Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 127 (2017) 193–200

Energy Procedia

www.elsevier.com/locate/procedia

International Youth Nuclear Congress 2016, IYNC2016, 24-30 July 2016, Hangzhou, China

Experimental study on transient characteristic of passive containment cooling system

CHENG Cheng*, WEN Qing-long, WU Xiao-hang, LI Yu, JU Peng

Reactor Engineering Experiment Research Center, China Nuclear Power Technology Research Institute, Shenzhen, 518000, China.

Abstract

Separated heat pipe is an efficient passive heat transfer device. It is widely used on chemical and aerospace industry. In this paper, the transient characteristics of the separated heat pipe which applied to a containment cooling system were studied. According to the experiment, the start-up transition characteristic of cooling system were mainly described. The influences of containment initial pressure and thermal load of separated heat pipe loop were analyzed. Based on the experimental data, it shows that the separated heat pipe is feasible for containment cooling system. It can remove the heat of containment vessel passively on design basis accident. And the separated type heat pipe cooling system has the working condition of flow instability region. The influence factors of which is relevant to cooling water tank temperature, containment pressure and system input power. The flow instability has little effects on the trend of containment pressure.

Keywords: passive containment cooling system; separated heat pipe; transient characteristic

1. Introduction

When a serious accident or design basis accident in the nuclear reactor such as loss of coolant (LOCA) or main steam line break (MSLB) happened, temperature and pressure of containment vessel will continue to rise due to the blowing out of primary loop medium (water, vapor, hydrogen, etc.), which may cause containment pressure to exceed the design limit. Passive containment cooling technology, which has been used on EPR1000 of Europe,

* Corresponding author. Tel.: +86-0755-88620131; fax: +86-0755-88620065.
E-mail address: chegcheg@163.com

10.1016/j.egypro.2017.08.081

SPWR of Japan, VVER1000 of Russia and AP1000 of America, is the main characteristic of advanced pressurized water reactor.

Separated heat pipe is an efficient passive heat transfer device. Containment cooling system which based on separated heat pipe is one of the most important research directions of passive engineered safety feature on advanced pressurized water reactor. It's start-up characteristic and natural circulation transition characteristic are also the focus of researches at home and abroad[1-4]. The CGN (China General Nuclear Power Corporation) COTHASE (Comprehensive Thermal-hydraulic and Safety Labs) has designed and built the passive containment cooling system comprehensive thermal-hydraulic test facility (PACON). Liquid head start-up transient characteristics of heat-pipe passive containment cooling system have been researched, as well as the influence of containment pressure and input power.

This paper is about to describe a separated heat pipe system, which applied to a containment cooling system for the first time in nuclear field. It is feasible or not depends on the start-up characteristic and natural circulation transition characteristic. Flow rate is important surface feature for natural circulation transition characteristic. So this paper mainly described the flow rate of separated heat pipe system on stat-up stage, as well as the influence of containment initial pressure and thermal load to flow rate.

Nomenclature

Q	Input power
m	Flow rate
P	Pressure
T	Temperature
τ	Time

Subscripts

s	Containment initial parameters
c	Containment process parameters
m	Separated heat pipe system
o	Outlet of evaporator

2. Test facility and test method

2.1. Test facility

The test is carried out on the passive containment cooling system comprehensive thermal-hydraulic test facility in CGN COTHASE, Shenzhen, China. The facility includes a loop system, electrical system, meter system, controlling system and data acquisition system.

The loop system includes steam-water natural circulation loop, water supplying loop and vacuum loop. Major equipment is composed of evaporator, condenser, cooling tank, containment simulator, valve and pipes. Evaporator and condenser are made up of 37 Φ57 × 3.5mm tubes connected in parallel, the test parameters are shown in Table 1. Initial filling rate of heat pipe system is defined as the volume ratio of the heat pipe filling water to evaporator capacity.

Table 1. Test Parameters Range.

Parameter	Value	Unit
Height difference of heat source and heat sink	5500	mm
Down-comer tube diameter	20	mm
Riser tube diameter	150	mm
Initial temperature of cooling tank	～30	℃
Initial water level of cooling tank	2700	mm
Capacity of containment simulator	13	m^3
Inner diameter of containment simulator	2000	mm