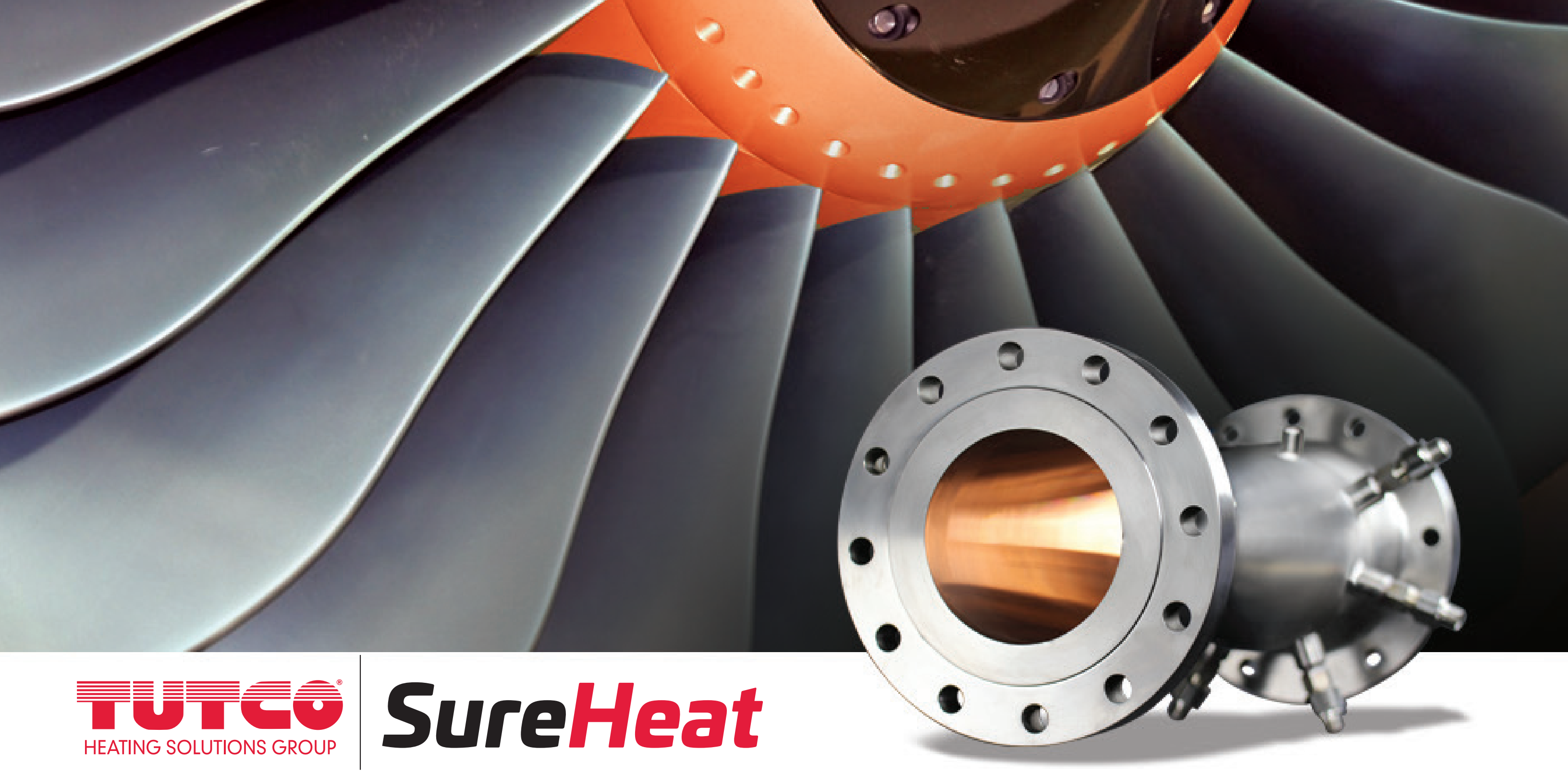


TUTCO HEATING SOLUTIONS GROUP | SureHeat

By Matt Hargreaves
General Manager

The advantages of open-coil technology for high-temperature and high-pressure testing in the aerospace and aviation industry

High-capacity electric in-line air heaters, as an integral part of a compressed air system, are used throughout the aviation and aerospace industry for R&D simulation of the high-temperature and high-pressure conditions produced by an aircraft turbofan compressor. Open-coil electric heaters provide the most optimum heating solution for rig testing as compared with traditional sheathed ('tubular') heating elements.

A turbofan engine's compressor stage generates the high-temperature and high-pressure air that directly feeds the engine internal combustion process, and indirectly feeds the environmental control systems via high and low 'bleed' ports in the compressor stages. These environmental control systems use a system of air cycle machines (ACMs), flow control valves, and heat exchangers, to provide a clean pressurized cabin air environment to passengers.

Traditional Heater Technology

Original equipment manufacturers (OEMs) of turbofan engines, ACMs, flow control valves, and other auxiliary equipment need a compact, efficient, and controllable system to provide pressurized hot air to enable their ongoing development efforts for new products. Similarly, FAA-certified repair stations also need this capability to provide pass/fail testing as part of the routine service and repair work on the ACMs, valves and other components necessary to extend the operating life of the aircraft. Historically, the aviation industry used sheathed element type electric heaters for heating the compressed air for testing. The iron alloy (FeCrAl) resistive heater element is a wound helical coil encased in an insulation material, typically magnesium oxide (MgO), which, in turn, is encased in a steel alloy tube (incoloy, etc). This basic tube or ribbon type construction is very similar to what you would find on an electric stove element.

