Available online at www.sciencedirect.com
ScienceDirect
International Communications in Heat and Mass Transfer 34 (2007) 103 – 113
International Communications in HEAT and MASS TRANSFER
www.elsevier.com/locate/ichmt

A brief survey and economical analysis of air cooling for electronic equipments☆

Akın Burak Etemoglu

Uludağ University, Faculty of Engineering and Architecture, Mechanical Engineering Department, Görükle Campus, TR-16059 Bursa, Turkey

Available online 6 October 2006

Abstract

The techniques used in the cooling of electronic equipments vary widely depending on the particular application. Cooling with liquids and impinging air jets become important where classical cooling techniques may be insufficient, while a single or array jet is employed where highly localised cooling is desired. This paper provides a comparative survey of advanced methods of cooling for electronic systems and an economical analysis of cooling electronic equipments using slot and circular jets.

Keywords: Electronic cooling; Impinging jets; Economical analysis

1. Introduction

With the trend towards further microminiaturization of electronic packages the thermal design problem is recognized as one of the factors limiting the achievement of higher packaging densities. The reliability of machines is, therefore, becoming more critically dependent on the accuracy of heat transfer analysis, which traces the heat flow from chips to the air. High power dissipation may require new cooling techniques, but where possible, direct air cooling still remains an attractive method because of its mechanical simplicity. The problem is that conventional cooling techniques are no longer adequate. However, advanced methods are emerging that prevent overheating and offer other benefits as well. Novel structures such as miniature heat pipes, jet impingement cooling, thermoelectric coolers (solid-state refrigerators) liquid cold plate, as well as special fluids (liquid heat sink, direct immersion cooling) and packaging schemes, will take electronics to the densities and speeds that next generation application demand [1].

Single and multiple impinging air jets are widely used in many industrial applications because of high heat and mass transfer coefficients which are developed in the impingement region. They are most commonly applied in processes such as cooling of electronic components, print drying, drying of paper and textiles, tempering of plate glass, annealing of metal, printing on plastics, the systems of cooling assemblies of gas turbine blades, VTOL aircraft design and thermal development of photographic films etc. In general, two types of jets have been used either single or arrays: (1) circular or axisymmetric jets, (2) slot or two-dimensional jets. In industrial applications such as paper mill roller cooling or cooling of high energy density electronic components, where highly localized cooling is

☆ Communicated by W.J. Minkowycz.

E-mail address: aetem@uludag.edu.tr.

0735-1933/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.icheatmasstransfer.2006.08.005

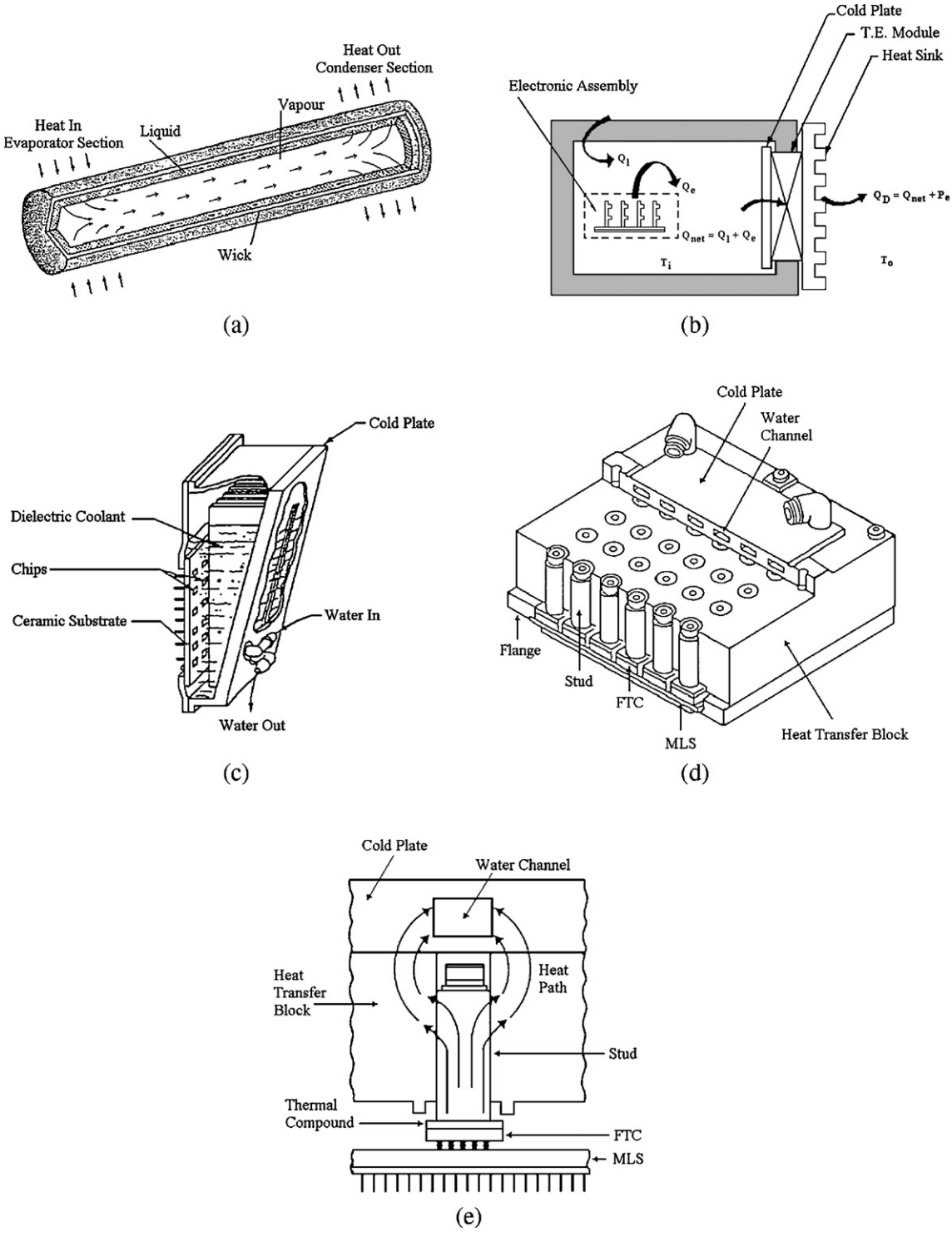

Fig. 1. Various techniques for electronic equipment cooling. a) Basic Construction of Heat Pipe [7]; b) Thermoelectric Cooling of an Electronic Assembly [9]; c) LEM (Liquid Encapsulated Module) [11]; d) NEC Liquid Cooled Module (LCM) [12]; e) Heat Flow Path in the LCM [12].