出國報告（出國類別：出席國際會議）

2015 年第二屆應用力學與機械自動化國際學術論文發表會議暨發表論文
(2015 2nd International Conference on Applied Mechanics and Mechanical Automation, AMMA2015)

服務機關：國立嘉義大學
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派赴國家：香港
出國期間：2015 年 4 月 18 日至 23 日
報告日期：2015 年 4 月 27 日

摘　要

2015 年第二屆應用力學與機械自動化國際學術論文發表會(2015 2nd International Conference on Applied Mechanics and Mechanical Automation, AMMA2015)，此會議是由 Defence University College, India 主辦，開會地點在香港帝都酒店，會議期間：104 年 4 月 19-20 日。本出國計畫為作者運用計畫管理費款項之經費，將執行計畫的研究成果，研提論文於該會議中報告發表與交流。此次發表的論文有二：

一為艾群教授論文為「Adaptive Measured Model for Cell Adhesive Force Using Dielectrophoresis Force」，其內容是將人類臍靜脈內皮細胞培養在目前廣泛被應用的生醫材料聚二甲基矽氧烷(polydimethylsiloxane，PDMS)上，並以微製程技術製作出微電極，應用介電泳力進行對內皮細胞貼附力之量測。本研究亦針對工作溶液的選擇、PDMS 基板樣式、工作頻率、膠原蛋白塗佈等參數進行探討，最後得到評估細胞貼附力最適化量測模式為主要之目的。

二為連振昌副教授論文為「Development for a hot-water heating system using biogas energy in the pig farm」，其內容是本研究目的是開發研製一套運用沼氣為加熱能源的分娩舍仔豬熱水保溫系統，利用沼氣燃燒爐來加溫熱水，藉由輸送管路讓熱水流經仔豬保溫箱內導熱鋁板，以便仔豬能藉由金屬的熱輻射對周圍空氣加熱以達到保溫效果。研製完成後先對此套沼氣熱水保溫系統進行模擬測試，在設定的熱水溫度下，探討不同熱水流量對仔豬保溫箱內溫度對時間的變化，以作為進行實地測試的設定條件參考。

關鍵詞：影像處理、介電泳力、即時監控、區域二值化、凸形封包、貼附量測、仔豬、沼氣、分娩舍、熱水保溫系統

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壹、計畫緣起與目的

參加 2015 年第二屆應用力學與機械自動化國際學術論文發表會(2015 2nd International Conference on Applied Mechanics and Mechanical Automation, AMMA2015)，此會議是由 Defence University College, India 主辦，開會地點在香港帝都酒店，會議期間：104 年 4 月 19-20 日。本出國計畫為作者執行研究計畫後，運用計畫管理費款項之經費，出席參加者為生物機電工程學系艾群教授及連振昌副教授，主要目的是將執行計畫的研究成果，研提論文於該會議中報告發表與交流。

貳、參加研討會過程與內容

一、會議議程及議場主題

2015 年第二屆應用力學與機械自動化國際學術論文發表會(2015 2nd International Conference on Applied Mechanics and Mechanical Automation (AMMA2015))，此會議是由 Defence University College, India 主辦，開會地點在香港帝都酒店，內容涵蓋了對提交感興趣的主題包括機械工程的許多領域：聲學與噪聲控制、空氣動力學、應用力學、自動化，機電一體化和機器人、汽車工程、彈道、生物力學、生物醫學工程、CAD / CAM / CIM、複合材料和智能材料、可壓縮流、計算力學、動力學與振動、能源工程與管理、工程材料、疲勞與斷裂、流體力學、流體力學及機械、骨折、燃料和燃燒、地質力學、傳熱傳質、空調、儀表和控制、內燃機、機械及機械設計、製造和生產工藝、海洋系統的設計、材料工程、材料科學與加工、機械設計、機械動力工程、機電一體化、MEMS 和奈米技術、奈米材料工程、新能源和可再生能源、噪音和振動、噪音管制、非破壞性檢測、非線性動力學、塑性力學、污染與環境工程、精密機械、品質保證和環境的保護、固體力學、結構動力學、系統動力學及仿真、摩擦學。

2015 年第二屆應用力學與機械自動化國際學術論文發表會（AMMA2015）於 2015 年 4 月 19 日至 20 日在中國香港舉行，所有投稿發表論文都被同行審查和評估其原創性，學術性和研究內容及深度。此次會議為期二天，大會從 2015 年 4 月 19 日上午 9 點到下午 6 點報到，4 月 20 日上午 8 點 30 分開始進行開幕及分組議場的主題報告。邀請印度機電控制專家學者 Prof. Anil K. Bhatnagar 進行 KEYNOTE SPEECH 的專題演講。艾群教授與連振昌副教授論文發表的題目分別為『daptive Measured Model for Cell Adhesive Force Using Dielectrophoresis Force』及『Development for a hot-water heating system using biogas energy in the pig farm』，壁報發表時間為 4 月 20 日 PART 4: POSRER SESSIONS，上午 8 點 30 分在報告會場的走廊上，一主辦單位提功

的位置張貼壁報，壁報發表時間至下午三點結束，發表過程順利。本組 AMMA2015 論文發表者除了臺灣外，有來自大陸、阿根廷、巴西、挪威泰國、韓國等國的專家學者進行口頭發表及壁報發表，整個議場共計約 200 多人與會，AMMA2015 的口頭發表及壁報發表的論文篇數總計有 99 篇。

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PART 1: PROGRAM SCHEDULE

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14:00-18:00	Conference Registration	
Morning, April 20, 2015		
08:30-08:45	Open Ceremony	Jasmine Room Royal Park Hotel, Hong Kong
08:45-09:30	Keynote Speech *Prof. Anil K. Bhatnagar*	
09:30-10:00	Coffee Break	
10:00-12:00	Oral Session 1 *PEEE2015 & AECA2015*	Jasmine Room 1 Royal Park Hotel, Hong Kong
10:00-12:00	Oral Session 2 *MEITA2015*	Jasmine Room 2 Royal Park Hotel, Hong Kong
12:00-13:00	Buffet Lunch	2+2 Café Royal Park Hotel, Hong Kong
Afternoon, April 20, 2015		
13:00-17:00	Oral Session 3 *ERMM2015*	Jasmine Room 1 Royal Park Hotel, Hong Kong
15:00-15:15	Coffee Break	
13:00-17:00	Oral Session 4 *AMMA2015*	Jasmine Room 2 Royal Park Hotel, Hong Kong
15:00-15:15	Coffee Break	

Development for a Hot-Water Heating System Using Biogas Energy in the Pig Farm

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Keywords: Piglets, Biogas, Farrowing house, Hot-water heating system.

