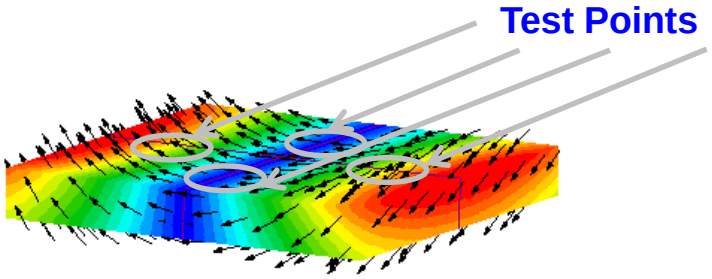
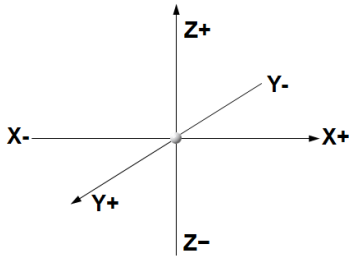
The through-plane case

Less costly approach

- Array of through-plane sensors, offset from the center of the sensor chip assembly
- SFM improves the **through-plane case**:
  - For through-plane sensors, field strength can be 50% greater







Note: Coloration reflects field in normal (Bz, vertical) direction

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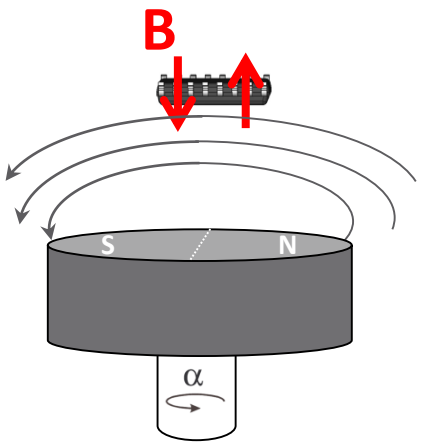
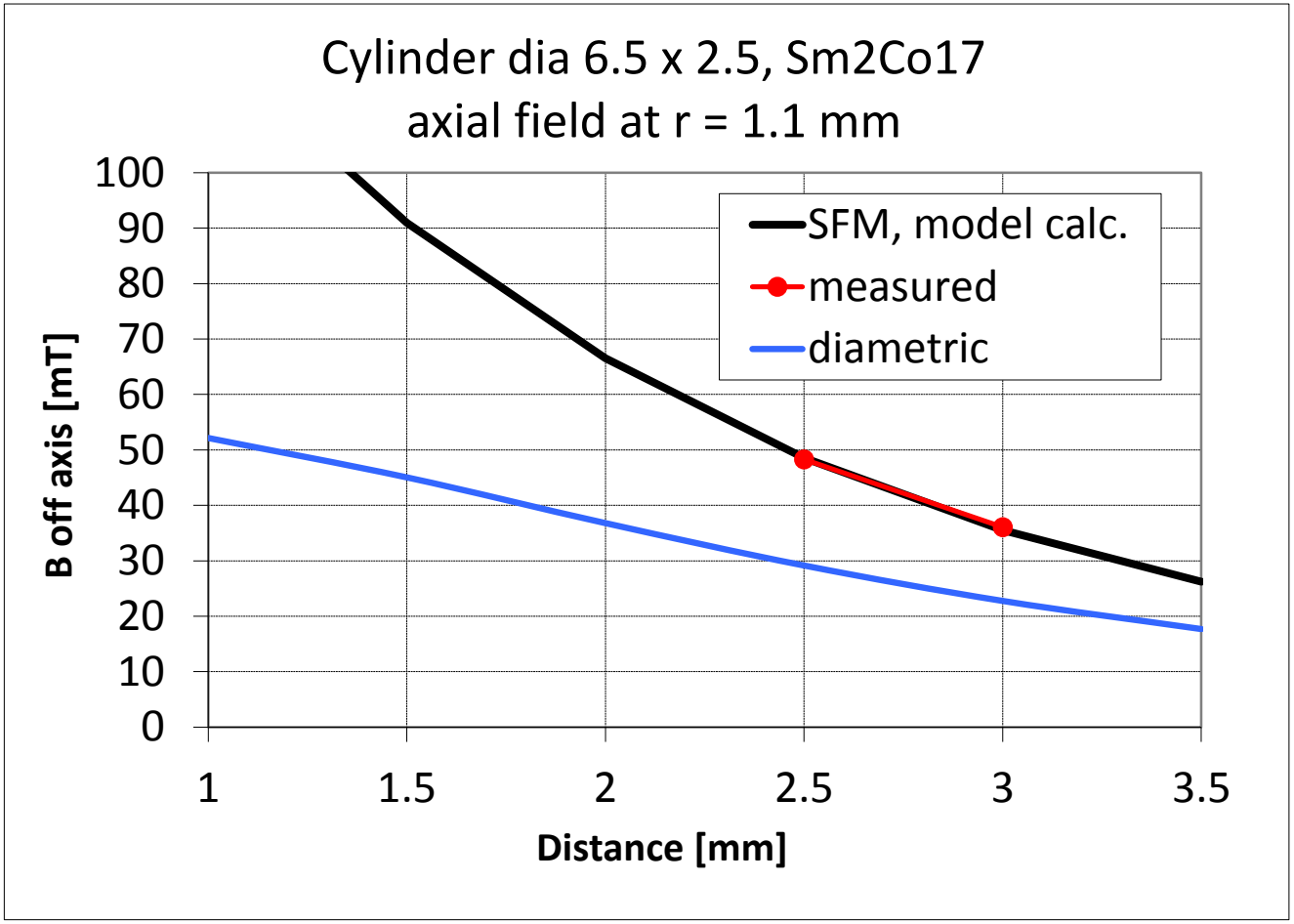
Sensor Magnets – through plane



