

MiTi[®] Developments

Mohawk Innovative
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OIL-FREE, MOTORIZED COMPRESSOR SYSTEMS

As a result of recently completed product development projects¹, a series of oil-free, motor driven compressors has been designed, built and are undergoing extensive testing. The developed compressors range in size from 5 to 175 HP and combine MiTi[®] foil bearings with permanent magnet or induction motor technologies and advanced Variable Frequency Drives (VFDs). In developing these totally oil-free, variable speed centrifugal compressor and blower products, MiTi[®] combined its world-leading expertise in compliant foil gas bearings and high speed rotating machinery developments with state of the art motors and VFDs as well as years of complimentary turbocharger and oil-free compressor development activities.



Figure 1. MiTi[®] 100 HP, 60,000 rpm oil-free single stage compressor

The MiTi[®] 100 HP unit shown in Figure 1 is a very compact, variable speed, brushless DC synchronous motor driven blower. Maximum external dimensions are approximately 18.5 inches in length and height. Each of the water cooled units can be customized to meet specific customer needs.

MiTi[®]'s Fuel Cell Compressor/Expander shown in Figure 2 is powered by either the 16 HP brushless DC motor with a VFD and/or a radial inflow turbine all on a simple single shaft. Operating speeds from 15,000 to 120,000 rpm are possible for this unit. Contained in a single housing, with no couplings or lube system requirements, each motorized compressor incorporates MiTi[®]'s developed and enabling technologies to achieve unparalleled performance and efficiency, combined with the life and reliability requirements of both automotive and industrial industries. This unit can be configured without the turbine for an even more compact system configuration if needed.



Figure 2. MiTi[®] 16 HP Permanent Magnet Motor Driven Blower/Compressor for Fuel Cell Systems

Figure 3 through Figure 5 present peak averaged vibration spectra for the fuel cell compressor as it was operated from start up to maximum speed of 120,000 rpm. In the configuration with the motor and compressor wheel only, operation to 120,000 rpm is achieved and maximum shaft vibration amplitude is less than 0.001 inch (25.4 micron) at full speed (see Figure 3). Following demonstration with only a compressor wheel and the motor installed on the shaft, a new compressor and matched turbine were installed on the shaft for testing under combined turbine and motor power. Figure 4 and Figure 5 present turbine rotor displacement and case mounted vibrations from start up to full speed. Rotor displacements are well controlled and are less than 0.001 inch (25.4 micron) at full speed. Maximum case mounted vibrations are less than 0.6 G and generally remain well below 0.4 G for most of the entire speed range.

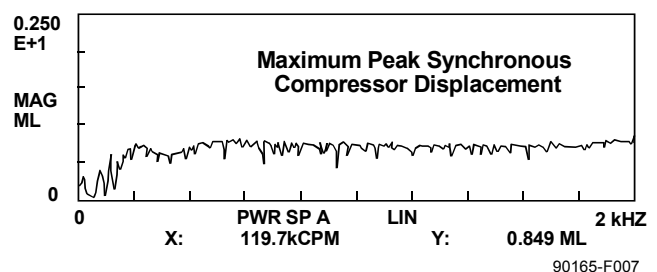


Figure 3. Power spectrum plot showing maximum synchronous vibration amplitude during operation to 120,000 rpm with motor and compressor only.

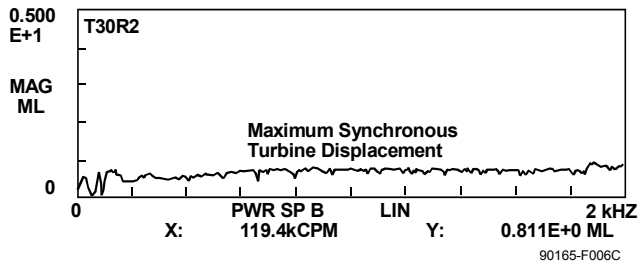


Figure 4. Maximum averaged synchronous turbine displacement from start up to 120,000 rpm under combined turbine and motor power.

