

# 5

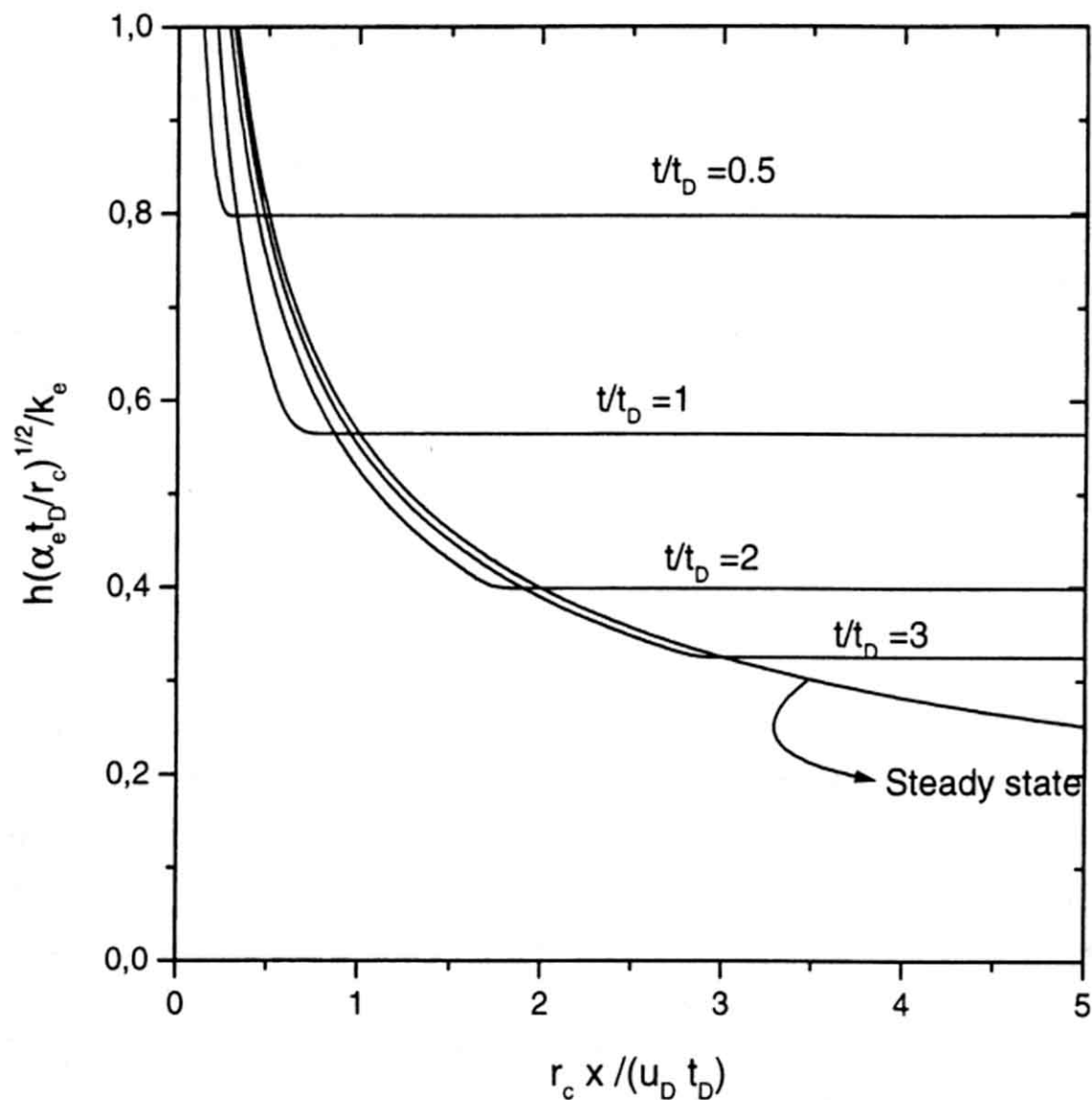
## Forced Convective Heat Transfer in Porous Media

**Guy Lauriat and Riad Ghafir**

*Université de Marne-la-Vallée, Marne-la-Vallée, France*

### I. INTRODUCTION

Forced convective heat transfer in porous media has been the subject of many studies because of its important practical application in packed-bed chemical reactors, thermal insulation, compact heat exchangers, drying technology, electronic cooling, and numerous other applications. Up to the end of the 1970s, the overwhelming majority of existing studies were based on the Darcy flow model. For forced convection, this model leads to slug flow profiles so that the heat transfer results related to the assumption of slug flow can be directly transposed to the study of forced convection in porous media, provided that the assumption of local thermal equilibrium is valid. When the pore Reynolds number exceeds unity it has been established, beginning with Reynolds (1900) and Forchheimer (1901), that the inclusion of a quadratic term is required to account for flow recirculations, flow instabilities, and turbulence inside the pore volumes. However, the velocity profiles predicted by using the Darcy-extended Forchheimer momentum equation are still flat for boundary layer and duct flows for which the pressure does not depend on the normal coordinate to the wall. Similarly to clear fluids, the heat transfer results for external and confined flows are overestimated when using slug flow profiles, since viscous effects have been proved to be of significant importance to the convective transport of energy at the macroscopic scale. These effects should be considered in many practical applications in which porous media with relatively high porosities and permeabilities are used, especially for reducing pressure



**Figure 2.** Variation of the local heat transfer coefficient for transient Darcy flow ( $F = 0$ ).