"Through-plane"

Experimental result



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Sensor Improvements Using SFMs

…it's for real

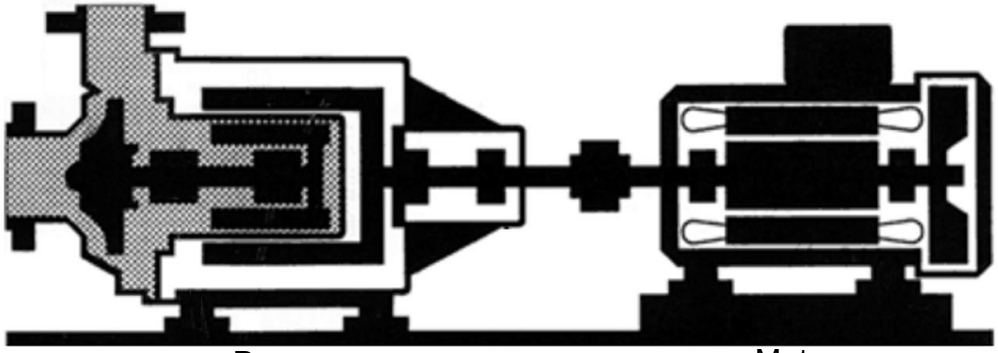
Better-than-expected improvements measured in field trials, with angle errors less than 1°

