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# SHORTER COMMUNICATION*

# HEAT TRANSFER FROM SLOTTED FINNED TUBES

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## NOTATION

- $D$, Tube diameter at root of fin (in.);
- $H$, Conductance of tube, measured directly from heat released by steam, with temperature drop corrected for steam/copper film conductivity and conductivity of copper tube wall. (Btu/hr °F ft length of tube);
- $h$, Heat transfer coefficient of tube, based on $H$ and full extended surface of tube and fins. (Btu/hr ft$^2$ °F);
- $V_{max}$, Maximum velocity between tubes, obtained from measured duct velocity and ratio of minimum free area between tubes in bank and the area of the duct (ft/sec);
- $\sigma$, Relative density referred to air at 60°F, 14·7 p.s.i.a. (dimensionless).

LYMER [1] gives the results of a series of tests designed to measure the local heat transfer coefficients over the surfaces of the fins in banks of finned tubes in cross flow. He found that regions of low heat transfer were present on the parts of the fins upstream and downstream of the tube. Stagnation of the flow in the wake of the tube probably causes the low heat transfer in this region, while that upstream may be caused by the effect of the pressure distribution due to the tube on the boundary layers on the fins. As the static pressure increases from its free stream value to the stagnation point at the front of the tube, the boundary layers on the adjacent faces of the fins will thicken, and may join to produce a stagnant region ahead of the tube.

A radial slot cut in the fin at either of these points should modify the flow in a way which might improve the heat conductance. A slot upstream of the front stagnation point would remove the surfaces on which the fin boundary layers are found, and hence should remove the stagnant region ahead of the tube, while a slot downstream would offer a path of lower resistance which might induce more fluid to flow near to the cylinder, reducing the size of the stagnant region in the wake.

To investigate this, tests were made with a bank of tubes in close-pitched, staggered formation, mounted in a duct 1 ft square. (Details in Table 1.) Measurements of the heat transfer were made for individual tubes with slots up to ¾ in. wide mounted in central positions in the first and fourth rows of the six-row bank, the rest of the bank being unheated. The tube on test was heated by steam, in a manner similar to that used by Lymer, but with a steam trap immediately before the entry to ensure low wetness of the supply, and a steam bleed at the base of the tube to prevent air-locks. The tubes were treated inside with Di-octadecyl-xanthate, and from inspection after tests it appeared that dropwise condensation was occurring on a large proportion of the surface.

*Table 1. Experimental tube arrangements*

| |
|---|
| I.C.I. Integron high-fin tubes code 07 8 064 in copper |
| Tube ID. 1 in., root dia. 1·128 in., fin height 0·351 in. |
| Mean fin thickness 0·024 in., 7 fins/in. |
| Close-pitched formation—Tube pitch 1·893 in. |
| Bank arranged in alternate rows of 5 and 6 tubes |

The conductances measured are shown in Figs. 1 and 2 (see Notation). The values for an unslotted tube in the fourth row agree quite closely with the formula, for air outside staggered tubes,

$$h = 1{\cdot}83\,(\sigma V_{max})^{0{\cdot}6}/D^{0{\cdot}4}\ \text{Btu/hr ft}^2\ {}^\circ\text{F}$$

obtained in tests on banks of similar tubes [2], while the ratio between conductances of tubes in the first row and the fourth row is nearly the same as that reported in MacAdams for banks of plain tubes [3]. The effects of the slots may be summarized as follows:

*Forward facing slot in first row.* Conductance falls steadily with increase in slot width.

*Forward facing slot in fourth row.* Conductance changes very little for slot widths up to ⅜ in. and then falls with slot widths of ½ in. and ¾ in.

*Rearward facing slot in first row.* Very little change at higher wind speeds, and slight deterioration at lower speeds.

*Rearward slot in fourth row.* Small increase in conductance at higher speeds, particularly with slots up to ⅜ in., but reduction at lower speeds.

A short series of tests on steel tubes of rather similar geometry showed a consistent reduction in the conductance of the tube as the slot width was increased.

* EDITOR'S NOTE. This section is open to short manuscripts reporting new developments or comments on previously published papers. Such manuscripts are published, after an abbreviated reviewing procedure, in the issue which next goes to press.

