出國報告（出國類別:參加會議發表論文）

海軍軍官學校徐慶瑜副教授應邀赴馬來西亞吉隆坡參加 2017 年第 7 屆土木及結構工程國際研討會(2017 7th International Conference on Advances in Civil and Structure Engineering- CSE 2017)
發表論文
返國報告

服務機關:海軍軍官學校
姓名職稱:徐慶瑜副教授
派赴國家:馬來西亞
報告日期:106 年 07 月 7 日
出國時間:106 年 06 月 30 日至 07 月 04 日

摘要

2017年第7屆土木及結構工程國際研討會(2017 7th International Conference on Advances in Civil and Structure Engineering, CSE 2017)由美國工程師和醫生研究所(Institute of Research Engineers and Doctors, IRED)所主辦，於馬來西亞吉隆坡HOTEL G TOWER舉行，邀請與土木、機械、結構、資訊、生醫、環境、材料、電子計算機領域相關研究學者、工程師、技術人員、及業者人員參加，本次會議由馬來西亞技術大學(UNIVERSITI TEKNOLOGI MARA (UITM), MALAYSIA學PROF. LOO, HUCK SOO及馬來西亞大學(UNIVERSITY OF MALAYA(UM),MALAYSIA) PROF. CHING YERN CHEE,擔任會議主席。

海軍軍官學校徐慶瑜副教授應邀發表論文,論文題目: 氣墊船襯裙承受高壓氣泡衝擊之動態反應(Dynamic Response of Air Cushion Vehicle’s Skirt under High Pressure Bubble Impact)，**並獲頒最佳論文獎**。

本次國際學術會議主要論文主題包括有：土木、機械、結構、資訊、生醫、環境、材料工程等項目，對國內學術界及機械、材料、電機及電子計算機等產業界極有助益。

目次

海軍軍官學校出席國際學術會議心得報告

會議名稱：2017 年第 7 屆土木及結構工程國際研討會(2017 7th International Conference on Advances in Civil and Structure Engineering, CSE 2017)

會議時間：2017 年 7 月 01 日至 2017 年 7 月 02 日

會議地點：馬來西亞吉隆坡

主辦機構名稱：美國工程師和醫生研究所(Institute of Research Engineers and Doctors, IRED)

參加會議目的:應邀發表論文，並增加海軍軍官學校國際學術能見度，提升學術地位與影響力。

發表論文題目：

中文題目：氣墊船襯裙承受高壓氣泡衝擊之動態反應

英文題目：Dynamic Response of Air Cushion Vehicle’s Skirt under High Pressure Bubble Impact

一、參加會議過程：

1.在6月30日早上由桃園出發，約5小時後到馬來西亞吉隆坡之HOTEL G TOWER參加研討會。

會議的議程摘要如下：(參見第19頁之附件一的會議議程)

2017/7/02 報到註冊及歡迎茶會

2017/7/03上午為開幕儀式及專題演講，並同時舉行論文報告。

2017/7/03下午發表文章及聆聽其他國家或地區學者的研究成果。

2017/7/03下午繼續聆聽其他國家或地區學者的研究成果，並利用休息時間與其他學者交換意見。

2017/7/04 離開馬來西亞吉隆坡，搭機返台。

2.2017年第7屆土木及結構工程國際研討會(2017 7th International Conference on Advances in Civil and Structure Engineering, CSE 2017)由美國工程師和醫生研究所(Institute of Research Engineers and Doctors, IRED)所主辦，於馬來西亞吉隆坡HOTEL G TOWER舉行，

邀請與土木、機械、結構、資訊、生醫、環境、材料、電子計算機領域相關研究學者、工程師、技術人員、及業者人員參加，本次會議由馬來西亞技術大學(UNIVERSITI TEKNOLOGI MARA (UITM), MALAYSIA學PROF. LOO, HUCK SOO及馬來西亞大學(UNIVERSITY OF MALAYA(UM),MALAYSIA) PROF. CHING YERN CHEE,擔任會議主席。