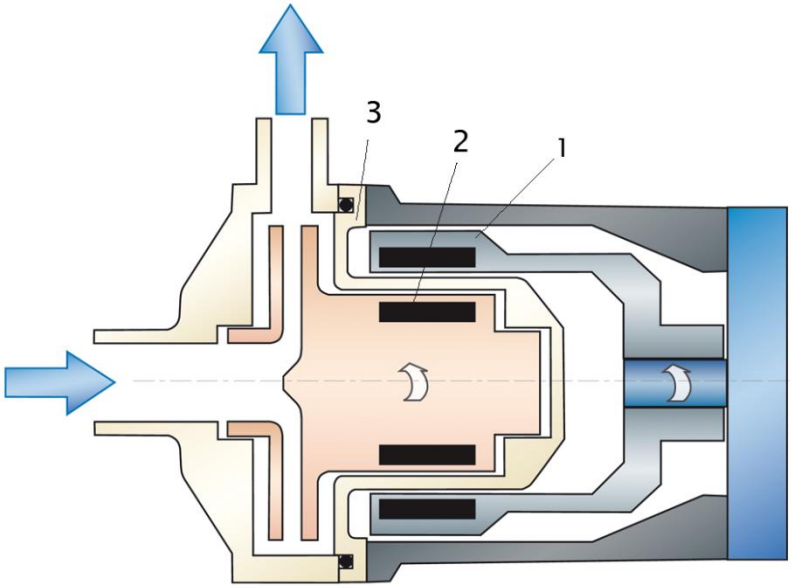
Arnold is in an approval process for a new automotive application

Planned production in the coming year for >1.2 million pieces

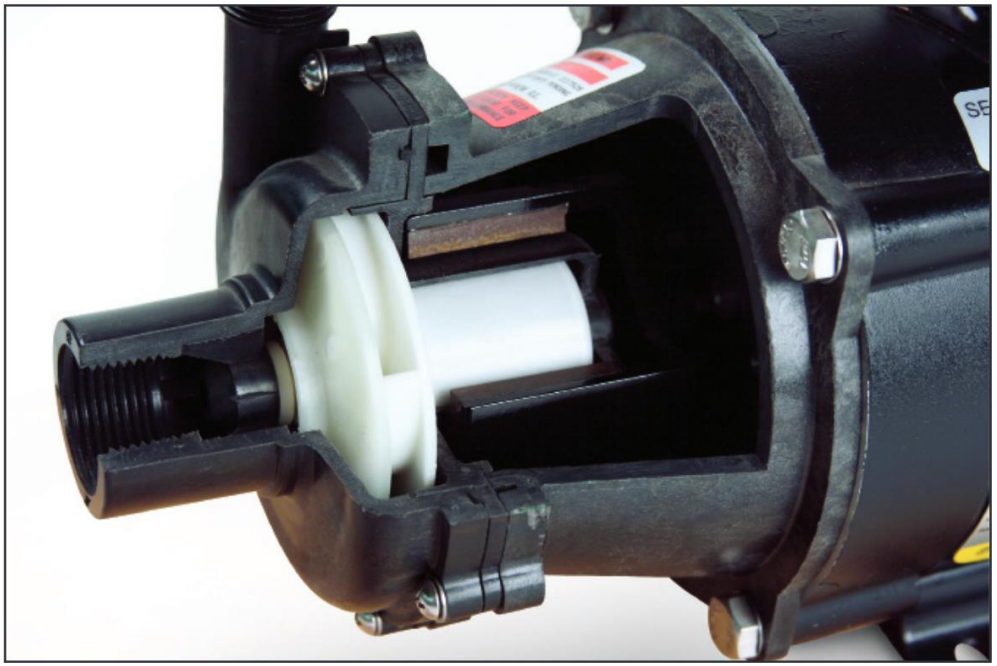
A Classic Case – Torque Transfer Coupling

Especially useful for pumping hazardous (hot, toxic, bio-hazard) liquids or gases





http://www.tapflo.com/site/en/pages/magnetic-drive-pumps



http://www.marchpump.com/site/files/966/110094/376709/645776/March_Pump_Catalog_2013.pdf

