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Air cooling of a finned cylinder with slot jets of different height

F. Gori*, M. Mascia, I. Petracci

Department of Mechanical Engineering, University of Rome – "Tor Vergata", Via del Politecnico 1, 00133 Rome, Italy

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ABSTRACT

This work presents new experimental results in the cooling of an externally finned cylinder with a submerged slot jet of air. Two slots are employed with D/H equal to 2 and 4, where D is the diameter of the cylinder without fins and H the slot height. Local and mean Nusselt numbers are evaluated at several Reynolds numbers and distances from the slot exit. Empirical expressions are proposed to correlate the experimental mean Nusselt numbers and the convective heat transfer coefficients. The two slots are compared also according to the concept of efficiency, which takes into account the cooling rate and the mechanical power necessary to drive the flow.

1. Introduction

Enhancement of heat transfer is very important because many industrial processes are requesting an increasing amount of energy. The techniques of enhancement are passive if they do not require power, or active if they need additional power [1]. Several enhancement methods are described in [2,3] with fourteen different techniques and several convective heat transfer techniques. One of the possible techniques is the impinging jet which has a high efficiency because of the flow concentration and the limited expenses required to move the relatively small amount of fluid.

Impinging jets of air have been proposed as cooling method inside the engine of heavy trucks [4]. In this application external air, entering throughout the fan of the vehicle, is used to cool the cylinder where hot air, coming from the compressor, is flowing to the intercooler. A nozzle after the fan is suggested to converge the jet flow onto the hot-air tube. The jet flow increases the cooling performance but can be not enough because of the high temperature of air on the outlet of the compressor. Then, it is proposed to use an externally finned tube instead of a smooth one.

In order to reach Euro standard emissions in heavy duty trucks, several solutions have been proposed in [5], with a strong impact on the heat rejection requirements and on the dynamic and static pressure loads of the heat exchangers. The increase of the heat exchanger performance cannot cope the increased cooling requirements, also because there is no more frontal surface available. The air jet is then directed towards the finned tube, where air is coming out from the turbo-compressor [4], because heat transfer is not given to the radiator and the power absorbed by the fan is not increased.

Preliminary experiments have been carried out at the Iveco Testing Laboratory, designed to test radiators, after-cooler and fans [6]. Heat transfer experiments have been carried out at the Heat Transfer and Energy Engineering Laboratories of the University of Rome, "Tor Vergata", with the conclusion that the experimental mean Nusselt numbers on a finned cylinder are higher than those measured in a non finned cylinder [7].

The aim of the present work is to use slot jets of different cylinder diameter to slot height ratios, i.e. D/H, in order to study the configuration which enhance the cooling performance, as done with smooth cylinders [8–11].

2. Literature overview

Heat transfer between finned cylinders and cross-flow of air has been extensively studied to improve the cooling of airplane engines and fin-and-tube heat exchangers. A trade off between the increase in the surfaces and the demand of smaller systems is necessary. All the articles of the literature, most of them mentioned in [12–14], have dealt with a flow of air of larger dimension than the finned cylinder to be cooled. This flow condition, mentioned as full flow, is quite different from the case of a ratio D/H greater than 1, called jet flow.

* Corresponding author. Fax: +39 06 72597129.
E-mail address: gori@uniroma2.it (F. Gori).

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