Abstract. A water heating system which utilized biogas energy as a heat source in farrowing house of pig farm was developed in this study. The hot water which was heated by the biogas-burners flowed through the delivery pipeline to heat the metal panel made of aluminum alloy in the piglet's incubator. The ambient air temperature in the piglets incubator could be raised by way of the thermal radiation of the aluminum panel and then kept the piglets warm. The simulation tests of the hot-water heating system was aimed to find out the reference conditions of the field tests by measuring the temperature of the hot water under different flow rate of the hot water and investigating the air temperature change rate in piglets incubator. The results of simulation tests showed that the ambient air temperature of the piglets incubator can achieve above 28 °C within 30 minutes in the conditions of 90 °C hot water and 45.3 L/min water flow rate. The influence of flow rate to the ambient air temperature in the piglet's incubator was not significant. The results of the field tests obtained that the heating panel surface temperature increased significantly with the rising hot water temperature. Under the condition of 85 °C hot water and 45.3 L/min flow rate, the raised air temperature was 5.2 °C within 25 minutes in the piglets incubator where 13-day-age eight piglets stayed. This hot-water heating system can switch by hand to the electric-auxiliary heating device when there is no enough biogas to use. The hot-water heating system can achieve the purpose of saving electric energy and reducing the emissions of the greenhouse gas. It is feasible to operate and adjust the suitable temperature for the growth environment of piglets.

Adaptive Measured Model for Cell Adhesive Force Using Dielectrophoresis Force

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Keywords: Polydimethylsiloxane, Endothelial cell, Dielectrophoresis Force, Cell adhesive force

Abstract. The Human Umbilical Vein Endothelial Cell Line (ECV304) was seeded on the polydimethylsiloxane(PDMS). The object of this study is to find out the adaptive measurement of cell adhesive force, which works in the optimal environment parameter, such as solution, working frequency, collagen smearing etc., to avoid the bubble formation in the solution. The result showed the cells seeded on the large area substrate with 2 mm structural spacing and the small area substrate with 100 μm structural spacing have better adhesive force. It was also clear to find that large area substrates also showed faster cell growth and expansion. They are more suitable as culture substrates for the measurement of cell adhesion force. As for work solution, 2% glucose solution that has relative low conductivity and concentration has the best measurement that effectively obtained cell adhesion force.

二、研討會發表內容摘述

（一）艾群教授

本研究是將人類臍靜脈內皮細胞(Human Umbilical Vein Endothelial Cell Line，ECV304)培養在目前廣泛被應用的生醫材料聚二甲基矽氧烷(polydimethylsiloxane，PDMS)上，並以微製程技術製作出微電極，應用介電泳力進行對內皮細胞貼附力之量測。本研究亦針對工作溶液的選擇、PDMS 基板樣式、工作頻率、膠原蛋白塗佈等參數進行探討，最後得到評估細胞貼附力最適化量測模式為主要之目的。由研究結果顯示，於 PDMS 基板上設立微結構將有助於改善因 PDMS 的疏水性造成膠原蛋白塗佈不均勻的問題，同時將細胞培養於結構間的區域可有效減少膠原蛋白的用量，並可確認待測細胞是否位於塗有膠原蛋白之區域。實驗中並嘗試將細胞培養於平面、大面積、小面積等三種不同結構之 PDMS 培養基板，由結果發現細胞培養於結構間距為 2 mm

的大面積與結構間距為 100 μm 的小面積培養基板上時擁有較佳的貼附力曲線；且將細胞培養於大面積培養基板時，可明顯發現細胞增生、拓展速度較快，因此較適合作為細胞貼附力量測時的培養基板樣式。在工作溶液方面，則以導電度、濃度較低的 2.0 %葡萄糖溶液作為本實驗中的工作溶液，其進行量測的效果最好，可以有效的得到細胞貼附力量值。

（二）連振昌副教授

研究開發研製一套運用沼氣為加熱能源的分娩舍仔豬熱水保溫系統，利用沼氣燃燒爐來加溫熱水，藉由輸送管路讓熱水流經仔豬保溫箱內導熱鋁板，以便仔豬能藉由金屬的熱輻射對周圍空氣加熱以達到保溫效果。研製完成後先對此套沼氣熱水保溫系統進行模擬測試，在設定的熱水溫度下，探討不同熱水流量對仔豬保溫箱內溫度對時間的變化，以作為進行實地測試的設定條件參考，從模擬試驗結果得到，在熱水溫度 90℃、熱水流量 45.3 L/min 的條件下，保溫箱在 30 分鐘內可達到 28℃以上，熱水流量大小對保溫箱的溫度改變影響並不明顯。從實地測試結果得知，熱導板的溫度隨著熱水溫度的上升而有明顯的上升，在日齡 13 日 8 隻仔豬的保溫箱內，熱水設定溫度為 85℃時，在 25 分鐘內保溫箱內的溫差是 5.2℃。當本系統無足夠沼氣使用時，可切換利用電熱輔助裝置來加熱；本系統可以節約電能、降低溫室氣體排放，進而達到節能減碳之目的。系統操作方便又可隨著仔豬的成長而調整其適合的溫控環境，且當沒有沼氣使用時可切換到電氣加熱於水。

三、與會見聞或新知

2015 年第二屆應用力學與機械自動化國際學術論文發表會(2015 2nd International Conference on Applied Mechanics and Mechanical Automation (AMMA2015))，提高機械工程與自動化工程相關的技術研究人員和從業人員之间的溝通。本次參與此國際會會議期能瞭解目前國際在細胞力學方面的各種應用，以期未來能夠進一步做相關方面的研究。本次會議經評審過的論文，將全部出版在國際期刊 Applied Mechanics and Materials(ISSN: 1662-7482)，在該刊物發表的論文將被 EI Compendex 和 ISTP 收錄。壁報發表的過程順利，充分強調研究的重點，會後也和與會人士討論相關的研究主題及成果，收穫豐富。