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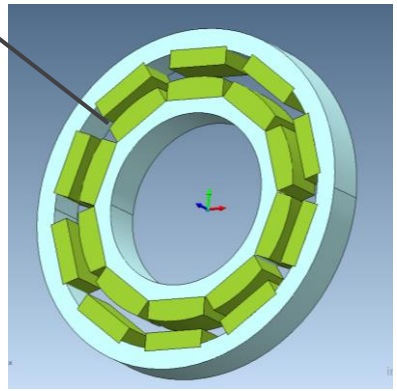
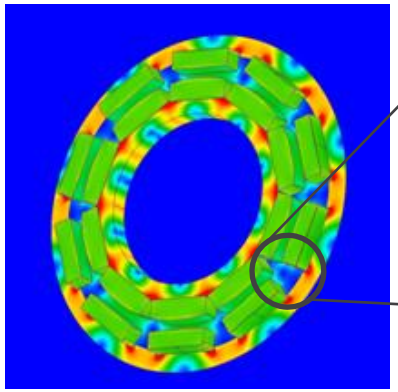
A Classic Case – Torque Transfer Coupling

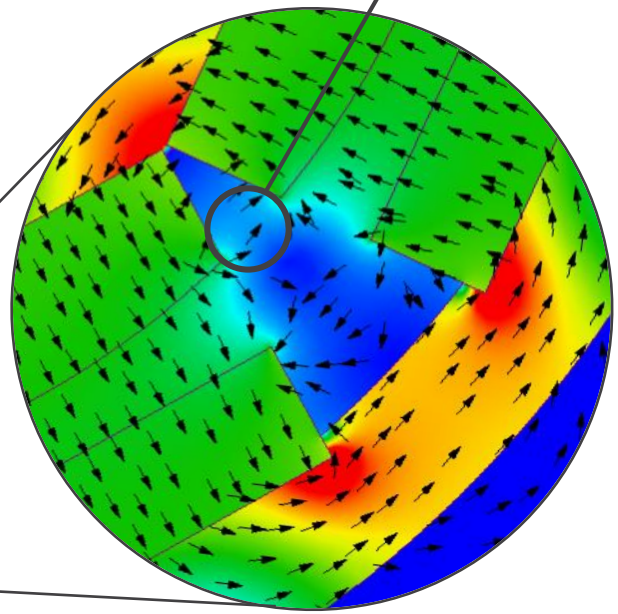
- **Traditional coupling:** a pair of alternating-pole rings transfer torque without contact
- Steel backing provides mechanical support and a magnetic yoke for the magnets
- The system has certain **inherent inefficiencies:**
  - **Back iron bulk** for magnetic stability
  - **Field fringing** between neighbors on the same ring