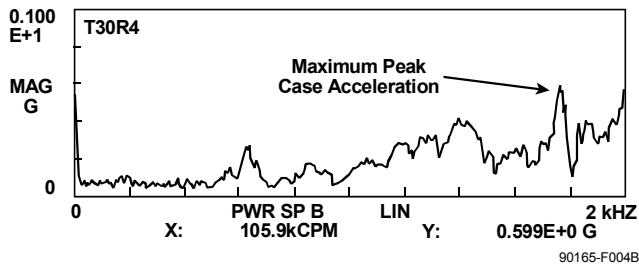


Figure 5. Fuel cell system case acceleration from start up to maximum speed under combined turbine and motor power. Less than 0.6 g at full speed.

The preliminary performance data obtained by MiTi[®] for the fuel cell compressor are presented in Figure 6. Additional data measuring input power required and the impact of combined input power from both the motor and the turbine are being acquired to map overall system efficiency.

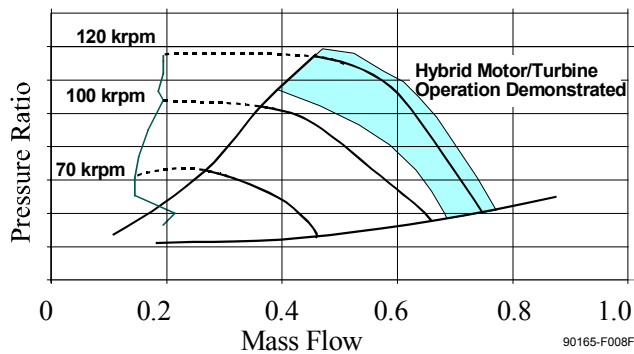


Figure 6. Preliminary fuel cell compressor performance

Additional motor driven spindle designs are also available for customization by MiTi[®] into applications such as HVAC blowers, blowers for beverage, food processing, pharmaceutical industries, water treatment plants and even grinding spindles to name a few. Additional MiTi[®] drive spindles include both 42 and 46 HP, 60,000 rpm asynchronous and synchronous units (see Figure 7 for a photograph of the 42 HP asynchronous drive unit). MiTi[®] motorized spindles can accept single or multiple compressor impellers or a compressor/turbine mix to meet a wide array of operating requirements. Individual systems can be optimized to meet the needs of specific applications.

The system can operate in a horizontal, vertical or intermediate rotor orientation, depending upon installation needs. The outstanding load carrying and damping capacities of the MiTi[®] foil bearing make this high-speed operation possible and assures smooth, stable operation throughout the entire operating range. No comparable system is available from any other source.

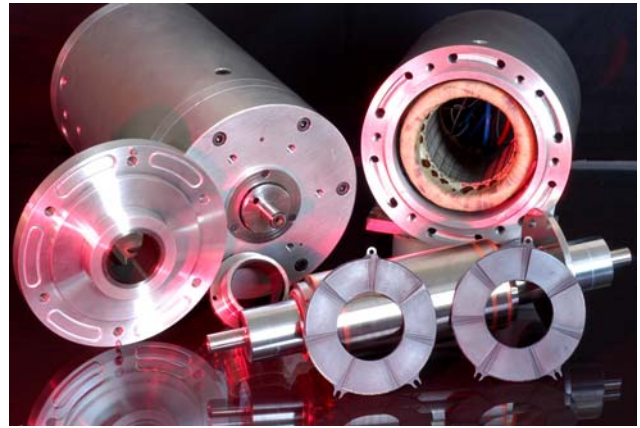


Figure 7. 42 HP, 60,000 rpm compressor system asynchronous drive motor

MiTi[®] foil bearings use our KOROLON[™] coatings which have been formulated to meet varying temperatures and duty cycles. Successful tests of MiTi[®] foil bearings, protected by our proprietary KOROLON[™] bearing surface coatings, have been conducted by government agencies and commercial machinery manufacturers to temperatures of 815°C and in saturated ammonia gas. The outstanding wear characteristics of KOROLON[™] coatings also provide long, maintenance-free operational life. The low friction coefficient supports rapid acceleration to rotor levitation speeds (lift-off), enabling use of minimal power source size to meet starting torque requirements.

Each unit motor driven uses a water-cooled jacket to maintain stator temperatures within design limits. Thermal management of the bearing system is effectively integrated with the electric motor.

MiTi[®] stands ready to work with you or your vendors to license the technology or design a new product using our foil bearings or to integrate this unit with your existing design and operating requirements.

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