3.本次國際學術會議主要論文主題包括有：土木、機械、結構、資訊、生醫、環境、材料工程等項目，對國內學術界及機械、材料、電機及電子計算機等產業界極有助益。

4.本次會議總計有370篇論文投稿，來自28個國家，經論文審查程序後，計有215篇論文獲接受，通過率為58.10%(如圖1論文接受函所示)。

5.投稿論文以亞洲及非洲為多，會議有專家學者約50餘人參加，此次會議全部為口頭報告論文，每篇論文均具有相當好之學術及應用價值。筆者在此次研討會共投稿1篇論文，並出席該研討會。(筆者於會場論文發表及研討會議進行過程如圖2所示)。

6.本次會議於2017年7月1日開始於馬來西亞吉隆坡HOTEL G TOWER辦理報到與資料領取；並從7月2日上午進行專題演講，參加會議開幕人數約有50位，場面極為溫馨而熱鬧。本次會議中計有2場專題演講，分別為:

(1) PROF. LOO, HUCK SOO

馬來西亞技術大學(UNIVERSITI TEKNOLOGI MARA (UITM), MALAYSIA

講演題目：ERGONOMICS IN THE PRODUCTION OF FIBER INSULATOR SHEETS FOR AIR CONDITIONING

專題講演內容摘述如下:

本次專題講演PROF. LOO, HUCK SOO，係從人因工程角度說明進行空調系統所需隔熱複合材料製造時，透過生產人員製作過程中，人員姿態及機械加工所需相對設置位置及進料速度等因子進行研究，以獲得製造人員之最適配置組合，以提高生產效能。

(PROF. LOO, HUCK SOO講演過程如圖3所示)

(2) PROF. CHING YERN CHEE

馬來西亞大學 (UNIVERSITY OF MALAYA(UM), MALAYSIA)

講演題目：PROTECTIVE COATING SYSTEMS FOR STRUCTURES BASED ON PLASTIC MATERIAL

專題講演內容摘述如下:

PROF. CHING YERN CHEE 在此次專題講演，詳細介紹應用於溫室結構中，所需之保護表面塗層，透過塗層材料之配置及層數安排，使得溫室結構可有效阻隔有害光射線，並保持溫度避免熱量散失，以增加溫室內相關農作物之生長週期，增加產量。

(PROF. CHING YERN CHEE講演過程如圖4所示)

專題講演完成後，於上午11:00接著議程為口頭報告論文(國外學長論文發表過程如圖5所示)。

本次國際論文研討會，筆者並藉由此次論文發表機會，與各國學者交換研究心得，並介紹筆者研究領域，目前台灣研究現況(如圖6)

7.筆者此次參加此次研討會，發表之論文為：

<u>氣墊船襯裙承受高壓氣泡衝擊之動態反應</u>

會議論文如附件二，論文之重點摘要如后：

襯裙為氣墊船（ACV）之一部分，主要功能係在船體結構與水面之間產生過壓（高於大氣壓），此壓力係用來提升主船體結構，以便通過不同的表面作為海面，泥土和陸地，故襯裙在氣墊船中扮演重要角色。為了可承受水下爆炸（UNDEX）所引發之高壓氣泡，故取用合適材料之氣墊船是必要的。本論文建立結合有限元素法及耦合歐拉-朗格朗日（CEL）計算方法策略，進行高壓氣泡衝擊氣墊船（ACV）之數值模擬以計算相關結構動態反應。為了驗證本論文所建立之計算方法，本論文應用Klaseboer（2005）和A. M. Zhang等人研究來驗證計算模型和方法的精度。採用上述模型，對ACV襯裙模型進行高壓氣泡衝擊的有限元素數值模擬，並討論氣墊船模型之襯裙響應。本論文獲致之成果可提供做為氣墊船結構之設計參考。

8.**論文最後並由主辦單位評為最佳論文獎，並接受表揚**(如圖7及圖8所示)。

9.本次研討會主辦單位規劃嚴謹，整體的會議及安排等服務均可接受。

二、與會心得：

1.本論文感謝科技部對筆者參加此次國際研討會的各項經費補助，使筆者發表的論文得以與國際相關專家學者充分討論。

2.本次論文研討會，筆者研究團隊獲得最佳論文之獎項，使得研究成果獲得國際肯定，大大彰顯台灣之國際能見度，讓筆者在研究領域深獲鼓舞，並有更大熱情投入研究，亦感謝科技部及國防部對於本人研究之支持。

