Spool Compressor Technology Introduction

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The Next Generation in Refrigerant Compressor

Introduction

The sluggish economy is just the tip of the iceberg of business challenges impeding the growth of the margin sensitive, highly competitive refrigerant compressor market, which encompasses both the air-condition and refrigeration markets. The prolonged increase in the cost of raw materials – including cast iron, steel and copper – is further shrinking already tight margins. New construction rates – down 38 percent during the 2007-2009 period with limited growth in 2010-2011 – have left compressor original equipment manufacturers, or OEMs, with excess supply and limited demand, essentially commoditizing the compressor market.

These challenges, combined with increased production costs and complex manufacturing processes, are killing margins and forcing compressor OEMs to sacrifice innovation for cost reduction. By focusing solely on finding ways to further reducing unit costs, often by mere fractions of cents, OEMs miss the opportunity to innovate and develop new technologies that have the potential to completely transform the industry. The silver lining? Others are stepping into the innovation gap.

The Next Stage of Compressor Technology Evolution

The quest for cost reductions is not new to refrigerant compressor OEMs. Cost pressures have optimized manufacturing process, led to the relocation of plants to more cost-effective locations, streamlined the supply chain and led to the creation and development of better compressor technologies.

Nevertheless, the current fraction-of-a-penny cost reduction tactics are simply not delivering the required margin improvements. Refrigerant compressor OEMs need a new technology breakthrough capable of significantly reducing manufacturing costs and improving margins.

This new technology is here: spool compressor technology represents the next stage in compressor innovation. With its unique architecture and elegant design, the

Spool Compressor Technology: The Next Generation in Refrigerant Compressor

TORAD Spool Compressor will power the transformation required to significantly improve margins for the refrigerant market.

> ***"TORAD's innovative Spool Compressor could deliver the much needed margin improvements refrigerant compressor OEMs have been searching for."***
>
> *~Roy R. Crawford, Ph.D.*
> *Director, Research & Technology Development, Texas Allergy, Indoor Environment & Energy Institute*

Transforming the Industry

Spool compressor technology is a significant breakthrough in compressor simplicity, capacity density and manufacturing cost.

The Spool Compressor has a simple design, compact form, and low part count. In fact, with only four components, the Spool Compressor can be easily manufactured on cost-effective machine tools, reducing compressor manufacturing costs by 25-35 percent. The complete compressor unit yields a 15-20 percent in cost reduction – a significant breakthrough for refrigerant compressor OEMs.

The Spool Compressor's unique design enables it to scale and to be easily configured across a broad capacity range, from 1hp to 400hp . The Spool Compressor effectively bridges the gap between the practical high end of scroll compressor technology and the economical low end of screw compressor technology for both air-conditioning (Figure 1) and refrigeration applications (Figure 2).

Figure 1. Compressor Ranges for Air Conditioning Applications

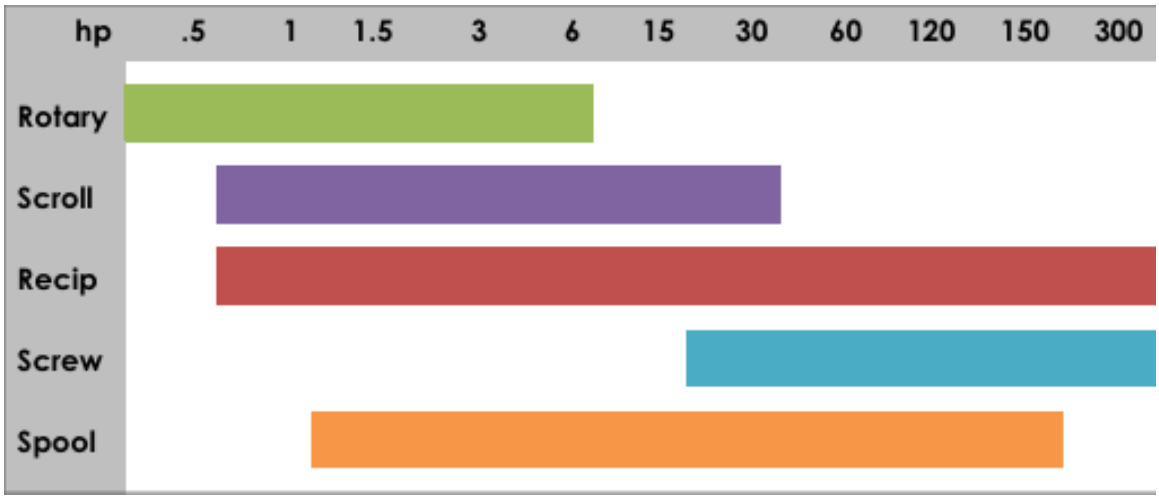
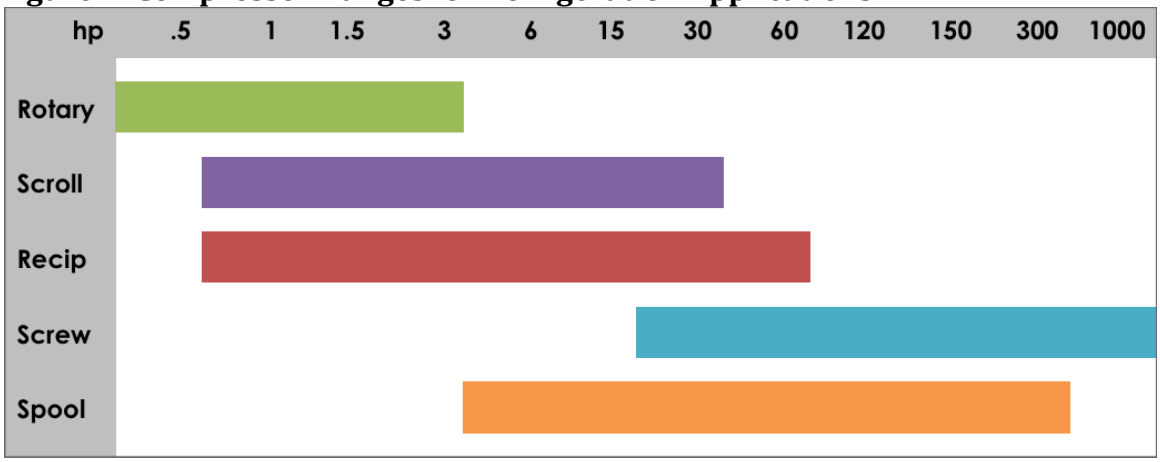


