THE USE OF OPEN COIL ELECTRIC AIR HEATERS FOR DEVELOPMENT AND TESTING OF AVIATION SYSTEMS.

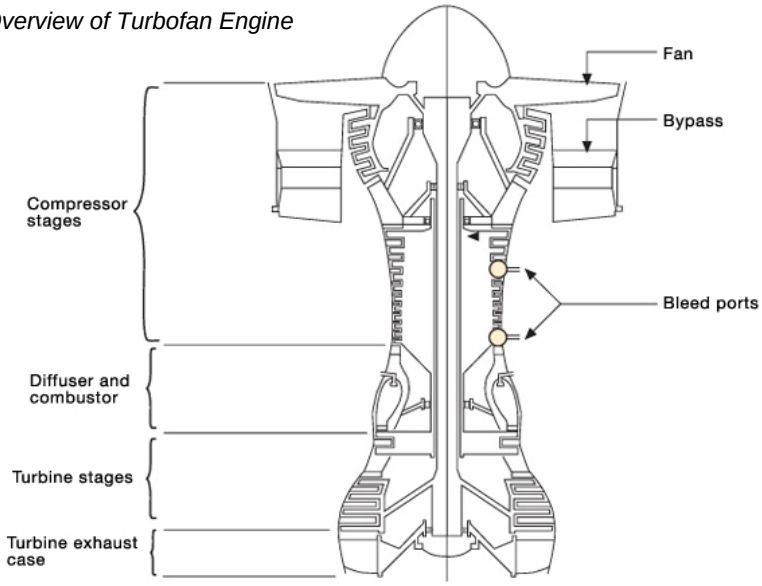
GAS TURBINE AND ENVIRONMENTAL CONTROL SYSTEMS – *A MORE EFFICIENT APPROACH.*

Contents

Overview

High capacity electric “inline” 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. This whitepaper explains why open coil electric heaters provide the most optimum heating solution for rig testing as compared with traditional sheathed (“tubular”) heating elements.

Fig. 1 – Overview of Turbofan Engine



Background

A turbofan engines’ 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. It is these Environmental Control Systems which 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.

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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.

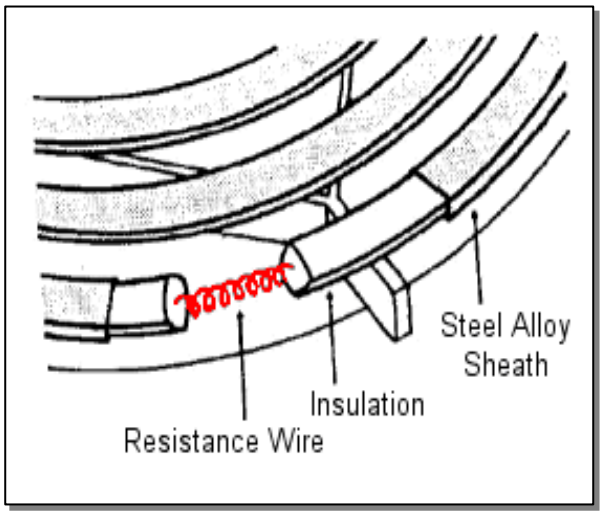
Historically, the Aviation industry used sheathed element type ("Tubular") electric heaters for heating the compressed air for testing. The basic construction of a tubular heater is shown in Fig. 2.

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 identical to what you would find on an electric stove element:

Fig. 2 – Sheathed Element "Tubular" Heater

This protective construction surrounding the heater element 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.

Fig. 3 – Cross Section of a Typical Element



Similarly, the internal heater element must operate at extremely high temperatures just to overcome the thermal mass of the insulation and the alloy sheath.

The end result is not only poor efficiency but shorter element life resulting from the elevated element wire temperatures.

Open Coil 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 the heater element greatly improving the heat transfer.

There are several key advantages to using an open coil heater for air/gas heating:

1. The heating element can operate 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.
2. The safe maximum process air temperature can be much higher while still maintaining long life of

Fig. 4 – Open coil heater element with insulator tube partially removed.

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the element. This allows for more operating flexibility with more demanding test conditions.

3. The time to reach operating temperature and/or cool down the heater during a typical operating cycle is significantly shorter allowing for much more productive use of the heating equipment, and allows for more flexible and dynamic operating conditions.

4. 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.

Application to Aerospace Industry

Larger open coil inline 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 100 lbs/min (1.7 lb/sec) can be heated to 1500°F using the 400kW OSRAM SYLVANIA heater shown here in Figure 5, at pressures up to 300 psi and beyond. The compact 10" diameter pipe size x 60" length makes it easy to install into existing compressed air lines and 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 start-up time is significantly reduced.

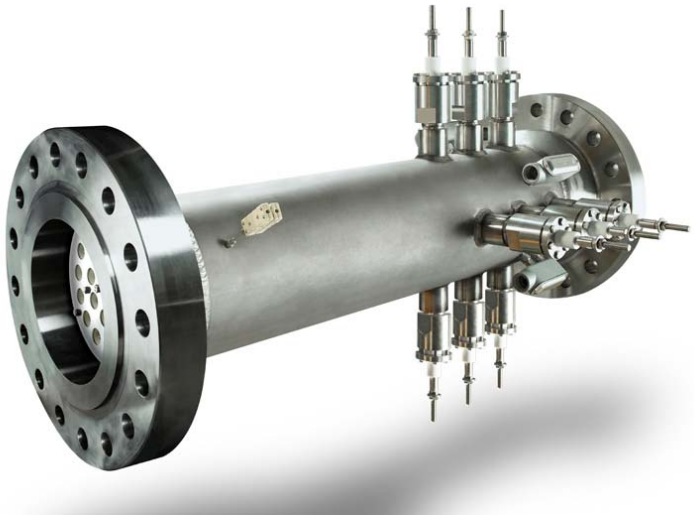

Fig. 5 – OSRAM SYLVANIA 400kW high pressure heating unit containing 24 open coil elements.

OSRAM SYLVANIA offers standard and custom designed heaters to meet your needs and requirements. See our standard product line at www.sylvaniaheaters.com, or contact us at (603) 772-4331.

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