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International Conference on Applied Sciences and Smart Technologies

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INCASST 2023

EASTPARC HOTEL YOGYAKARTA, INDONESIA

OCTOBER 18, 2023 – OCTOBER 19, 2023

About

In 2020, the world faced the COVID-19 pandemic which causes various problems. Now in 2023, the pandemic has subsided and many activities have returned to normal. Even so, there are still many problems left behind, including economic, social, educational, health, and so on. As an academic community engaged in science and technology, the Faculty of Science and Technology, Sanata Dharma University (FST SDU) is called to participate in overcoming various problems caused by this pandemic.

Therefore, FST USD intends to hold the international seminar InCASST 2023 (International Conference on Applied Sciences and Smart Technologies) in Yogyakarta, Indonesia, on October 18 2023 with the theme "Science and Technology Disruption in the Post Pandemic Era with Sustainable Development for Better Life Quality". The InCASST 2023 international seminar is also part of the 30th Anniversary of FST USD.

In this seminar, academics and practitioners around the world are invited to share ideas and best practices relevant to the theme of the seminar above in various appropriate fields of knowledge. Selected papers will be proposed to be submitted for publication to a reputable international proceeding. Through these publications, the dissemination of ideas can be expanded so that they become a contribution to solving various post-pandemic problems towards a better quality of life.

All selected paper will be published by **E3S Web of Conferences (Scopus Indexed)**. Papers that are not selected will get back a publication fee.

Conference Proceeding

Theme

Science and Technology Disruption in the Post Pandemic Era with Sustainable Development for Better Life Quality

Scope :

1. Renewable energy technologies and systems
2. Climate change and global warming
3. Sustainable agriculture and land use practices
4. Environmental impact assessment and management
5. Energy policy and planning
6. Clean energy and green technologies
7. Waste management and recycling
8. Air and water pollution control
9. Environmental biotechnology and microbiology
10. Carbon capture and sequestration

Keynote Speaker :



Prof. Ir. Sudi Mungkasi, Ph.D. (Sanata Dharma University-Indonesia)

Prof. Ir. Sudi Mungkasi is a full professor at the Department of Mathematics, Faculty of Science and Technology, Sanata Dharma University, Yogyakarta, Indonesia. He is also a member of the Indonesian Mathematical Society (IPM) and the Indonesian Association of Applied Mathematics (IAAM).

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University, Yogyakarta, Indonesia. He obtained the degree of Sarjana Sains (S.Si.) in Mathematics from Gadjah Mada University, Yogyakarta, Indonesia in 2004. He received the degrees of Master of Mathematical Sciences (M.Math.Sc.) and Doctor of Philosophy (Ph.D.) in Mathematical Sciences from The Australian National University, Canberra, Australia in 2008 and 2013, respectively. He was a postdoctoral fellow at the Mathematical Sciences Institute of The Australian National University in 2013. The professional degree of Insinyur (Ir.) in Engineering Sciences was obtained from Sanata Dharma University in 2021. His research interests include applied and computational mathematics as well as modeling and simulation for physical, biological, chemical, and engineering problems. Currently, he serves as Vice Rector for Academic Affairs of Sanata Dharma University



Prof. Tokuro Matsuo (Advanced Institute of Industrial Technology - Japan)

Prof. Tokuro Matsuo is currently a Full Professor (tenured) at the Advanced Institute of Industrial Technology (AIIT) in Public University Corporation Tokyo Metropolitan University since 2012. Also, he is currently a Director of the Research Center for Artificial Intelligence and Service Science at AIIT and CEO of the International Institute of Applied Informatics (IIAI). His current research interests include agent-based electronic commerce, qualitative reasoning and simulation, material informatics, IT and business management, and IoT. He delivered 150 keynotes and invited talks at international conferences, symposia, and seminars in this decade. He also received over 10 awards on research and over 30 research grants from the government, research foundations, and companies.