Back iron bulk





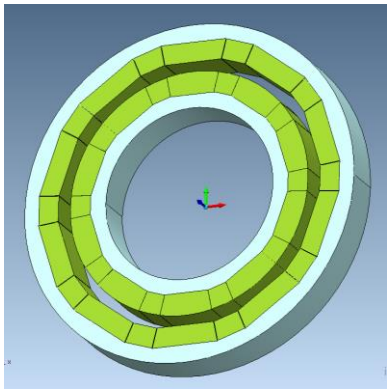
Field fringing

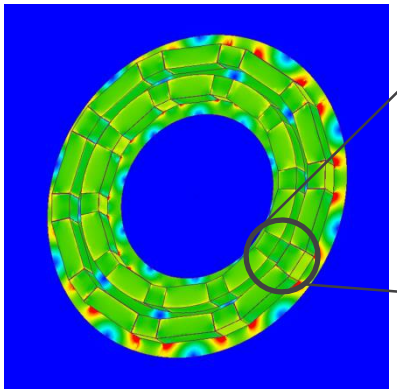


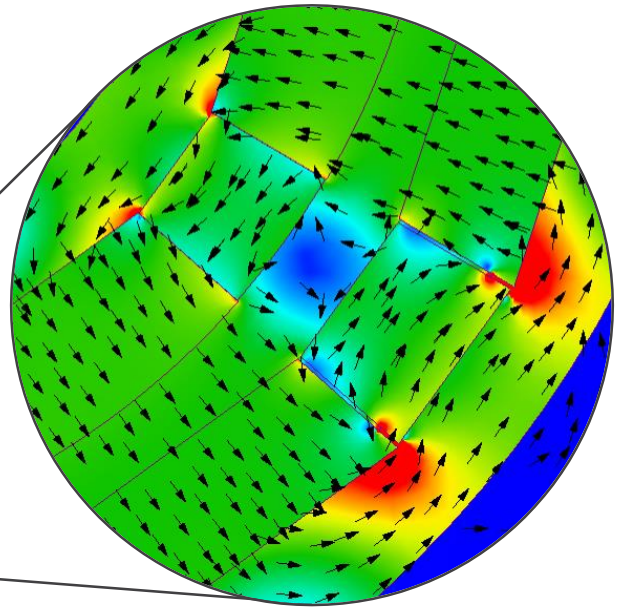
A Possible Solution – Halbach Configuration

- By using magnets with rotating orientation, many aspects are improved by concentrating the field in the working zone
- But – this introduces several new disadvantages:
  - Cost
  - Complexity
  - More magnets
  - Increased weight

  ...a complex solution for most torque transfer applications

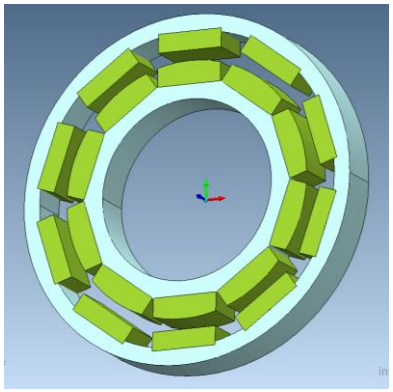


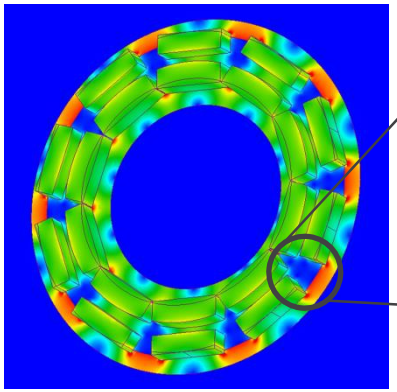


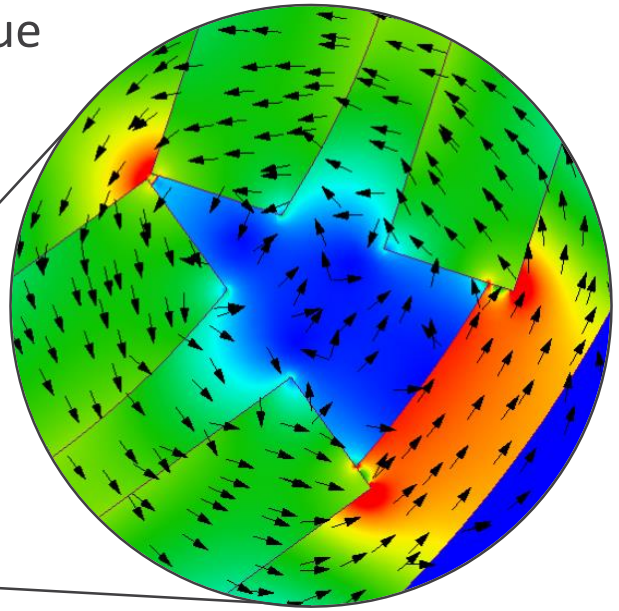


A Better Solution – Shaped Field Magnets

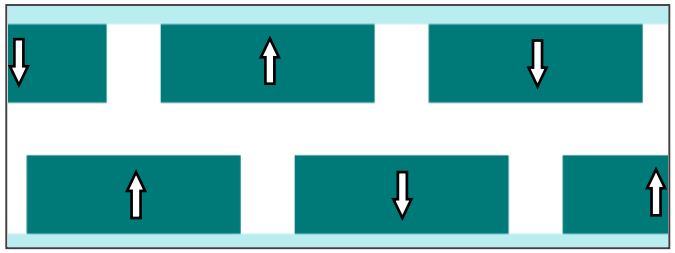
- With SFMs, the Halbach pattern is imparted into the magnet material itself
- **Direct substitution** of SFMs: coupling with 20% more torque than original design
- **Design from the ground up** with SFMs:
  - **Gain torque** in a fixed volume
  - **Reduce coupling size** and keep constant torque
  - **Reduce cost** by using a smaller system
  - **Reduce overall mass**, extending bearing life