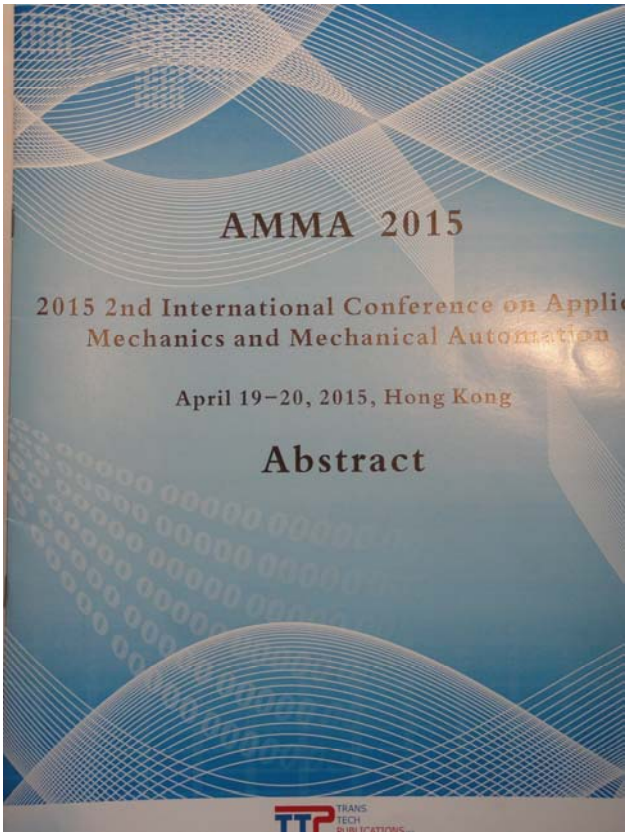
會後攜回參加會議論文發表證明及相關資料如下：

(一) 會場參加相片

(二) AMMA2015 論文摘要集

(三) 會議程序手冊


Welcome to
AMMA2015
ERMM2015
PEEE2015
AECA2015
MEITA2015
April 19 and 20, 2015 in Hong Kong


AMMA 2015
2015 2nd International Conference on Applied
Mechanics and Mechanical Automation
April 19–20, 2015, Hong Kong
Abstract


AMMA 2015
2015 2nd International Conference on Applied
Mechanics and Mechanical Automation
ERMM 2015
2015 2nd International Conference on Education
Reform and Modern Management
MEITA 2015
2015 International Conference on Management
Engineering and Information Technology Application
AECA 2015
2015 International Conference on Agricultural
Engineering and Computer Application
April 19–20, 2015, Hong Kong
Conference Program

參、心得與建議事項

一、心得

能夠有機會參與 2015 年第二屆應用力學與機械自動化國際學術論文發表會，並與生物機電研究的相關領域跟各地專家相互討論交流與分享研究成果，感覺獲益良多。在相關議題相互討論及分享研究成果與實務經驗，進而強化國內相關學術研究領域應用視野，對與會的國內學者有顯著助益。

與來自各地的專家學者齊聚一堂，針對生醫工程與生物機電研究的相關議題相互討論、彼此交流、分享研究成果與實務經驗，實在是獲益良多。會議期間與數位大陸優秀學者進行學術交流，瞭解到現今中國學術研究已漸漸蓬勃發展，深深地覺得臺灣要繼續保持學術優勢需不斷的提升自我的學術能力，多與全球進行學術交流，擬定學術研究正確的方向，避免閉門造車之撼。

二、建議事項

參加這次會議，有些感觸與建議，這裡提出幾點建議意見：

(一) 香港在舉辦國際研討會很熱絡，由此次的參與過程可知，此可交由專門公司承包，減輕承辦人員的負擔。反觀我國所有大小事情全需要承辦單位包辦，但事事受限於會計法，承辦人員會很累。

(二) 由大會中發表的論文可看出，除了應用力學、生物醫學工程和機電控制研究領域之外，各國專家學者都積極的從事於新興科技的研究，如微奈米科技、生醫工程和感測技術的開發。此在生物機電未來的研究上，運用新興科技是生物機電工程人員必須著墨的範疇。

肆、附錄

附錄一　論文接受通知信函

一、艾群

Acceptance and Invitation Letter

2015 2nd International Conference on Applied Mechanics and Mechanical Automation (AMMA2015)
http://www.amma2015.org
April 19-20, 2015, Hong Kong

Paper ID: A105

Paper title: Adaptive Measured Model for Cell Adhesive Force Using Dielectrophoresis Force

Authors: Cheng-Chang Lien, Jie-Yu Cheng, Chao-Wang Young, Chyung Ay*

Dear Authors,

Thank you for submitting the above paper to the 2015 2nd International Conference on Applied Mechanics and Mechanical Automation (AMMA2015). AMMA2015 will be held on April 19-20, 2015, in Hong Kong. All the papers accepted by AMMA2015 will be published in the Journal "Applied Mechanics and Materials (ISSN: 1662-7482)" and indexed by EI Compendex and ISTP. Excellent papers will be selected and published on SCI and EI journals.

As a result of the reviews and revisions, we are pleased to inform you that the paper above has been formally accepted for publication on the above AMMA2015 conference proceedings. We appreciate if you could send the final version of the manuscript at your earliest convenience, to ensure a timely publication of the paper. When submitting the final version, please highlight any changes or amendments made to the manuscript.

Thank you for your contribution to the AMMA2015 and we are looking forward to your future participation on April 19-20, 2015, in Hong Kong.

Welcome to AMMA2015, welcome to Hong Kong.

Yours sincerely,

AMMA2015 Organizing Committee

October 28, 2014

二、連振昌

Acceptance and Invitation Letter

2015 2nd International Conference on Applied Mechanics and Mechanical Automation (AMMA2015)
http://www.amma2015.org
April 19-20, 2015, Hong Kong

Paper ID: A101

Paper title: Development for a hot-water heating system using biogas energy in the pig farm

Authors: Cheng-Chang Lien, Jeng-Liang Lin , Perng-Kwei Lei

Dear Authors,

Thank you for submitting the above paper to the 2015 2nd International Conference on Applied Mechanics and Mechanical Automation (AMMA2015). AMMA2015 will be held on April 19-20, 2015, in Hong Kong. All the papers accepted by AMMA2015 will be published in the Journal "Applied Mechanics and Materials (ISSN: 1662-7482)" and indexed by EI Compendex and ISTP. Excellent papers will be selected and published on SCI and EI journals.

As a result of the reviews and revisions, we are pleased to inform you that the paper above has been formally accepted for publication on the above AMMA2015 conference proceedings. We appreciate if you could send the final version of the manuscript at your earliest convenience, to ensure a timely publication of the paper. When submitting the final version, please highlight any changes or amendments made to the manuscript.

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Welcome to AMMA2015, welcome to Hong Kong.