Assoc. Prof. Dr. Peerapong Uthansakul (Suranaree University of Technology - Thailand)

Peerapong Uthansakul has been working as the Associate Professor at the School of Telecommunication Engineering and the Director of the Institute of Research and Development, Suranaree University of Technology, Thailand. He has got more than one hundred research publications and is the author/co-author of various books related to MIMO technologies. Furthermore, he is the editor of "Suranaree Journal of Science and Technology" and other leading Thai journals related to Science and Technology. He has won various national awards from the government of Thailand due to his contributions and motivation in the field of Science and Technology. His research interests include green communications, wave propagation modeling, MIMO, Massive MIMO, Brain Wave Engineering, OFDM and advanced wireless communications, wireless sensor network, embedded systems, the internet of things, and network security. His current research interest is in Artificial Intelligence and Bio-Signal studies.



Assist. Prof. Dr. Eng. Rando Tungga Dewa (The Republic of Indonesia Defense University-Indonesia)

Dr. Eng. Rando Tungga Dewa focuses on the fracture mechanics field in advanced technology. He is an Assistant Professor in the Mechanical Engineering Department, RIDU (The Republic of Indonesia Defense University). He has done some research topics including Nuclear Reactor Gen-IV design, vibration fatigue on structures, and advanced additive manufacturing technologies on energetic materials. He, at least published more than 20 peer-reviewed articles and attended 50 symposiums with H-index 8

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- Acceptance Notification : September, 20 2023
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- Full Paper Submission of Accepted Abstract : September 18, 2023
- Conference Day : October 18, 2023

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PREFACE

The 1st International Conference on Applied Sciences and Smart Technologies (InCASST 2023) has been organized by the Faculty of Science and Technology, Sanata Dharma University, Yogyakarta, Indonesia. This event was held on October 18–19, 2023, in Yogyakarta, Indonesia. As an effort to contribute in distributing research outcomes, especially in the search for renewable and clean energy, waste management, environmental management, and sustainable agriculture. InCASST 2023 presented four honorable international keynote speakers from representative countries: 1) Prof. Tokuro Matsuo, Advanced Institute of Industrial Technology - Japan; 2) Prof. Ir. Sudi Mungkasi, Ph.D., Sanata Dharma University-Indonesia; 3) Assoc. Prof. Dr. Peerapong Uthansakul, Suranaree University of Technology – Thailand, and 4) Assist. Prof. Dr. Eng. Rando Tungga Dewa, The Republic of Indonesia Defense University-Indonesia. This event selected local researchers and overseas fellows to share their best research works at this conference to reach a broader network of researchers. After a rigorous selection process, the Scientific & Editorial Board decided to publish 46 papers in E3S Web of Conferences, open-access proceedings in environment, energy, and earth sciences, managed by EDP Sciences, and indexed on Scopus, Scimago.

The published papers have passed all necessary improvement requirements following the Web of Conferences standard, reviewer's comments, and similarity tests by the Turnitin program. We want to thank the official committee, scientific & editorial boards, and organizing partners. Thanks to our co-host partners, Universitas Katolik Widya Mandala Surabaya, Universitas Prasetya Mulya, and Institut Teknologi Nasional Yogyakarta, for trusting and supporting this conference. Finally, we would like to briefly thank all presenters and attendees for their participation in sharing wonderful ideas and making creative decisions to inspire further research and exchange scientific reasons. We hope this time, all papers can be compiled into scientific works as the first publication of the 2023 InCASST. Lastly, we hope this conference encourages further research collaboration and see you at the next conference.