3.此次會議主辦單位規劃與辦理皆屬中規中矩，在專題演講及論文發表的安排上有條不紊。

4.本次會議註冊費並不比一般國外學術會議低，且會議地點選擇馬來西亞首都吉隆坡，並非是國外旅遊勝地，因研討會的論文可刊登於EI等級國際期刊，故仍能吸引相當多的學者與學生參加。由於此會議為國際學術研討會必須以英語進行論文發表，這對許多學生的訓練與經驗而言助益頗大。

5.近年來各單位亦積極爭取國際學術研討會在台舉辦，且有相當成果，然而爭取主辦國際學術研討會實為不易，特別是大型國際學術研討會，如IEEE或ASME等知名學會。由於參加國外的學術研討會牽涉到經費的補助，致使許多有意參加國際會議的學者與學生怯步，雖然目前科技部及各校皆有許多補助出席國際會議的辦法，在有限經費下仍有不足，特別是學生部份，將造成學生參加國際會議與英語論文發表的訓練與經驗不足。

6.參與此次研討會，除使發表的論文獲得充分討論外，並與世界各國相關專長領域之學者熟識，了解彼此研究現況，對未來的研究及教學工作將有莫大的幫助，更值得鼓勵國內學術單位及政府單位多多參加國際性學術研討會。

考察參觀活動：

(本次未參加舉辦單位安排之考察活動)

三、結論與建議：

1.本次會議主要目的為應邀發表論文，並增加海軍軍官學校國際

學術能見度，提升學術地位與影響力。

2.科技部各學門可積極規劃爭取主辦的國際學術研討會，並鼓勵國內學術單位及政府單位適度參與或多篇論文發表，將科技論文發表的聲勢壯大後，以增加主辦研討會議的機會，提升國際學術交流與地位。

3.積極規劃中小型國際研討會，雖然此種小規模論文發表的國際研討會與歐美大型會議無法比擬，但亦可藉由小型國際研討會來吸引國際專家學者的與會，一來可與會議與會人士討論，二來建立籌辦國際研討會的經驗，此可為國內未來籌辦國際學術研討會之學習參考。

攜回資料名稱及內容：

攜回本次會議之大會手冊及論文光碟片(如圖9)，若有需求請洽筆者，筆者十分樂意提供。

其他：無

Ref No: - IRED/17/CSE /L107
Dated: - 27-April-2017

Subject: Letter of Acceptance and Invitation

Dear Author (**Ching-Yu Hsu**),

We are pleased to inform you that after hard review process your paper entitled as **"Dynamic Response of Air Cushion Vehicle's Skirt under High Pressure Bubble Impact"** with paper ID "**CSE-17-1416**" has been accepted for Oral presentation and publication in Late Round of "Seventh International Conference On Advances in Civil and Structural Engineering - CSE 2017." The conference will be held at Kuala Lumpur, Malaysia during 01-02 July, 2017. We invite you to present your full research paper at the conference and please bring PPT slides of your paper for presentation at the conference as there are data projectors at the venue.

Benefits of Publication:-

- Your paper will be included in the Conference Proceedings which will be published online with ISBN and will be archived in SEEK Digital Library so that it will be universally accessed. Seek Digital Library is being accessed by thousands of Students, Researchers and Scientists over the globe. Seek Digital Library is an Open access library. You may visit the Library at www.seekdl.org.
- Each paper will be assigned Digital Object Identifier (DOI) from CROSSREF.
- Registered Papers will be published in various Issues of International Journals with ISSN Numbers.
- You will get the chance to attend the conference and to meet the researchers from the globe.

We have received more than 370 research articles for review in Late Round from more than 28 countries and only 215 articles has been accepted for publication and oral presentation with acceptance ratio of 58.10%. The Review Process has gone through Peer Review Process. The Editorial Committee focused on quality research articles to maintain the credibility of the conference.