Yours sincerely,

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October 28, 2014

附錄二 發表論文內容

一、艾群

Adaptive Measured Model for Cell Adhesive Force Using Dielectrophoresis Force

Cheng-Chang Lien [#1], Jie-Yu Cheng[#2], Chao-Wang Young[#3], Chyung Ay[#4*]

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Keywords: polydimethylsiloxane, endothelial cell, dielectrophoresis force, cell adhesive force

Abstract—The Human Umbilical Vein Endothelial Cell Line (ECV304) was seeded on the polydimethylsiloxane(PDMS). The object of this study is to find out the adaptive measurement of cell adhesive force, which works in the optimal environment parameter, such as solution, working frequency, collagen smearing etc., to avoid the bubble formation in the solution. The result showed the cells seeded on the large area substrate with 2 mm structural spacing and the small area substrate with 100 μm structural spacing have better adhesive force. It was also clear to find that large area substrates also showed faster cell growth and expansion. They are more suitable as culture substrates for the measurement of cell adhesion force. As for work solution, 2% glucose solution that has relative low conductivity and concentration has the best measurement that effectively obtained cell adhesion force.

Introduction

Many studies show that cells must attach and adhere to a substrate before they can start to spread on the substrate, proliferate, differentiate, and migrate. Therefore, the adhesion between cells and cells, or between cells and substrates, is an important aspect of cell-substrate behaviors.

Several studies have investigated the cell adhesion strength from mechanical point of view. In the past researches, cell adhesion strength has been studied as centrifugation force by centrifuge, tensile force by micropipette manipulation, shear force by parallel flow chamber and chemical binding force by atomic force microscope[1][2][3][4]. However, centrifugation force by centrifuge and shear force by parallel flow chamber can't work on a single cell and hence the measured strength of cell adhesion may not be accurate. Tensile force by micropipette manipulation and chemical binding force by atomic force microscope are both complicate and expensive techniques for the analysis of cell adhesion strength. DEP is the phenomenon in which a particle, such as a living cell, is polarized and moved by the electrical gravity in a non-uniform electric field[5]. Like gel electrophoresis, DEP can move neutral particles in a non-uniform AC electric field, for the separation and analysis of a variety of biological particles such as cells, DNA, and viruses[6][7][8]. In here, we utilized the DEP force acting on the cells to induce spatial movement for studying the cell adhesion strength. DEP may provide a new and cheap technique in cell adhesion measurement.

MATERIALS AND METHODS

● Dielectrophoresis Theory

When an electrically neutral cell is placed in an electrical field, the cell can be polarized by the external force of the electrical field. DEP force is a phenomenon in which a force is exerted on a dielectric cell when it is subjected to a non-uniform electric field. The most commonly used electrode geometry to generate the non-uniform electric field. Cells will then move towards stronger or weaker regions of the electrical field. The movement of the cells depends on the cells properties, working

solution, and the strength of the electrical field.

The dielectric constant ε (fards/m) for the suspension solution of a living cell indicates the tendency of cell polarization when partial charges of the cell are subject to an electric field. Conductivity σ (S/m) can indicate the tendency for the free charges on the cell to move in an electric field, and usually depends on the solution ion content, dissociated ion concentration, charge amount and ion mobility. In this study, bioparticles are represented as cells. The average DEP force acting on a cell, which immersed in a medium and exposed to a spatially non-uniform can be described by [9]:

$$F_{DEP} = 2\pi\varepsilon_m\left[\frac{\varepsilon_p - \varepsilon_m}{\varepsilon_p + 2\varepsilon_m} + \frac{3(\varepsilon_m\sigma_p - \varepsilon_p\sigma_m)}{\tau(\sigma_p + \sigma_m)^2(1+\omega^2\tau^2)}\right] r^3 \nabla E^2 \quad (1)$$

Where in this study some constants be assumd:

ε_0 ：dielectric constant in vacuum, 8.854×10^{-12} (farads/m) (Ogata et al., 2001)

ε_m： dielectric constant of solution (glucose), 76.5 ε_0 (farads/m) (Mckee et al., 2000)

ε_p ： dielectric constant of biological particle, 60 ε_0 (farads/m) (Morgan and Green, 2003) , 3.53 (μS/cm)

σ_m ：Electric conduction coefficient of solution (glucose)

σ_p ：Electric conduction coefficient of biological micro-particle, 0.5 (S/m) (Morgan and Green, 2003)

τ ：characteristic time of dipole charge(sec)　　r ：cell radius (m)

∇E^2 ：gradient of electric field squared $(V/m)^2$　　ω ：electric field frequency (rad/sec)

Hence, DEP force (F_{DEP}) is can be calculated from the above equation. Since the DEP force is directed along the gradient of electric field intensity, ∇E^2, and electric field intensity (E) is proportional to the electric potential (V) which works in the electric field when the length of medium between two electrodes is constant.

● Materials

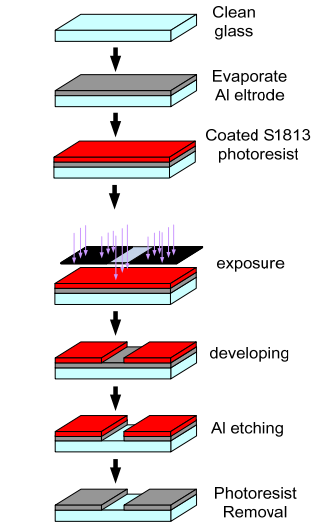
The human endothelial cells, ECV304 was obtained from America Type Culture Collection (ATCC). SYLGARD® 184 silicone elastomer kit was purchased from Dow Corning (Taipei, Taiwan). All culture materials were purchased from Gibco (Grand Island, NY, USA) and all chemicals of reagent grade were obtained from Sigma (St Louis, MO).

● The measurement of cell adhesion force

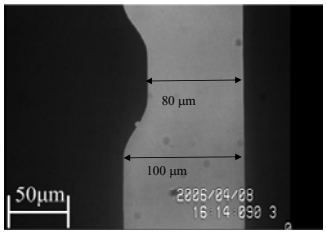
The experiment utilized micro-processing technology to etch a glass plate with two different width electrodes to produce non-uniform electric field (Fig. 1a). For DEP force generation, electrical potential was supplied to the aluminum electrode (Fig. 1b) by a function generator and a power amplifier to produce an uneven electrical field. The scheme of dielectrophoresis (DEP) force measurement system is shown in Fig. 2. For measurement of cell adhesion strength, cells were first seeded on collagen type 1 and fibronectin coated PDMS membranes respectively. At certain time intervals after cell seeding, the PDMS membranes were covered with two different width electrodes plate (deposition aluminum with a height of 800 nm; the shorted distance between electrodes set at 80 μm, with the greatest distance between electrodes at 100 μm) to produce DEP force with the supply of electrical charge (Fig. 1b). During the measurement of cell adhesion strength, electrical potential was increased in the rate of one-third voltage per second from 0 to 10V and then changed to one-tenth voltage per second until the focal cell was detached from the PDMS surface. Till cell detached from the PDMS surface, the electrical potential (V) is recorded to be the strength of cell adhesion.