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Science and Technology Disruption in the Post Pandemic Era with Sustainable Development for Better Life Quality

18th October, 2023

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Prof. Ir. Sudi Mungkasi, Ph.D.
Sanata Dharma University
Indonesia



Assoc. Prof. Dr. Peerapong Uthansakul
Suranaree University of Technology
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Date and editor's signature

December 14, 2023

Ir. Damar Widjaja, Ph.D

An experimental investigation on CCFL characteristics during gas/low surface tension liquid counter-current two-phase flow in a small-scaling PWR hot leg typical geometry

Achilleus Hermawan^{1,3*}, *Dede Rafico Saleh*^{2,4}, *Indarto*^{2,4}, and *Deendarlianto*^{2,4}

¹Department of Mechanical Engineering, Universitas Sanata Dharma, Kampus III USD Maguwoharjo, Yogyakarta 55282, Indonesia

²Department of Mechanical and Industrial Engineering, Universitas Gadjah Mada, Jalan Grafika No 2 Kampus UGM, Yogyakarta 55281, Indonesia

³Centre for Smart Technology Studies, Universitas Sanata Dharma, Kampus III USD Maguwoharjo, Yogyakarta 55282, Indonesia

⁴Centre for Energy Studies, Universitas Gadjah Mada, Sekip K-1A Kampus UGM, Yogyakarta 55281, Indonesia

Abstract. A sharp increase in world energy demands which further results in another large progress in the development of nuclear energy establishes comprehensive developments on corresponding mitigation studies. Therefore, as a scenario of accident called LOCA is fundamentally considered, the related phenomena, i.e., the counter-current flow followed by flooding in the primary circuit of PWR, is of a great importance. The present work investigates characteristics of the flooding during a pair of gas/low surface tension liquid counter-current two-phase flow in a complex conduit representing a down-scaled of PWR hot leg typical geometry. Visual observations were obviously carried out to observe the flow phenomenology, while flow parameters were frequently varied. A typical result reveals that the gas flow rate to initiate the flooding decreases with the increase of liquid flow rate. Moreover, exhibiting locations of the onset called locus, a front flooding tends to occur during relatively low liquid flow rates while the higher liquid flow rates exhibit another flooding namely rear flooding. Accordingly, the present investigation provides a package of valuable information on a particular understanding towards the flooding characteristics to overcome the efforts on promoting safety managements on the operation of nuclear power plants..

1 Introduction

The issue of climate change, becoming a catalyst for the utilization of energy sources, as well as a sharp increase in world energy demands, results on another large progress on developments of nuclear energy. However, this source is considered as an environmentally

* Corresponding author: author@email.org

friendly energy which has capability to reduce greenhouse gas emissions [1]. This obviously implies the requirement of comprehensive studies on corresponding mitigation procedures. As both communal and environmental safety issues lead to the implications during operations of nuclear power plants, scenarios of various accidents during the operational of nuclear power plants, for an instance loss of coolant accident (LOCA), are specifically considered.

During LOCA, amount of steam flows counter-currently to condensate. This counter-current two-phase flow is only stable at certain conditions, and limited by the onset of flooding (counter-current flow limitation/CCFL), then followed by both partial delivery and zero liquid penetration (ZLP), respectively [2]. Herein, ZLP may contribute to the failure on core cooling mechanisms. As the corresponding phenomena are of a great importance, investigations on the basis of theoretical analyses, mathematical modelling, numerical simulations, and also experimental works have been widely reported [3]. Therefore, predicting CCFL is one of the most critical issues in nuclear safety evaluation [4].

On the basis of experimental investigations, studies on the basis of visualizations have been largely introduced [2,5-8] through detailed identifications of the obtained flow structures. Here, the mechanisms leading to flooding have been visually observed and supported by signal characterizations obtained by physical measurements such as pressures [9,10] as well as phasic fractions [11]. Subsequently, through these visual observations, CCFL has been largely reported to be characterized through a curve representing the phasic superficial velocity when the transition is initiated, well-known as CCFL characteristic curves.

During numerous studies of factors influencing the CCFL characteristics, effects of channel geometry have been widely reported as the dominant variable to be investigated, whereas effects of physical properties of working fluids have also been proposed, but in a rather small portion [12]. However, the operation of the real nuclear power plants involves dynamic characteristics in the fluid physical properties since it is relatively accompanied by both heat and mass transfers during the flow. Furthermore, the dynamic change in the liquid temperature and the system pressure corresponds the change in the surface tension between the phase, which further affects the momentum transfer. Therefore, the scaling on the fluid properties, for an instance the surface tension, exhibits the opportunity to enhance the database on CCFL characteristics as well as the scaling of channel geometry.