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圖1論文接受函


AUTHOR
Pengarang
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KUALA LUMPUR
MALAYSIA
7th International Conference On
Advances in Civil and Structural Engineering
Persidangan Antarabangsa ke-7 pada
Kemajuan Kejuruteraan Awam dan Struktur
CHING-YU HSU
TAIWAN
PAPER ID : CSE-17-1416
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01-02 JULY, 2017
Dynamic Response of Air Cushion Vehicle's Skirt under High Pressure Bubble Impact

圖2.筆者於研討會會場發表論文

圖3.PROF. LOO, HUCK SOO講演

圖4.PROF. LOO, HUCK SOO講演

圖5. 國外學者於研討會論文發表


圖6.筆者與國外學者交換研究心得

圖7.獲得最佳論文獎


圖8.研討會最佳發表論文獎頒獎

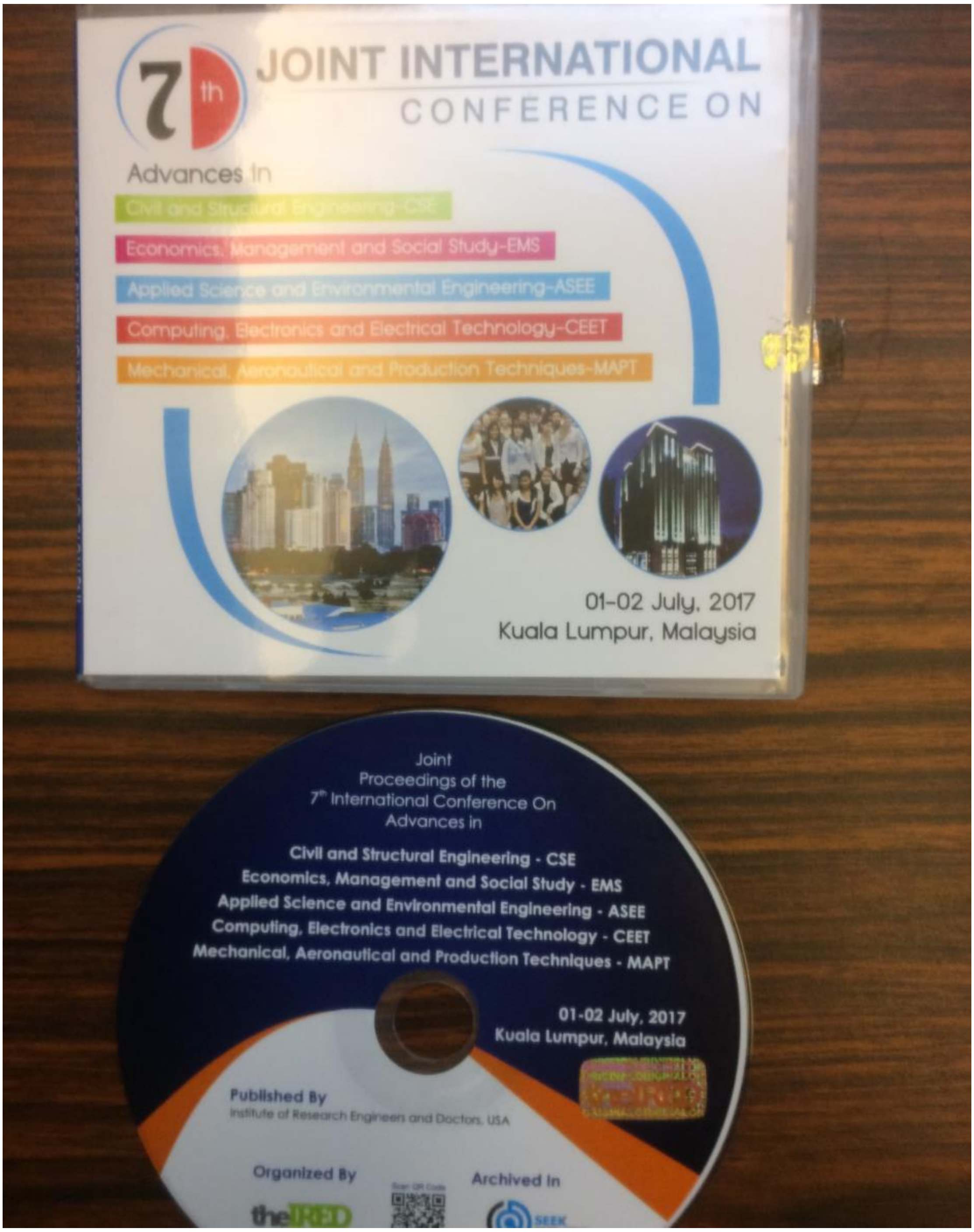

圖9.研討會發表論文光碟

附件一:論文會議議程


2017 theIRED Kuala Lumpur, Malaysia Conference Schedule
7th
Joint
International
Conference On
Participants From 14 Countries!
Advances In
Civil and Structural Engineering-CSE
Economics, Management and Social Study-EMS
Applied Science and Environmental Engineering-ASEE
Computing, Electronics and Electrical Technology-CEET
Mechanical, Aeronautical and Production Techniques-MAPT
01-02 07 2017
Kuala Lumpur, Malaysia
Venue
G Tower Hotel
199, Jalan Tun Razak, 50400 Kuala Lumpur, Malaysia
Institute of Research Engineers and Doctors

PROGRAM AT GLANCE

SATURDAY, 01 JULY, 2017
KLANG 1 FOYER

01:00PM TO 04:00PM	ARRIVAL, REGISTRATION AND BADGE COLLECTION

SUNDAY, 02 JULY, 2017
KLANG 1 ROOM

08:30AM TO 09:00AM	WELCOME REFRESHMENT
09:00AM TO 09:10AM	WELCOME SPEECH
09:10AM TO 09:35AM	EXPERT SPEECH A
09:35AM TO 09:40AM	GROUP PHOTO

TIMELINE	KLANG 1 ROOM - CEET/ASEE/CSE/EMS/MAPT
09:50am to 10:20am	Expert Speech B