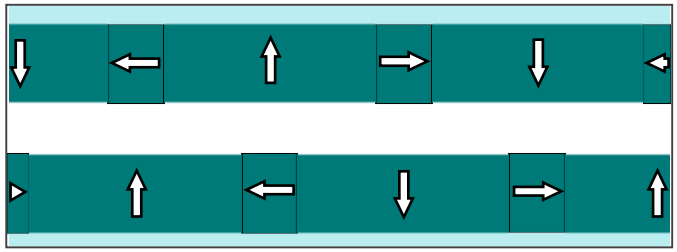




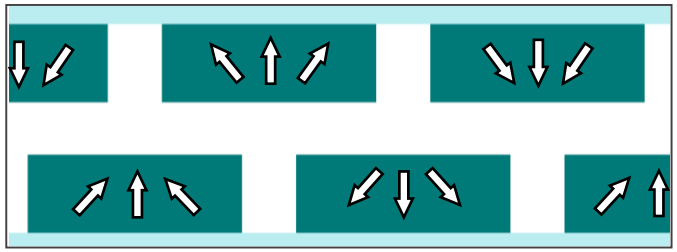
Coupling Forces (Torque)



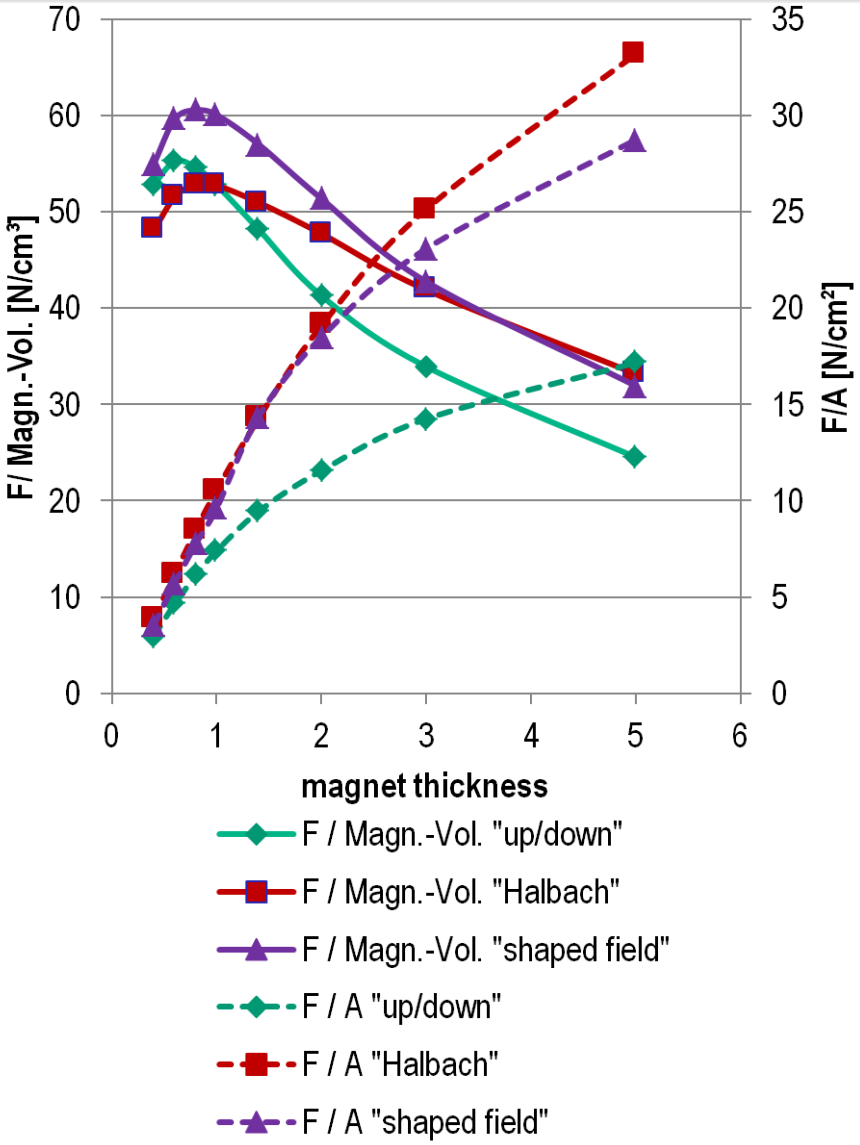
conventional “up / down”