The aforementioned brief literature surveys imply that comprehensive knowledge through obviously visual observations enhances the suitability to describe an understanding during either the mechanism leading to CCFL or the location of the onset. Therefore, the present work provides valuable information related a particular understanding on the flooding characteristics. It properly supports the efforts to either promote the safety management in the operation of nuclear power plant or overcome the environmental impact assessments and managements through further developments of both mechanistic models and validations for computational fluid dynamics.

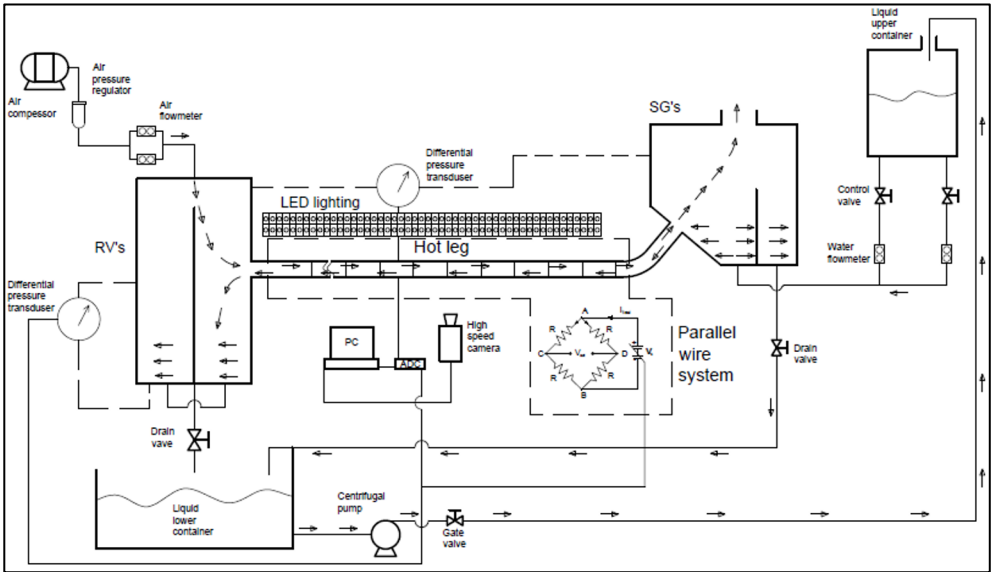


Fig. 1. A schematic diagram of the experimental apparatus.

2 Methodology

The experiments were carried out during a research framework to investigate the characteristics of counter-current flow in a small-scale facility representing a down-scaled model of German-Konvoi PWR primary circuit [9-12,13,14]. The experiment apparatus, which is schematically depicted in Figure 1, has been particularly developed in the Laboratory of Fluid Mechanics and Heat Transfers of Universitas Gadjah Mada, Indonesia. Details of construction of the facility, comprising the fluid supply and lighting systems, and also experimental procedures including the measurement techniques are described by previous reports [9-12,13]. Therefore, in the present reports only the test section is briefly explained in the following.

A test section which represents a 1/30 scaled-down of PWR typical geometry as depicted in Figure 2 was utilized. It is made of transparent acrylic resin to overcome visual observations, and has an internal diameter of 25.4 mm with a 635 mm of characteristic length. Along the horizontal part of the test section, 10 pairs of parallel wire array probes were arranged to acquire the instantaneous interfacial fluctuations during the experiments.



Fig. 2. A photograph of the test section [14].

In addition, particular information of physical properties of the tested fluids at an ambient condition are listed in Table 1. Furthermore, measurements of the density, viscosity and surface tension of the test liquids were particular carried out before and after the experiments. Herein, a gaseous phase utilized air from a unit of reciprocating air compressor, while amount

of an aqueous solution was used as the liquid phase. To decrease the static surface tension of the test liquid, amount of butanol was mixed to distilled water by 5% total volume of the solution.