● Methodology - Optimal measurement experiments

The object of this study is to find out the adaptive measurement of cell adhesive force, which works in the optimal environment parameter, such as solution, working frequency, collagen smearing etc., to avoid the bubble formation in the solution. It is to use collagen smearing to culture endothelial cells on different PDMS micro-structure substrate, investigate the experimental factors to affect cell adhesion, optimal smearing method, possible issues and solutions to obtain the desired cell growth condition.



(a)



(b)

Fig. 1. Micro-electrode process and product

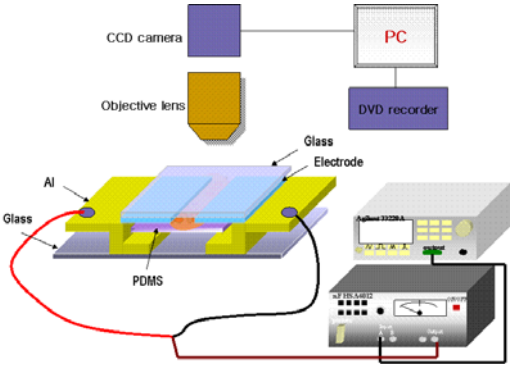


Fig.2 System Diagram

Since the cell seeded on the substrate in the research was polydimethylsiloxane (PDMS) which hydrophobicity prevented collagen smearing, microstructure was built on PDMS to hold the solution in the cell culture area by capillary effect. Investigation was also made between micro-structured and non-structured PDMS and for different structural spacing. Through this, whether structure could affect adhesion significantly would be known, as well as whether different structural spacing when cells have different growth space would generate different physiological mechanism.

D-1 Selection of Work Solution

Dielectric property, conductivity and dissociation degree for different work solutions would change the effect of DEP force on cell behavior. Overly high osmolarity can cause leakage of water inside cell membrane and crenation； overly low osmolarity can cause water from work solution to enter cell membrane and expand, or even rupture, the cell. Thus, selection of solution and concentration is an essential parameter in the experiment.

D-2 Style of cell culture substrate

The research used collagen smear on different PDMS micro-structure substrates for cell adhesion. Since PDMS is hydrophobic, when collagen is smeared on PDMS, its contact angle with PDMS is large due to surface tension and beads are formed. So it is necessary to have an integrated smearing process to provide each cell with identical growth condition. In this study, there are two ways to find out which style is better to cell culture. One way is compared no-modified and modified the surface property of substrate through oxygen plasma process. The others is changed the structure of substrate. It is hoped to reduce the usage of collagen and overcome hydrophobicity.

The specifications for the three substrates are as follows：

1. *Flat substrate*: flat PDMS substrate without any column structure and culture cells on it.
2. *Large substrate*： PDMS with an array of four columns (diameter 100 μm); culture cells on the cross flat area among the four columns; the width for flat area is 2 mm.
3. *Small substrate*: PDMS with three columns (diameter 100 μm); column spacing is 100 μm; culture cells on the blank area between columns.

III. RESULTS AND DISCUSSION

A. Selection of Work Solution to avoid bubble formation

The research used NaCl and glucose solution as the primary work solution. It was found in the beginning of cell seeding, the adhesion was small, so it was easy for DEP force to detach from the substrate, once the cell adhesion became large, the applied voltage increases, but the tendency of

electrolysis for aqueous solution also increased, and bubbles were formed on electrode surface and cell squeezing also occurred. Formation of bubbles affected measurement of cell adhesion. Besides, formation of bubbles also tended to damage the electrodes. Different solvent characteristic would have different concentration in water, so ion content and dissociation also vary, and there is different conductivity. The relationship between work voltage and solution to bubble formation is showed in Table 1. For each concentration, five experiments were conducted and voltage at each bubble formation was recorded into table for comparison.

From Table 1, it was found that when glucose solution was used as work solution for adhesion force measurement, with consideration that extremely low osmolarity would have impact to cell physiology or cell membrane rupture, it was suggested 2.0 % glucose solution was the optimal work solution to assess human endothelial cell adhesion by DEP force.

B. Style of cell culture substrate

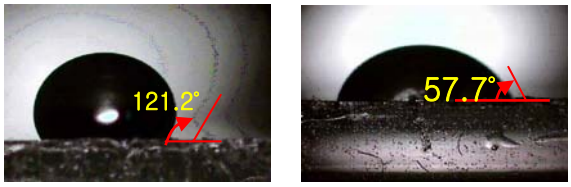
From Fig. 3 it was found that after surface modification by oxygen plasma treatment then contact angle changed a lot and the original hydrophobic nature was changed to hydrophilic. Therefore, after oxygen plasma treatment, experiment should proceed immediately to minimize errors due to surface property variation.

The experiment used 2.0 % glucose solution as work solution with work frequency of 1MHz, and used flat PDMS substrate treated by no treatment and oxygen plasma treatment, and then seeded cells for 0~7 hours prior conducting adhesion measurement.

Table 1 Work voltage of bubble formation under different work solution and concentration

solution	Concen-Tration (%)	#1	#2	#3	#4	#5	Voltage * (V)
NaCl	0.4	12.0	10.7	12.0	12.0	10.7	11.4
NaCl	0.9	8.2	8.2	8.2	8.2	8.2	8.2
NaCl	1.5	7.0	5.7	7.0	8.2	7.0	6.9
NaCl	2.0	10.7	10.7	10.7	9.4	10.7	10.4
NaCl	3.0	7.0	8.2	8.2	8.2	8.2	7.9
glucose	0.3	27.7	29.0	27.7	27.7	27.7	27.9
glucose	2.0	21.1	14.6	29.0	29.9	29.9	24.9
glucose	5.0	22.4	15.9	22.4	22.4	21.8	20.9
glucose	7.0	25.0	19.8	15.9	13.3	15.9	17.9
glucose	9.0	15.9	15.9	15.9	14.6	15.9	7.9

*(V): Average working voltage at bubble formation



(a) Before treatment (b) after treatment

Fig. 3 Contact Angle before and after Oxygen Plasma Treatment

Fig. 4 was adhesion diagram for flat substrate and indicated several parts that had abrupt drop of adhesion force. Since the culture dish and growth environment were identical and adhesion force was measured, theoretically adhesion force would increase with seeded time and start leveling off after several hours. But the unusual phenomenon found in the curve suggested hydrophobic PDMS made it difficult for collagen evenly smeared, and under-smeared area could have significant decrease in adhesion force. It was possibly because after PDMS substrate surface changed from hydrophobic to hydrophilic, although solution was easier to smear on the surface, the limited usage of collagen and no surface structure to hold the solution caused poor overall uniformity of smearing.

