Miniature High Speed Compressor Having Embedded Permanent Magnet Motor

Advantages
- Low power consumption and high efficiency with a 78% compression efficiency and 92% motor efficiency
- Ultra Compact (about 100mm x 70mm)
- Low maintenance, due to significant reduction of the overall size and weight of the compressor, and simplified supporting system to run the compressor
- High rotor speed (up to 130,000 RPM) and high flow rate (0.03 to 0.5 ft³/sec)
- Better reliability and lower costs due to the use of ceramic ball bearings compared to bearings used in prior art, such as magnetic, air-foil or air bearing

Invention
High efficiency, high reliability ultra-high speed miniature centrifugal gas compressor providing high pressure ratios and high throughput.

Background
Gas compressors are used in various applications in which either higher pressures or lower volumes of gas are needed. Gas compressors currently in use can generally be divided into two major categories, reciprocal and centrifugal. Centrifugal compressors are widely used in various fields such as industry, manufacturing, automobile, and aviation. Advantages of centrifugal compressors over reciprocating compressors include lower sensitivity to gas purity, mechanically simpler operation, and lower vibration levels. Centrifugal compressors generally require substantial machinery for obtaining large mass flow rates or large pressure ratios, but there is also a market for miniature centrifugal compressors which can be used for portable cryocoolers, mobile gas turbine/generator, and other similar systems. However, centrifugal compressors are difficult to miniaturize. A smaller impeller for the same pressure ratio requires a higher rotational speed, leading to major problems with rotor stress, cooling issues, and bearings. To handle the high speed impeller rotation, currently available centrifugal compressors all use some type of non-contact bearings or foil bearing, which are typically too expensive to implement and sensitive to the working environment. Therefore, what is needed is a miniature ultra-high speed centrifugal compressor design that provides high pressure ratios and high throughput and that it is also economical to produce.

The present invention introduces a high efficiency, high reliability, ultra-high speed miniature centrifugal gas compressor that provides kW level power output. This novel ultra-compact gas compression device compresses essentially any gas, including air, nitrogen, neon, carbon dioxide and the various freons. It is built with a permanent synchronous motor (PMSM) and a high rigidity rotor providing a bending mode speed of at least 100,000 RPM, which advantageously permits implementation of relatively low-cost ball bearing comprising supports. Furthermore, the development and application of the present invention will result in great advancements in areas where portability, compactness, and weight are the driving considerations.

Application
The present invention can be used in portable cryocoolers, mobile gas turbine/generator, aerospace gas compression, fuel cells, and cooling systems for personal use such as in chemical, biological, and fire protection suits. The invention is particularly useful for mobile applications due to its ultra-compact form factor and low power consumption.

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Selected References