Table 1. Physical properties of the test fluids.

Fluid	Density (kg/m ³)	Viscosity (kg/m.s)	Surface tension (N/m)
Air (assumed)	1.15	1.87×10 ⁻⁵	-
Distilled water + 5% Butanol	961	9.51×10 ⁻⁴	0.041

Moreover, Table 2 provides a set of information of an experimental matrix. Herein, two types of experimental run were carried out during a constant flow rate of both the liquid and gas, respectively. Under a constant liquid flow rate, QL= 24 gallons per hour (gph), the gas flow rate is stepwise increased by an increment of 5 liters per minute (lpm). It was conducted until the flooding is initiated, and continued to a point in which the liquid does not penetrate the RVs, i.e. ZLP.

On the other hand, during a constant gas flow rate, the air was supplied under the flow condition of QG= 30 liters per minute (lpm). Here, the liquid flow rate was increased by an increment of 2 gph in which an almost similar procedure of experiment was exhibited, but without the occurrence of ZLP.

Moreover, during two-phase flow, a flow parameter namely superficial velocity which assumes that a phase occupies the entire cross section has been considered as the most important variable to overcome developments of two-phase correlations, including CCFL correlations. Here, the phasic superficial velocity (J_k) is defined as the phase flow rate (Q_k) divided by the cross sectional area (A) of the channel. It is further formulated as written in Eq. (1).

$$J_k = \frac{Q_k}{A}$$

(1)

Additionally, since an experimental facility exhibits different in either channel geometries or fluid properties, scaling parameters were largely reported to be applied on the analyses during studies in counter-current flow [3]. Herein, a non-dimensional parameter introduced by Wallis [15] has been largely reported as a scaling function during studies in CCFL characteristics. Moreover, the phasic Wallis velocity (J_K^*), which is defined as the ratio of inertial to gravitational force, involves the density of liquid (ρ_L) as well as the gas (ρ_G), channel diameter (d) and gravitational acceleration (g). It is further formulated as written in Eq. (2).

$$J_K^* = J_K \sqrt{\frac{\rho_K}{gd(\rho_L - \rho_G)}}$$

(2)

Table 2. Experimental tested matrix.

ps (bar)	1					
J _{L,c} (m/s)	0.05					
J _G (m/s)	0	1.2	...	CCFL	...	ZLP

$J_{G,c}$ (m/s)	1.6					
J_L (m/s)	0.019	0.023	...	CCFL	...	0.086

3 Results and discussion

Figure 3 exhibits a typical series of visualization of the obtained interfacial-phasic structures during experiments. Here, the liquid flow rate was kept constant, $Q_L= 24$ gallons per hour (gph), while the gas flow rate was stepwise increased by a relatively small increment of 5 liters per hour (lpm). From the figure it can be seen that for relatively low gas flow rates, $5 \text{ lpm} \leq Q_G \leq 20 \text{ lpm}$, stratified structures with a smooth interface are obtained. Here, an inertial dominated region, called supercritical flow, was observed in the riser and the bend. Meanwhile, another gravitational dominated region, called subcritical region, was noticed along the horizontal section. This change of region allows the occur the hydraulic jump (HJ) phenomenon.

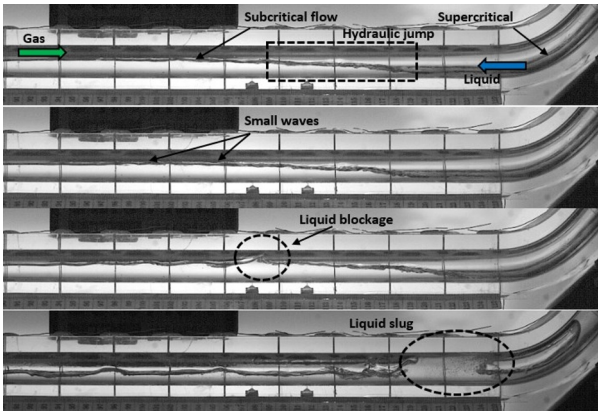


Fig. 3. Typically flow structures during experiments under the flow condition of $Q_L= 24$ gph.