C. Cell Adhesion Force for Different Microstructures

To test collagen smearing state, besides the original flat substrate, there were another two different PDMS microstructures. There were *flat substrate*, *large area substrate* and *small area substrate*.

From Fig. 5 it was found that the cell adhesive force in the experiment with three different substrate microstructures when cells were seeded on large area substrate and small area substrate. When further comparison was made to the abrupt drop of adhesion force, it was also found that there was a trend that adhesion force increased with seeded time. It can be found that when collagen was smeared on microstructure, capillary force between columns would keep the solution in the gap. Therefore, besides adhesion curve could prove that structured PDMS had better adhesion. When the

cells were seeded on large area substrate or small area substrate, it was clear that their adhesion force increased with seeded time.

From Figure 5 it was found that among the three substrates the adhesion force was mostly lower in the flat substrate, and its maximum adhesion force occurred at 2.5 hours and the adhesive force was about 7.2 nN. Further, with increasing seeded time, the adhesion force did not increase. When cells were seeded on large substrate and small substrate, the maximum adhesion force occurred at 7 and 6.5 hours and adhesion force was 21.6 and 15.4 nN. The large substrate had larger adhesion force than the smaller substrate.

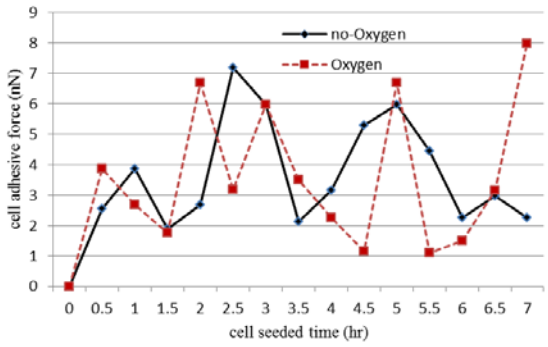


Fig 4 Cell Adhesion Force on Flat PDMS Substrate

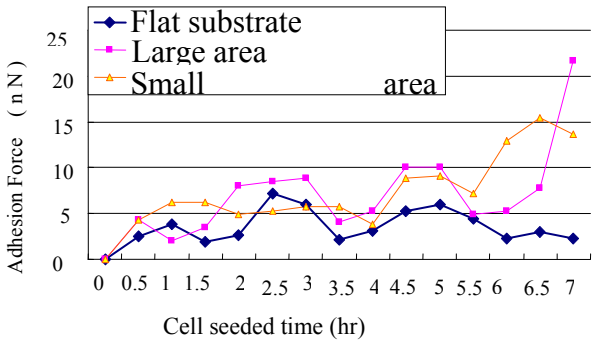


Fig. 5 Cell Adhesion Force for Different Substrates

Conclusions

The research is mainly to use DEP force to measure cell adhesion force and establish the optimal measurement model. The conclusions are summarized in the following：

1. When NaCl is used as work solution and the concentration is around 0.4 %~3 %, it is easy to form bubbles and affect adhesion measurement. If weak electrolyte, 2.0 % glucose solution, is used as work solution, adhesion measurement can be conducted smoothly.
2. For oxygen plasma treatment on flat PDMS substrate, both experiment results and literatures indicated surface hydrophobicity was clearly improved. Compared to non-treated PDMS flat substrate, the treated one has better adhesion force.
3. When the endothelial cells are cultured on structured large PDMS substrate and small substrate, the maximum adhesion occurs at 7 and 6.5 hours and the forces are 21.6 and 15.4 nN, compared to 0 nN before adhesion. The large substrate had larger average adhesion force than the small substrate. This means the large area substrate has better adhesion effect.
4. When the large area substrate with column spacing 2 mm is used to culture endothelial cells, it facilitates cell adhesion speed to obtain better growth condition. It is more suitable as the cell culture substrate for adhesion measurement.

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二、連振昌

Development for a hot-water heating system using biogas energy in the pig farm

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Keywords: Piglets, Biogas, Farrowing house, Hot-water heating system.

Abstract. A water heating system which utilized biogas energy as a heat source in farrowing house of pig farm was developed in this study. The hot water which was heated by the biogas-burners flowed through the delivery pipeline to heat the metal panel made of aluminum alloy in the piglets incubator. The ambient air temperature in the piglets incubator could be raised by way of the thermal radiation of the aluminum panel and then kept the piglets warm. The simulation tests of the hot-water heating system was aimed to find out the reference conditions of the field tests by measuring the temperature of the hot water under different flow rate of the hot water and investigating the air temperature change rate in piglets incubator. The results of simulation tests showed that the ambient air temperature of the piglets incubator can achieve above 28 °C within 30 minutes in the conditions of 90 °C hot water and 45.3 L/min water flow rate. The influence of flow rate to the ambient air temperature in the piglets incubator was not significant. The results of the field tests obtained that the heating panel surface temperature increased significantly with the rising hot water temperature. Under the condition of 85 °C hot water and 45.3 L/min flow rate, the raised air temperature was 5.2 °C within 25 minutes in the piglets incubator where 13-day-age eight piglets stayed. This hot-water heating system can switch by hand to the electric-auxiliary heating device when there is no enough biogas to use. The hot-water heating system can achieve the purpose of saving electric energy and reducing the emissions of the greenhouse gas. It is feasible to operate and adjust the suitable temperature for the growth environment of piglets.

Introduction

Biogas is a versatile renewable energy source, which can be used for replacement of fossil fuels in power and heat production. The production of biogas can drastically reduce greenhouse gas emissions compared to fossil fuels by utilization of locally available resources. Anaerobic digestion is often the only possibility to produce biogas from manure. By definition, anaerobic digestion is a microbiological process which organic matter is decomposed into biogas and microbial biomass in the absence of air. If handled properly, manure in pig farm can be a valuable resource for renewable energy production. The major of biogas are carbon dioxide (CO_2), ammonia (NH_3), hydrogen sulfide (H_2S) and methane (CH_4). Among them, hydrogen sulfide apparently is the most toxic to both humans and animals [1, 2, 3].

