19 Impinging Jets in Porous Media

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CONTENTS

19.1 INTRODUCTION

Heat transfer enhancement technologies play an important role, and they have been widely adopted, in several applications such as in refrigeration, automotive, aerospace, process industry, and solar energy heaters. The targets in terms of technical advantages and cost savings could be achieved by the employing suitable techniques. Jet impingement of a cold fluid is an efficient cooling method of a heated surface. This method is one of the techniques employed in heat transfer enhancement technologies. An intensive research activity has been developed on impinging jets as reported in the reviews given in Arganbright and Resch (1971), Martin (1977), Polat et al. (1989), Jambunathan et al. (1992), Viskanta (1993), Webb and Ma (1995), Han and Goldstein (2001), Sarkar et al. (2004), Zuckerman and Lior (2006), Ebadian and Lin (2011), Dewan et al. (2012), Harmand et al. (2013), Lindeman and Shedd (2013), and Molana and Banooni (2013).

The characteristics of jet impingement cooling through porous medium are becoming important in many engineering applications, for example, turbine blade internal cooling, electronic cooling systems, and solar collectors. Furthermore, new applications of high-permeability porous media are being developed to enhance heat transfer. This is the case of porous heat sink in electronic cooling and the use of porous inserts in injection molding. As indicated in literature, jets employed together with porous media with high porosity and thermal conductibility, such as aluminum foams, allow improvement in the heat removal from a heated surface. Moreover, it has been observed that several parameters have effects on the fluid and thermal behaviors and they should be investigated to evaluate optimal configurations in order to enhance the heat transfer. But also some fundamental studies are needed to understand and characterize the thermal and fluid dynamic behaviors of this system. The different investigations have been developed for system partially and totally filled by porous medium between the outlet section of the jet and the opposite solid surface, in Figure 19.1. The systems can be unconfined or confined as reported in Figure 19.1.

One of the first studies on impinging jets in porous medium was carried out by Fu and Huang (1997). A numerical investigation on the effects of a laminar jet on the heat transfer performance of porous blocks mounted on a heated plate was accomplished. In the study, three different shapes of porous blocks were examined, rectangle, convex, and concave, and only forced convection analysis

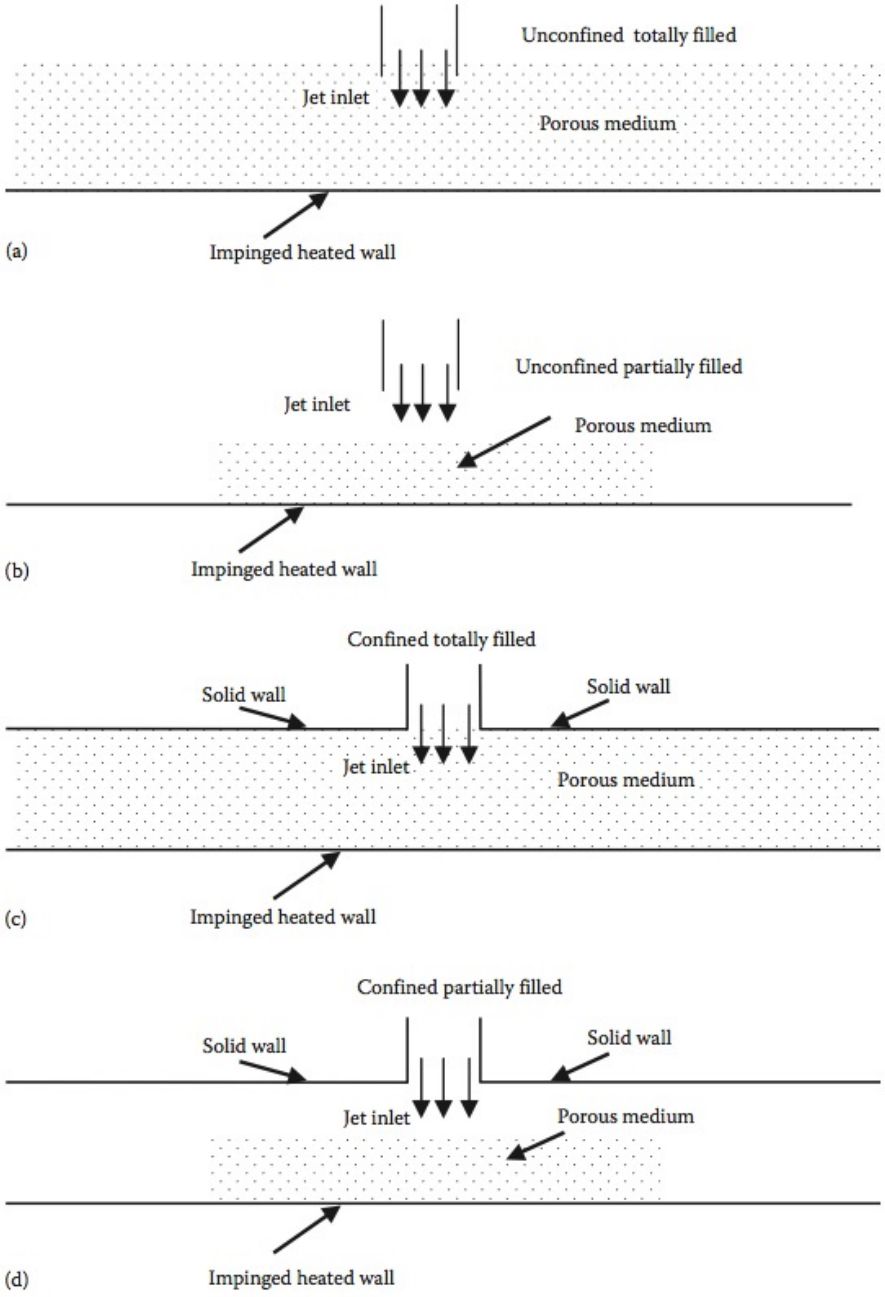

FIGURE 19.1 Sketch of impinging jet configurations.

was considered neglecting buoyancy effects. Results show that the heat transfer is mainly affected by a fluid flowing near the heated region. Moreover, for a lower porous block, the three types of porous blocks enhance the heat transfer, whereas for a higher porous block, the concave porous block only enhances heat transfer. The effects of the porosity distributed casually inside a porous block mounted on a heated region with a laminar slot impinging jet on flow and thermal fields were investigated numerically by Fu and Huang (1999). A one-equation thermal model with van Driest's wall function