An increase on the gas flow rate into $Q_G= 25$ lpm causes waves to be formed and propagate along the direction of liquid. As a result, relatively wavy interfaces are observed in which the location nearby the upper end of HJ invites a rather fluctuate interface than other locations along the subcritical region. Herein, as previously also reported by Prayitno et al. [16] during the liquid flow, the pressure of the liquid film decreases by the friction while the pressure difference of the interface increases. This leads to interface fluctuations as a compensation of the change in pressure difference on the fluid interface. Therefore, as time progresses, the interface between gas and liquid becomes unstable and waves appear. The instability of the interface boundary occurs due to the increasing friction of the gas and liquid interface.

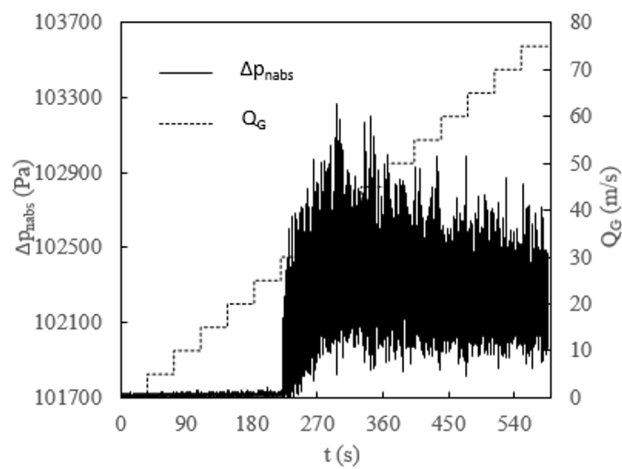


Fig. 4. A typical time-series of pressure fluctuations.

Subsequently, during the increase in gas flow rate at a constant liquid flow rate, the slip velocity increases. It causes the drag force increases. As reported by Zapke & Kroger [17], flooding relates to a phenomenon in which the weight of liquid is balanced by drag force in the direction of gas flow. Besides, the increase in wave height as its propagation may precede the flooding [5,6]. Therefore, it explains that a further increase in gas flow rate, $Q_G= 30$ lpm, results on a portion of liquid to block the entire channel cross section and initiates a slugging to start the flooding. The corresponding phenomena relates to a drastically increase on pressure fluctuations acquired through the pressure probes which are located on the RVs and SGs as typically shown in Figure 4.

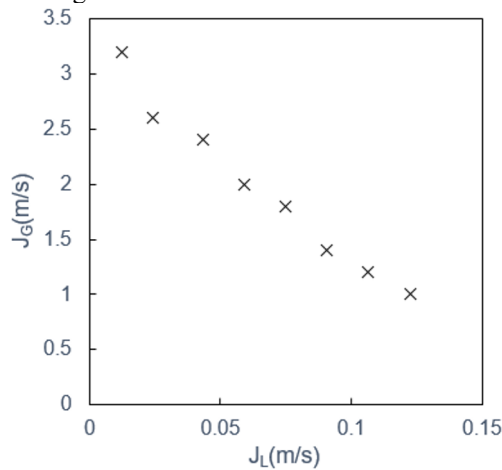


Fig. 5. A curve of CCFL characteristics in terms of phase superficial velocity.

Next, Figure 5 and 6 depict CCFL characteristics’ curves in terms of both phasic superficial velocity and Wallis parameter, respectively. It can be seen in the figure that the curve has a decreasing trend describing that the gas flow rate to initiate the flooding monotonously declines with the increase of the liquid flow rate. Here, as also previously reported by Astyanto et al. [14,18], as the liquid flow rate increases, the liquid film thickness increases and causes a narrower area to be pass by the gas. The more the narrow the area left, the faster the liquid blockage is reached.