“Halbach” array



shaped field magnets



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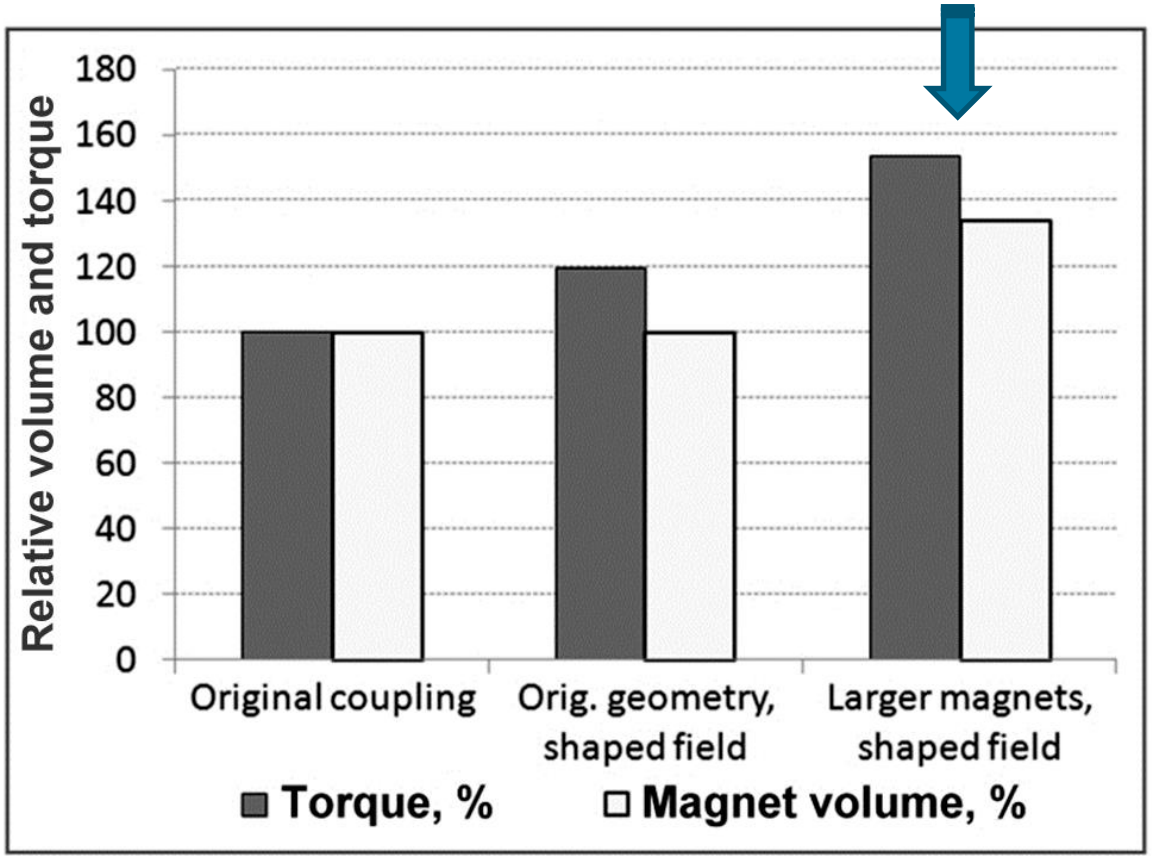
Torque-coupled Pump - Example

Enhancements in torque in a commercial coupling for chemical pumps.