10:25am to 11:05am	Presentation Session R1-1
11:10am to 11:40am	Expert Speech C
11:40am to 12:05pm - TEA/COFFEE BREAK	
12:05pm to 01:30pm	Presentation Session R1-2
01:30pm to 02:30pm - **INTERNATIONAL LUNCH**	
02:30pm to 03:30pm	Presentation Session R1-3
03:30pm to 03:50pm - TEA/COFFEE BREAK	
03:50pm to 06:00pm	Presentation Session R1-4

06:00pm-06:15pm Closing Ceremony

ASEE-17-517	"RELATIONSHIP BETWEEN TRACE METAL POLLUTION AND GENETIC POLYMORPHISMS IN THE BIOMONITOR *NERITA LINEATA* FROM PENINSULAR MALAYSIA" **CHENG WAN HEE** **MALAYSIA**
CEET-17-861	"SIMULATION BASED SENSITIVITY ANALYSIS OF SPLIT RING RESONATOR FOR DETECTING COMPOSITIONAL VARIATIONS IN MIXTURE OF POLAR LIQUIDS" **MALIK MUHAMMAD HARIS AMIR** **PAKISTAN**

Presentation Session R1-3(KLANG 1 ROOM)

02:30 pm – 03:30 pm

SESSION CHAIR: PROF. LOO, HUCK SOO, PROF. CHING YERN CHEE, PROF. CHEE-MING CHAN

PAPER-ID	PAPER-TITLE
CSE-17-1409	"ANALTSIS OF IN-PLANE MOMENT LOADED TUBULAR T-JOITS USING THE FINITE ELEMENT METHOD" **ANIS A. MOHAMAD ALI** **IRAQ**
EMS-17-1211	"SHOT BY BOTH SIDES TAX, THE ACCOUNTING PROFESSION AND THE INTERNATIONAL PUBLIC INTEREST " **GABRIEL DONLEAVY** **AUSTRALIA**
ASEE-17-519	"RESPONSE OF *CHLORELLA VULGARIS* AS WHOLE-CELL BIOINDICATOR FOR ATRAZINE AND 2, 4-DICHLOROPHENOXYACETIC ACID DETECTION" **WONG LING SHING** **MALAYSIA**
CEET-17-869	"RLG DITHER REMOVAL USING WAVELET TRANSFORMS" **KAKARLA SUBBA RAO** **INDIA**
CSE-17-1414	"DECREASING OF TRAFFIC DELAY WITH INTELLEGENT TRANSPORTATION SYSTEM ITS (RELATIONSHIP BETWEEN SPEED MANGEMENT AND TRAFFIC DELAY ALONG ARTERIALS)" **GHSSAN SULEIMAN** **JORDAN**

Presentation Session R1-4(KLANG 1 ROOM)