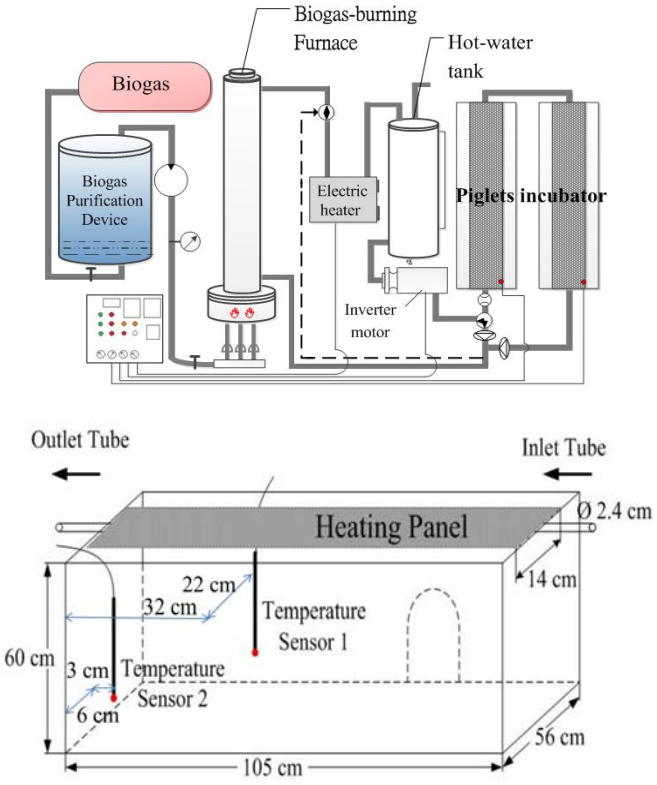
It is well-known that sows and piglets in farrowing house require different ambient air temperature. The sows feel comfortable at temperature between 18°C and 21°C while the piglets prefer higher temperature between 28 and 32°C in resting area. Piglets, especially in the first two weeks, need the additional heat source to increase ambient air temperature [4, 5]. However, if the ambient air temperature was higher than the temperature range that the sows required, it might be lead to negative effect for lactating sows' feed intake and milk production [6]. Therefore, the balance atmosphere has to be provided especially in farrowing houses because of the difference in heat requirement between sows and their piglets. The heating system plays a crucial role in nurturing of piglets in the farrowing house. Due to increasing price of electric energy, piglets heating with electric heaters and electric mats are more and more seldom used [7]. The heat insulation systems for piglets of the farrowing houses which use the renewable energy as heating resource have been studied in recent years [8, 9].

The purpose of this research is to design and test a heating system for piglets incubator in the farrowing house, and the changes of the air temperature to the time in piglets incubator under different temperature of the hot-water and number of piglets in a stationary flow are investigated. The water was heated by using burned biogas energy and let the hot water flow through the metal panel which is made of aluminum alloy with hot-water pipe in this study. The thermal radiation by the metal panel with high temperature was use to rise the ambient air temperature of the piglet incubator.

Materials and Methods

1. Hot-water heating system for piglets

The hot-water heating system was divided into three parts in Figure 1(a), one was the biogas-combustion device, another was the temperature-control device, and the other was the design of the piglets incubator. The biogas-combustion device utilized biogas as a heat source to heating water, and flowed through the delivery pipeline to heat the metal panel in the piglets incubator. The biogas-combustion device was combined with biogas purification device, biogas-burning furnace, electric heater, etc.



(a) (b)

Figure 1. (a) The schematic diagram of he hot-water heating system. (b) The schematic diagram of the design of the piglets incubator.

The temperature-control device includes an electrical control panel, two thermal sensors in the piglets incubators, a water temperature sensor which was installed at the electric heater and an inverter motor. Adjusting the frequency of the inverter motor as 15 Hz, 30 Hz and 60 Hz, meanwhile,-the flow rate of the water pipe corresponded to 10 L/min, 23.3 *L*/min and 45.3 L/min. The design of the piglets incubator (105 cm × 56 cm × 60 cm)) with the metal panel made of aluminum alloy is shown as the figure 1(b). The metal panel made of aluminum alloy was heated by the circulated hot water. There were two thermal sensors in the piglets incubator were set up. One was located at the side of 22 cm and away from the outlet tube about 32 cm (T1), the other was located at the sides of 3 cm and 6 cm (T2). Both of height were 15cm from the bottom of the incubator.

2. Simulations tests and field tests of the water heating system

The simulations test (Fig 2a) ensured that the water heating system could be operated normally. In addition, the results of the test would be used as a basis of the actual operation for the field test. The condition of the simulation test was conducted with the temperature 90 °C hot water and three kinds of the flow of the water.

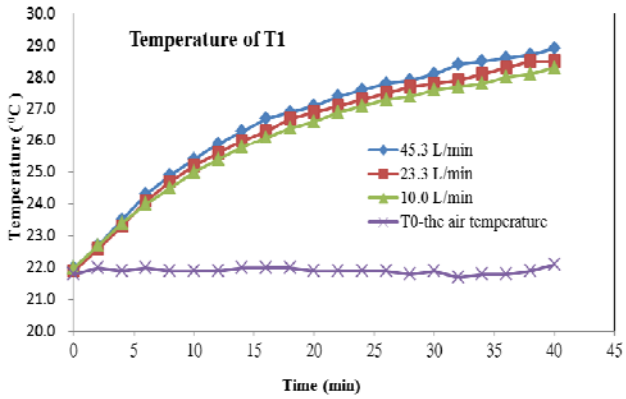
As the figure 2(b) shown that the water heating system was connected with the biogas-input port of the pig farm. At the same time, there were few piglets in the incubator in accordance with the test condition for the field test. Turn on the biogas burner to heat the water and set the temperature of hot water 65 °C, 75 °C and 85 °C. The temperature of metal panel was measured using infrared thermometer (MX4, Raytek, USA), and the ambient air temperature in piglets incubator was also measured using a thermal sensor (U10-003, HOBO,USA) and the rising of the temperature ($\Delta T=T1-T2$) of the piglets incubators could be calculated under different quantity of day-old piglets and different temperature of hot water.