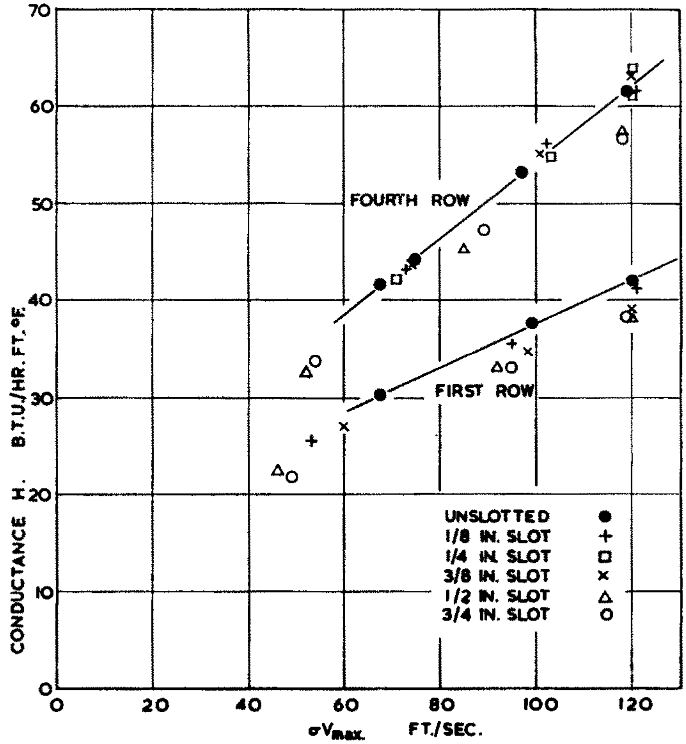


FIG. 1. Conductance of finned tube with forward slot.
$\sigma$ = Relative density referred to air at 60°F, 14·7 p.s.i.a.
$V_{max}$ = Maximum velocity between tubes.

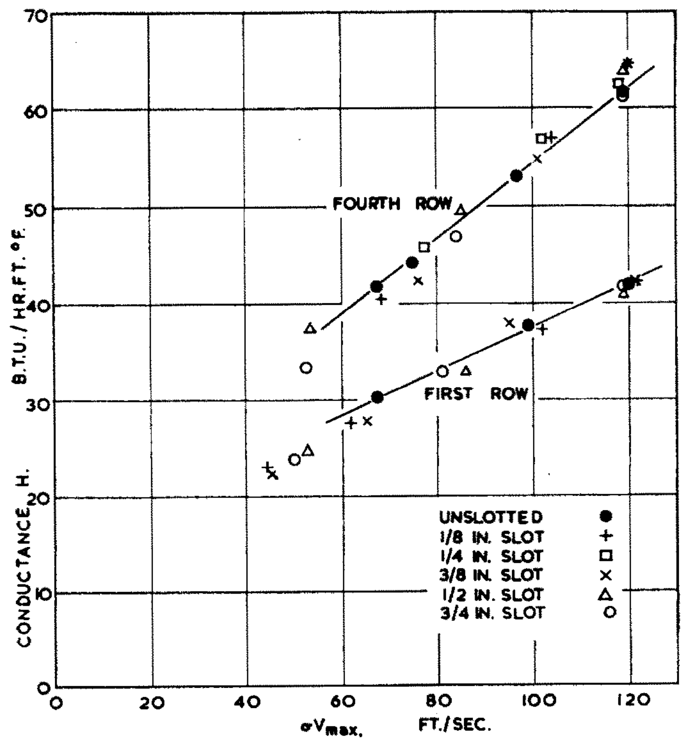


FIG. 2. Conductance of finned tube with rearward slot.
$\sigma$ = Relative density referred to air at 60°F, 14·7 p.s.i.a.
$V_{max}$ = Maximum velocity between tubes.

From these results it is clear that no marked improvement in the conductance of finned tube with fin height/fin spacing of about 3 : 1 can be obtained by slotting the fins. However, from the fact that in several cases removal of fin surface in the slots must have improved the heat transfer coefficient over the rest of the fin, it would be worth while to make similar tests if a tube with fin height/gap substantially greater than 3 : 1 were produced in copper or other material of high thermal conductivity.

As only single tubes in the bank were slotted, no attempt was made to measure the pressure drop. It seems unlikely that this will be much affected by slotting.

## REFERENCES

1. A. LYMER, The development of finned tubes for steam-raising units. *G.E.C. At. En. Rev.*, Vol. 1, No. 4 (1958).
2. *Integron High-Fin Tubes; Design Data.* I.C.I. Ltd., Metals Division (1957).
3. W. H. MACADAMS, *Heat Transmission*, 3rd Ed., 274–5. McGraw-Hill, New York (1954).