03:50 pm – 06:30 pm

SESSION CHAIR: PROF. LOO, HUCK SOO, PROF. CHING YERN CHEE, PROF. CHEE-MING CHAN

PAPER-ID	PAPER TITLE
CSE-17-1416	"DYNAMIC RESPONSE OF AIR CUSHION VEHICLE'S SKIRT UNDER HIGH PRESSURE BUBBLE IMPACT" **CHING-YU HSU** **TAIWAN**
ASEE-17-521	"AN ATOMIC FUEL PRODUCTION THROUGH ACCUMULATION OF SPECIFIC RADIOISOTOPES BY FISH IN OFFSHORE FUKUSHIMA, JAPAN" **KATSURA HIDEMITSU** **JAPAN**

附件二:研討會發表論文

Proc. of the Seventh International Conference On Advances in Civil and Structural Engineering - CSE 2017.

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Dynamic Response of Air Cushion Vehicle's Skirt under High Pressure Bubble Impact

Ching-Yu Hsu[a], Cho-Chung Liang[b], Phuong-Duy Vo[b], Hai-Anh Nguyen[c]

Abstract **- Skirt is a part of air cushion vehicle (ACV) which plays a substantial role to create an over-pressure (above atmospheric pressure) between floor of structure and water surface. This pressure lifts main hull structure in order to travel through different surfaces as sea-surface, mud, and land. A suitable materials of ACV's skirt is necessary to survive ACV before high-pressure bubble in under-water explosion (UNDEX). This paper builds up a technique which connects together the finite element method (FEM) and Coupled Eulerian- Langrangian (CEL) strategy to simulate and modify predicted data whereas the high-pressure bubble impact air cushion vehicle (ACV). To prove the promising results of this technique, authors conducted two feature studies from Klaseboer et al. (2005) [1] and A. M. Zhang again in Abaqus software [2], which showed the precision of the calculation model and method. With the similar above model, finite element simulation of the ACV's skirt model subjected to high-pressure bubble impact that were presented, and discussed the skirt response of the hovercraft model. The consequences of numerical methodology could be as an important reference to outline ACV's skirt structure.**

Keywords- **underwater explosion, high-pressure bubble, ACV's skirt design, hovercraft design.**

I. Introduction

Air Cushion Vehicle (ACV) is equipped for moving over land, water, mud, ice, and different surfaces. Sir Christopher Cockerell's experiment in England alluded to this idea in the prior period and was begun from 1955 [3].

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In this paper, high-pressure gaseous bubble will be attended as a main factor to cause the interaction from UNDEX. Following this major field of study's history, Rayleigh made the first analysis of a problem in cavitation and bubble dynamics (1917), he solved the problem of the collapse of an empty cavity in a large mass of liquid[4]. More recently the same type of problem has been considered in greater detail by several investigators including Devin (1959), Plesset & Hsieh(1960), Chapman& Plesset (1971), and Prosperetti (1976) [4]. The particular attention to the interaction between structure and bubble oscillation in underwater explosion nearby a wall by finite volume method was presented by H. Q. Zhang (2015) [5]. A three-dimensional model of collapsing bubble with jet formation and impact is presented in the Y. L. Zhang's study (2000). The main contents are the strong instabilities of the jetting process, impact, toroidal bubble rebound, and a smooth transition from a singly connected bubble to a doubly connected toroidal bubble [6]. Another attention to the much smaller-scale cavitation bubbles and associated theoretical and computational studies was conducted by A.Pearson (2001). The cubic splines are used to represent the surface of the bubble and the infinite free surface; with a non-linear distribution of nodes being employed on the free surface when bubbles are generated close to the boundary [7]. A high order of mesh regularity is maintained by a mesh refinement procedure. The circulation of the flow around the gaseous tube of the toroidal bubble is modelled by a generalization of the vortex ring method of Q. X. Wang (1995) [8]. The proposed elastic mesh technique (EMT) based on the segments was showed by C. Wang (2002). EMT employed in conjunction with the boundary integral method (BIM) for the simulation of three-dimension bubble dynamics in which problems relating to severe mesh distortion as the bubble evolves are a common occurrence (C. Wang, 2002) [9]. Majority of extant literature mainly focuses on underwater explosion bubbles and their interactions with a free surface. The volume-acceleration model was introduced to determine the initial conditions for bubble motion during underwater explosions that the initial and boundary conditions of the fluid field, were