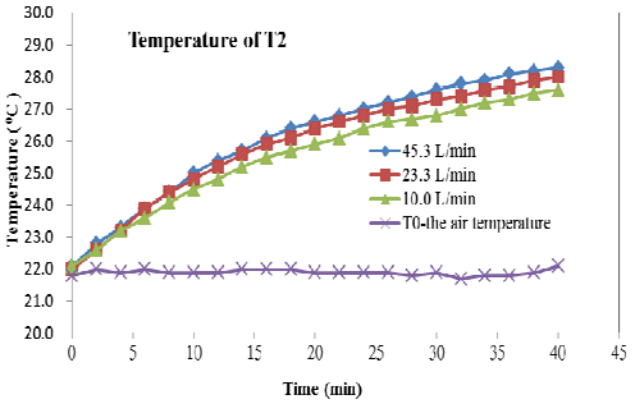
(a) (b)

Figure 2. (a) The simulation test of the water heating system. (b) The field test in the farrowing house of the little pig farm.

Results and Discussions

The simulations were conducted with three levels of flow rates as 10 L/min, 23.3 *L*/min and 45.3 L/min. Two thermal sensors were set as T1 and T2 to measure the inner temperature and the side temperature of the piglets incubator. Besides, the temperature sensor of T0 was set to measure the air temperature outside the incubator which was 22°C, and the result is shown as the figure 3.





(a)

(b)

Figure 3. The ambient air temperature of the piglets incubator for thermal sensors T1 in Fig. (a) and T2 in Fig. (b) with 90 °C hot water and the different flow rate

In Fig.3(a), the ambient air temperature of the piglets incubator for thermal sensors T1within 30 minutes achieved 27.4 °C, 27.8°C and 28.1 °C when the flow of the water reached 10 *L*/min, 23.3 *L*/min and 45.3 *L*/min with 90 °C hot water. In the other word, the raised temperature were relative to the ambient air temperature of incubator about 5.2 °C, 5.9 °C and 6.1 °C. The ambient air temperature of the piglets incubator for thermal sensors T2 within 30 minutes was shown in Fig. 3(b) achieved 26.8 °C, 27.3°C and 27.6 °C. However, three level of flow rate did not influence remarkably the ambient air temperature of the piglets incubator. The difference between T1 and T2 was about 0.2-0.5 °C. It is estimated that the air temperature achieved to the required temperature for piglets (28 °C ~ 32 °C).

The relationship between hot water temperature (T_w) and heating panel surface temperature (T_{panel}) was shown in Table 1. The T_{panel} increased significantly with the raised T_w. Considered about the height and activities of the actual piglets for field test, the thermal sensors were placed at 25 cm above the undersides of the incubator. The field test was conducted in different number of 13-day-age piglets and different hot water temperatures under a stationary flow rate as 45.3 L/min. The raised air temperature of the piglets incubators within 25 minutes was recorded and the results were shown in Figure 4. The raised air temperatures (ΔT) in the piglets incubators with eight piglets were 2.7 °C, 3.4 °C and 5.2 °C for different hot water temperatures. The ΔT in the piglets incubators under 85 °C hot water were 1.4 °C, 2.3 °C and 5.2 °C for different number of the 13-day-age piglets. Because of body thermal capacity of the individual piglet, the ΔT in the piglets incubators with eight piglets was obviously higher compared to two and four piglets. It can be clearly found that the ΔT of the piglets incubators increased with the number of the 13-day-age piglets and the temperature of the hot water obviously. Generally there is about 10 piglets per parity for a sow that is enough to reach the required temperature as long as it takes more than 25 minutes.

Table 1. Relationship between hot water temperature T_w and heating panel surface temperature T_{panel}

T_{panel} (°C)	T_w (°C)		
	65	75	85
N	8	8	8
Mean[1]	57.8 [a]	66.8 [b]	74.6 [c]
std	0.72	0.31	0.29

[1]values with different superscripts are significantly different ($P<0.05$) in means by the Scheffé test

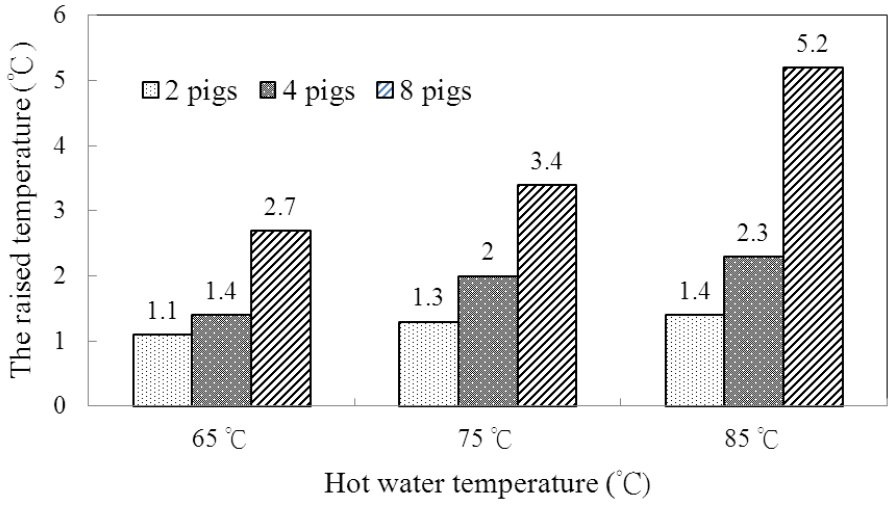


Figure 4. The raised air temperature (ΔT) of the piglets incubators within 25 minutes in different number of 13-day-age piglets and different hot water temperatures under a stationary flow rate as 45.3 L/min

Conclusions

The heating system for piglets in farrowing house is used hot water which heated by burning biogas to achieve the target of warming piglets. The results in the simulations tests show that the temperature of the piglets incubator can achieve to 28 ℃ within 30 minutes under the conditions of 90 °C hot water and 45.3 L/min flow rate. The results in the field tests obtain that the raised air temperature is 5.2 °C in the piglets incubator within 25 minutes where eight 13-day-age piglets stay Under the condition of 85 °C hot water and 45.3 L/min flow rate. It can clearly to know that the hot-water heating system for piglets is feasible and efficient through the simulations and field

test. The system is not only saving energy but also reducing greenhouse gas. Furthermore, it is worth to mention that the hot-water heating system can switch by hand to the electric-auxiliary heating device when there is no enough biogas to use

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