Figure 2. Compressor Ranges for Refrigeration Applications



The Spool Compressor's high displacement density allows it to be delivered in a form factor that can be as much as 40 percent smaller than legacy compressors of similar capacity. The comparisons illustrated in the tables below [Figure 3] highlight the significant size advantages of the TORAD Spool Compressor.

Figure 3. Size advantages of the TORAD Spool compressor

Compressor Size Comparison: 40 Ton Spool vs. 40 Ton Scroll

Characteristics	40 Ton Spool Compressor	40 Ton Scroll Compressor	Difference
Height	24"	30"	-20%
Diameter	10"	13"	-25%
Volume	1,884 in^3	3,892 in^3	-52%
Weight	280 lbs.	360 lbs	-25%

Compressor Size Comparison: 40 Ton Spool vs. 40 Ton Screw

Characteristics	40 Ton Spool Compressor	40 Ton Screw Compressor	Difference
Height	30"	43"	-30%
Diameter	10"	15"	-40%
Volume	2,356 in^3	7,600 in^3	-70%
Weight	360 lbs.	715 lbs	-50%

As a result, the TORAD Spool Compressor is poised to transform the industry by dramatically reducing costs while driving unprecedented efficiency and reliability.

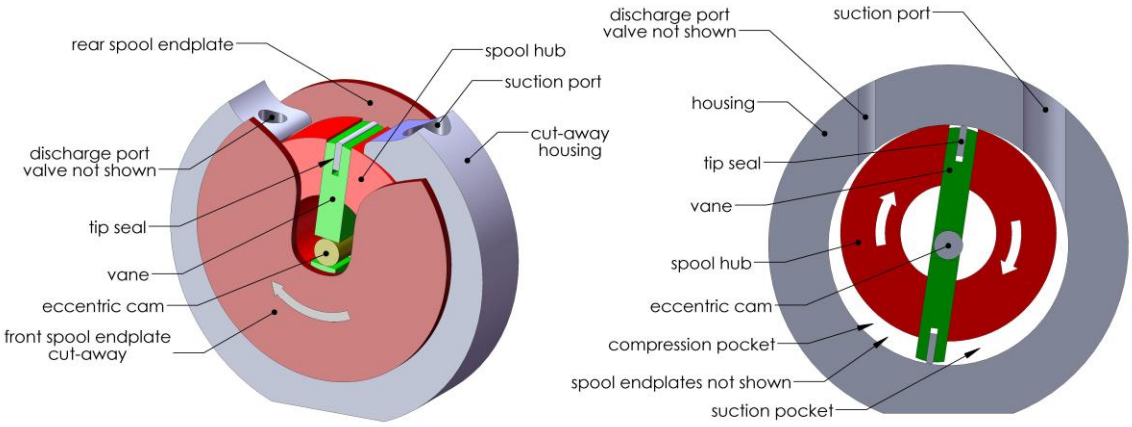
What is a Spool Compressor?

The TORAD Spool Compressor architecture is based on TORAD's patented spool machine technology. The spool machine, along with these four mechanisms, signifies a breakthrough in compressor simplicity, capacity density and manufacturing cost.

Eccentric Cam

The eccentric cam is at the heart of TORAD's patented spool compressor. The eccentric cam controls the rotating vane's position and maintains a near-zero constant distance between the distal end of the rotating vane and the stator bore, allowing the compressor to scale across large capacity and speed ranges. The eccentric cam reduces friction and wear by preventing sliding contact between the vane and the housing bore. What would be sliding contact between the tip of the vane and housing bore is replaced by rolling contact between the gate and eccentric

cam, resulting in very low friction and wear. Sliding friction is essentially removed from the fluid chamber, thereby reducing fluid heating to further improve the compressor's efficiency.