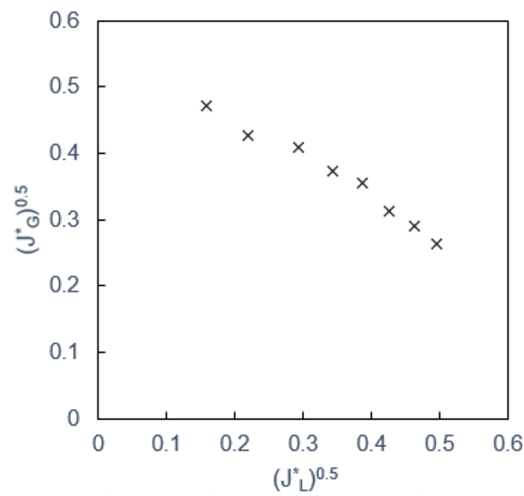


Fig. 6. A curve of CCFL characteristic curve in terms of phase Wallis velocity.

A visually distinguished typical flooding on the basis of the location of the occurrence of initial liquid blockage leading to slugging was reported by Badarudin et al. [19] as well as Deendarlianto et al. [5,6]. A couple type of flooding, namely the upper and rear flooding, by Deendarlianto et al. [5,6] was proposed during the flooding investigation in a straight geometry while front and rear flooding by Badarudin et al. [19] was observed during flooding in hot leg typical geometry. Here, applying the definition previously introduced, the front flooding is defined as the liquid blockage that initiates the flooding occurs at the half of characteristic length nearby the elbow while the rear flooding indicates the opposite location as described in Figure 7.

From the figure it is clearly noticed that the front flooding occurs at low liquid flow rates, while the relatively higher liquid flow rates exhibit the rear flooding. The visual observations reveal that these phenomena correspond to the location in which the hydraulic jump (HJ) occurs. As can also be seen in Figure 3, the upper end of HJ is found to coincide to the location of the onset of slugging. Herein, front flooding generally occurs in the middle of the horizontal pipe to the bend, while rear flooding occurs from the middle of the horizontal pipe to the liquid outlet.

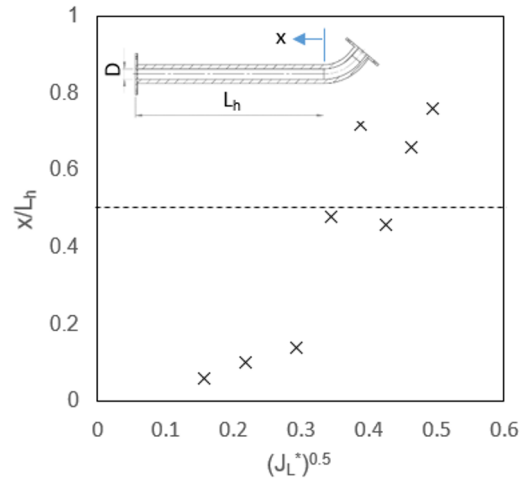


Fig. 7. Front flooding and rear flooding correspond to the liquid flow rate.

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4 Concluding remarks

An experimental-based study covering CCFL characteristics during a pair of gas/low surface tension liquid counter-current two-phase flow in a complex conduit representing a down-scaled of PWR hot leg typical geometry was carried out. Visual observations were obviously conducted to observe the flow phenomenology, while flow parameters were varied. A typical result reveals that the gas flow rate to initiate the flooding decreases with the increase of the liquid flow rate. Furthermore, exhibiting locations of the liquid blockage, a front flooding tends to occur during relatively low liquid flow rates while a rear flooding seems to correspond to higher liquid flow rates. Accordingly, the present study provides a number of valuable knowledge on particular understanding on CCFL characteristics to supports the effort on promoting safety managements in the operation of nuclear power plants.

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