Required Temperature Range:

Tutco SureHeat open coil electric air heaters can produce up to 1652°F (900°C) in standard designs and 1832°F (1000°C) in custom designs

Pressure Ratings:

Typical electric heaters can withstand up to 600psi (40 bar) standard, up to 3000psi (207 bar) in custom designs

Domestic Code Requirements:

Either ASME Section VIII Div. 1 or B31.3 (process Piping)

International Code Requirements:

Pressure Equipment Directive (PED) certification
Special control requirements
On-site startup assistance or training

This protective construction is ideal for heating liquids or corrosive gases, but the high thermal mass and poor heat transfer between the element and the casing make it very inefficient for heating air, steam, or other inert gases. Similarly, the internal heater element must operate at extremely high temperatures to overcome the thermal mass of the insulation and the alloy sheath. While, the slow responsiveness of the tubular element reduces ramp rates and decreases outlet temperature accuracy. The end result is not only poor efficiency, but shorter element life resulting from the elevated element wire temperatures.

Serpentine Heat Technology

In contrast, the preferred solution for air or gas heating is to use an open coil heater, which allows the air stream to make direct contact with and high-pressure testing in the aerospace and aviation industry the heater element, greatly improving the heat transfer. There are several key advantages to using an open coil heater for air/gas heating, including:

– The heating element actually operates at a lower temperature to produce a given air temperature. The result is an improved element life due to less thermal stress on the heater wire.

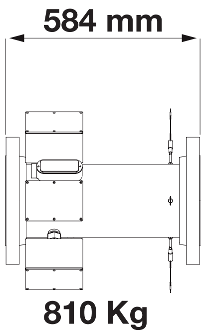
– The safe maximum process air temperature can be much higher while still maintaining long life of the element. This allows for more operating flexibility with the more demanding test conditions typical of aerospace and aviation.

– The time to reach operating temperature and/or cool down the heater during a typical operating cycle is much shorter—increasing productivity and reducing energy consumption to heat and pressurized air. This allows for much more productive use of the heating equipment under more flexible and dynamic operating conditions.

– The higher watt density in an open coil heater allows for a significantly smaller overall package, which reduces weight, floor space, and minimizes the need for heavy rigging equipment to install and service the unit.

200KW HEATER SIZE COMPARISON

Traditional Immersion Heaters are large and slow to temperature.



Tutco SureHeat Specialty Flanged Inline Heaters save space and are quick to temperature.

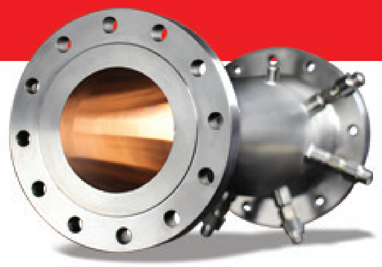
Control Method

Open-coil heaters require faster responding control systems to safely operate; however this can be achieved easily with modern power and temperature control systems. Key components to a good control system include the use of a phase angle-fired or burst-fired (zero crossing) SCR power controller, PID loop temperature controller, and high-limit safety devices.These control systems can be easily configured for remote or local operator access. The block diagram in the figure above shows an example of a typical control setup for Tutco SureHeat in-line heater with open-coil elements.

In this configuration, one K-type thermocouple probe is used for process temperature control, while another separate probe is used for a high limit. At the heater inlet is a flow-sensing device to ensure the system does not operate unless a minimum flow rate is achieved through the heater. The combination of these devices ensures a safe, reliable system.

Application to Aerospace Industry

Larger open-coil in-line heaters are commercially available to handle the extremely high pressure and flow requirements needed by the aerospace industry. For example, air mass flow rates as high as 200 lb/min (3.4 lb/sec) can be heated to 1,000°F using the 800kW Tutco SureHeat heater above left, at pressures up to 300 psi and beyond. The compact 14 inch diameter pipe size and 60in length makes it easy to install into existing compressed air lines and it can be positioned much closer to the test articles. By placing the heater indoors and close to the test article, the system is much more convenient and accessible, and the heat losses and startup time is much reduced.



Sizing and Selecting

A number of considerations must be given to sizing and selecting an open coil heater. Of primary importance is to specify the temperature rise across the heater needed, and the air mass flow through the heater. A simple formula for sizing the heater power (kilowatts) is given by: kW = SCFM x (Delta T)/3000, where SCFM is the mass flow rate in standard cubic feet per minute, and the Delta T is given in degrees Fahrenheit across the heater. When determining the temperature rise across the heater, the customer should take into consideration the heat losses that occur between the heater and the test point. This may require a higher heater temperature in order to reach a desired process point temperature.

The next step to selecting a heater is to know the maximum static pressure the heater will be subjected to in order to correctly size the pipe and flange material. Depending on temperature and pressure conditions, the materials can vary from common 304 stainless steel to high-performance super alloys, which is a major driver in the overall unit cost.

With safety in mind, the demands of aviation and aerospace customers are arguably more critical than those of other industrial customers. So when selecting a new heater system, it is essential to select a partner which has the right products and experience for the job.

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