HEAT TRANSFER AND FLUID FLOW IN
RIB-ROUGHENED RECTANGULAR DUCTS

BENGT SUNDÉN
Division of Heat Transfer
Lund Institute of Technology
Box 118, 221 00 Lund, Sweden

Abstract. This lecture considers flow fields, friction factors, and local and average heat transfer coefficients in rib-roughened ducts for applications in compact heat exchangers and cooling systems in gas turbine systems. Details of the flow pattern and the influence of rib configuration, rib angle, rib pitch and height are discussed, and physical interpretations of the results are provided.

1. Introduction

Improvement of the heat transfer process is desired in heat exchangers to enable reductions in weight and size, to increase the heat transfer rate or to diminish the mean temperature difference between the fluids and thus to improve the overall process efficiency. In gas turbine cycles the turbine inlet temperature becomes higher and higher to improve the cycle efficiency. Efficient cooling of the first rows of guiding vanes and blades is therefore very important. Internal cooling by air in duct flow is now very common. However, only a limited amount of the air flow is available for such cooling, and thus efficient heat transfer is required. Similarly in combustor wall cooling, the trend is to apply pure convective cooling or combined convective and impingement cooling methods in ducts. Here also, a limited amount of air flow is available, and the pressure drop has to be low. This calls for a very effective heat transfer process.

The methods to improve or enhance the heat transfer usually involve extended surfaces or some form of surface modification, destabilisation of the flow field and/or generation of secondary flow. The methods being used for heat transfer enhancement are referred to as active or passive. The active methods require external power such as surface vibration, electric or acoustic fields. The passive methods use surface modifications or specific types of surface geometries and in some cases fluid additives are used to establish the enhancement. In [1], Webb has presented an overview of heat transfer enhancement in general. In this lecture rib-roughened ducts are considered.

2. Problem Statement

Figure 1 shows a sketch of a rectangular duct with transverse ribs, inclined ribs and V-shaped ribs. In addition to these geometries, a rectangular duct with multiple V-shaped ribs will be considered here.

![Figure 1. Principal sketch of a rectangular duct with various ribs.](image)

In Figure 2, two real rib-roughened radiator tubes with inclined ribs are shown. The outside top surfaces are highlighted. The aspect ratios, H/W, are 1:8.4 and 1:13.1. The rib height to hydraulic diameter ratios are 0.058 and 0.065. The pitch to height ratios are 22.2 and 20.