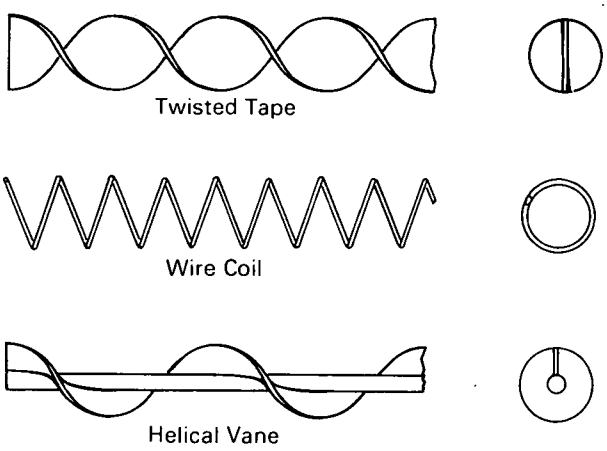
September 1970

Brief 70-10362

NASA TECH BRIEF

Single-Phase Heat Transfer Improved by Helical Inserts in Tubes

Use of swirl-generating inserts within tubes is a well-established technique for enhancing heat transfer to single-phase fluids. Recently, use of such inserts has been extended to the tubes of high-temperature liquid-metal boilers for electric power plants; the inserts not only improve heat transfer in the all-vapor (superheat) regions but also permit higher rates of transfer in the boiling regions. Use of these devices brings substantial savings in a boiler's size and weight.



Three Types of Insert

Types of insert that have been used in, or are being considered for, boilers are the twisted tape, the wire coil, and the helical vane (see fig.) which may be termed "passive" devices; that is, their enhancement of heat transfer results from the rotational velocity imparted to the fluid, the fin-conduction effect being generally small.

The helical-vane insert has several advantages over the other two configurations; it creates a single, well-defined, helical flow passage. Maldistributions of flow have been observed between the two passages formed by a twisted tape in a tube. Heat-transfer data from the wire coil indicate substantial bypassing of flow. With the helical-vane insert, the bulk of the flow must follow the helical passage; consequently more reliable predictions and extrapolations of the thermal and hydraulic performance of this insert can be expected. The core of the helical-vane insert is not needed to support the vane, but it is a convenient housing for instrumentation (such as thermocouples), which do not disturb the flow.

The single-phase pressure losses and heat-transfer coefficients of a tube containing four full-length helical-vane inserts differing in ratio of pitch to tube diameter were measured experimentally over a Reynolds-number range from about 30×10^3 to 300×10^3. The heat-transfer coefficients and the pressure losses increased with increase in mass-flow rate and with decrease in the insert's pitch-to-tube diameter ratio. A mathematical momentum analysis, based on solid-body rotation, resulted in new theoretically based expressions for the momentum and frictional pressure losses for fully developed flow with these inserts. Helical-vane friction factors and Stanton numbers, computed from the experimental data in accordance with parameters derived from the analysis, correlated with modified plain-tube expressions.

Notes:

1. This information may interest designers of single-phase heat-transfer equipment and of forced-convection boilers such as those used in central power plants and Rankine-cycle (low-pollutant emission) engines.

(continued overleaf)

2. The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference:
NASA-TM-X-52665 (N70-23224) Augmentation of Single-Phase Heat Transfer in Tubes by Use of Helical Vane Inserts

3. Technical questions may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B70-10362

Patent status:

No patent action is contemplated by NASA.

Source: M. U. Gutstein
Lewis Research Center
(LEW-11063)