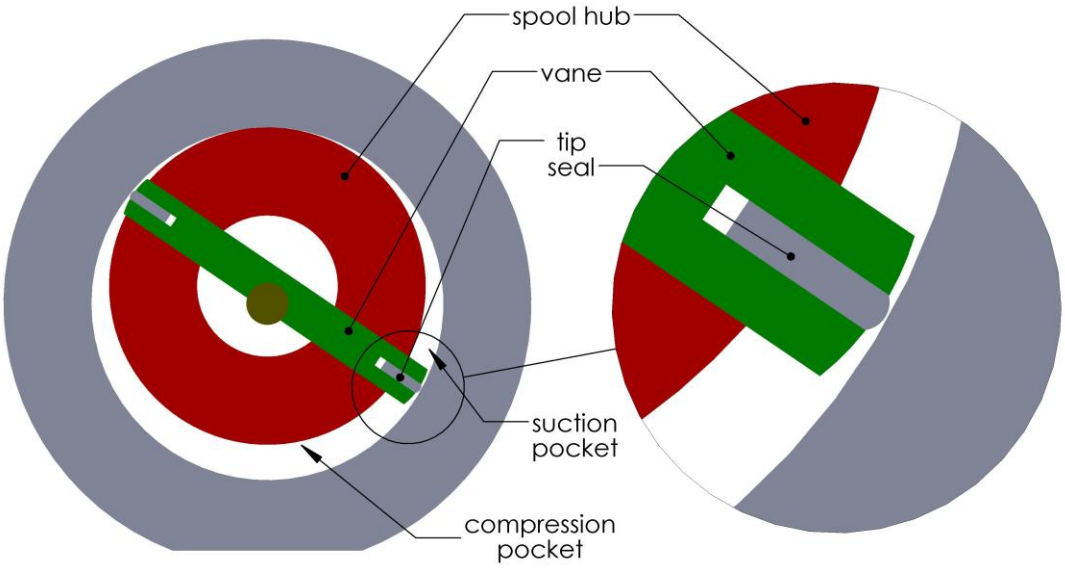


Rotating Vane

The eccentric cam's surface geometry interfaces with the rotating vane to restrain and control the vane's position throughout the spool's rotation, preventing the vane from contacting the housing bore. As a result, the size and weight of the rotating vane has extremely low impact on kinematic and friction losses. The rotating vane can be constructed with a robust cross section that allows the spool compressor to handle high compression ratios and absolute pressure differentials while easily scaling to larger capacity applications.

Tip Seals

Pressure activated tip seals are pressure activated and placed inside slots at each end of the vane, isolating the suction and compression chambers. The seals, constructed of a lightweight, low friction plastic alloy, cover a very small gap and experience very low force. As a result, the tip seals generate ultra-low friction with limited wear and outstanding reliability.



Spool Assembly

Spool endplates are attached to the spool hub to form the rotating spool assembly. These endplates enable various means for sealing the fluid chambers between the endplates and the compressor housing. Sealing can be achieved through pressure-activated seals, labyrinth seals or close-tolerance geometry. Multiple sealing options make the spool compressor adaptable across a broad range of operating conditions, capacities and a wide range of refrigerants. Because the endplates rotate with the vane with minimal radial relative movement, sliding friction between the vane and the endplate is virtually eliminated. This reduction in friction and wear contributes to significant improvements in reliability and efficiency.

Advanced Compression Techniques

Due to the spool machine's simple geometry – which allows for easy access to the compression process – implementation of advanced compression techniques, such as vapor injection, oil injection, and economizing, can easily be achieved at minimal cost.

Variable Speed Operation

Most compressors achieve peak efficiency at a set speed and become increasingly inefficient at variable speeds. The spool compressor's volumetric and overall efficiency remains constant across a broad speed range. Since air-conditioning and refrigeration systems operate in variable load environments, the spool compressor's variable speed operation is an excellent solution for variable capacity applications.

Less Is More

Due to its unique architecture – consisting of only four major components easily manufactured on cost-effective machines – the Spool Compressor represents a breakthrough in innovation and design. Compared to most legacy compressor technologies, the spool compressor is smaller in size, lower in weight, and easier to manufacture, yielding a significantly lower overall cost. The TORAD Spool Compressor is poised to transform the refrigerant compressor market by delivering significant cost savings and much-needed profit margin improvements for OEMs.

Next Steps

The TORAD Spool Compressor is recognized as the rising challenger in the refrigerant compressor market, creating an opportunity for leaders and visionaries to break the status quo and make the leap to the next generation of compressor technology.

Join other refrigerant OEMs who are embracing innovation and exploring how they can use TORAD's Spool Compressor technology to dramatically reduce processing costs and improve profit margins.

Contact us today by calling 678.366.3399 or email info@toradengineering.com. See the Spool Compressor in action by visiting the www.toradengineering.com.