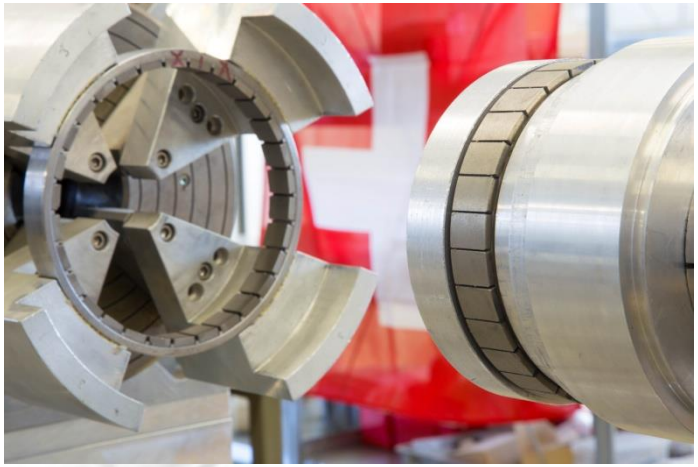
Design optimized for shaped field magnets; same overall package size but with reduced steel allowing use of larger magnets.



Results for Torque Transfer

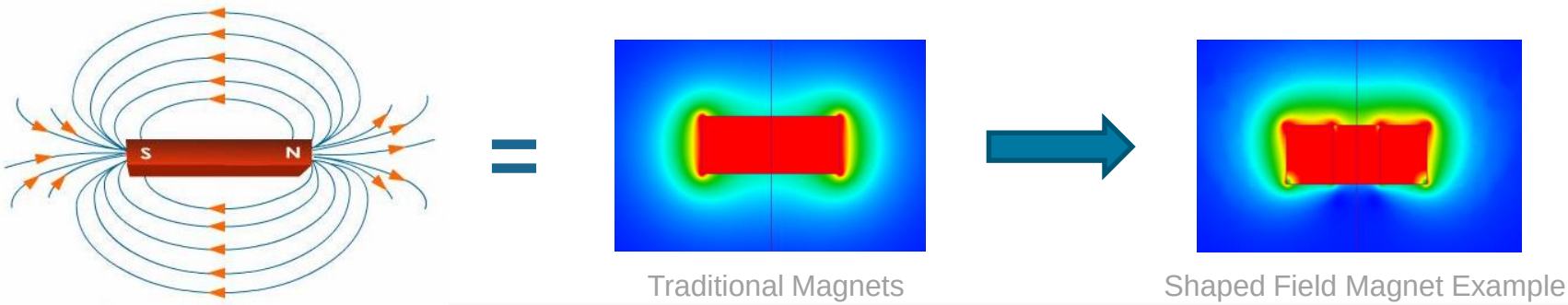
- Proof-of-concept SFM prototypes yielded an average of 19% increased torque.
- Arnold is currently working with a customer to deploy SFMs across their entire suite of products.

. . . increased efficiency for next-generation performance



Arnold *Shaped Field Magnets - Summary*

- Field permanently shifted to focused flux for optimum performance
- It is a structural change, not just a difference in magnetizing
- Can be applied to Neo, SmCo, Ferrite magnets
- Design possibilities include
  - Through-plane sensor application sees up to 50% improvement in flux density which allows greater stand-off distance and stronger, more reliable signals
  - Torque coupled drives: 20% or more improvement in coupling with overall lighter design using less back iron and down-sized pole pieces



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The science of doing more with less.

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