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developed based on the MSC.DYTRAN software were used by Jian Li (2011) [10]. The interaction between a bubble and a free surface as basis, the simulation the dynamic behavior of a bubble near a free surface, including the ring rebound of the bubble and the spray dome of the free surface were illustrated [11]. The application of finite element program for solving UNDEX bubble problem has been addressed by Ching-Yu Hsu (2014). This study used the Eulerian technique in ABAQUS to simulate the first oscillation cycle of a 3-D UNDEX bubble in a free field. The availability of many materials in this technique allowed the simultaneous simulation of three materials, explosive gas product, air, and water, in the same Eulerian domain [12]. The numerical methodology to model and study the bubble dynamics produced by an underwater explosion when it occurs in infinite medium with any surrounding obstacle as the free surface, the seabed or deformable structures (surface ship or submarine) were indicated by G. Barras (2012) [13]. The Euler-Lagrangian approaches were also developed in the 1980s. Johansen and Boysan published an axisymmetric model for bubble plumes in reactors. It has been argued that in full 3D and for relevant gas release rates, Lagrangian tracking of the resulting number of bubbles is very demanding on computer resources, and thus an Eulerian-Eulerian approach is preferable for bubble plumes with a huge quantity of bubbles. Jan Erik Olsen (2016) applied an Eulerian-Lagrangian CFD model to imitate the underwater bubble plumes emerge from subsea releases of gas. It accounts for relevant physics including buoyancy, turbulence, gas expansion and dissolution [14].

The behavior of an oscillating bubble near a floating structure was described by E. Klaseboer (2005) using the boundary integral method. The proposed modification of the BIM method was used to visualize the dynamics of (large) bubbles near a free surface and a (fixed) floating structure are investigated [1]. This procedure will be reproduced in Abaqus application. The results comparison of the consequence between two methods is a proof of accuracy. The air cushion vehicle (ACV) is the advanced marine vehicle that provides not only excellent performance on rough surfaces but also the high speed that other conventional marine vehicles could not achieve. Hence, a large number of ACVs have been utilized for various purposes and missions. The flexible skirt system is recognized as the most updated and advanced skirt system. The ACV's skirt system geometry is optimized to modify an undesirable heave response for the better ride quality by using the Genetic Algorithm (GA) (Joon Chung, 2004) [3]. In the aforementioned literature the UNDEX response was primarily studied for ships and submerged structures; however, no studies exist on dynamic responses of an air cushion vehicle's skirt. For that reason, applying an UNDEX situation to ACV's skirt is the main issue of this research.

II. Theoretical background

In this paper, the response of a hovercraft Russian Zubr-class (Project 1232.2, Pomornik, Weight: 555 tons -full load; Length: 56.2 m; Beam: 25.5 m; Draught: 1.6m; Speed: 60 knots [110 Km/hr]; Range: 300 miles [480 Km]; Crew: 31) [15] is the main concern within. The results of simulation can predict and choose an appropriated material of skirt to design a future ACV. The chemical reaction produces gases at very high temperatures and pressures. The internal energy of the gas at this time is small and is less than half of the maximum radius that it will eventually reach. At this low pressure, it is reasonable to apply the incompressible flow equations to determine the behavior [16]. The empirical equation of maximum bubble radius (A_{max}) and the time of the first pulse (T) [16]:

$$T = K_5 \frac{W^{1/3}}{(D+9.8)^{5/6}} \tag{1}$$

$$A_{\max} = K_6 \frac{W^{1/3}}{(D+9.8)^{1/3}} \tag{2}$$

where K5, K6 are constants depending on explosive charge type; D is the depth of the explosive in meters. For the numerical simulation of the interaction between a high-pressure bubble phenomenon and structure, the acoustic structural coupling method from the ABAQUS software was applied[17]. Eulerian material can interact with Lagrangian elements through Eulerian-Lagrangian contact; simulations that include this type of contact are often referred to as coupled Eulerian-Lagrangian (CEL) analyzes. This powerful, easy-to-use feature of Abaqus/Explicit general contact enables fully coupled multi-physics simulation such as fluid-structure interaction [17-18].

III. Validation of the simulation

A. *Simulation of bubble and free dynamics in underwater explosion*

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To validate calculation model, the interaction between a bubble and a free surface, the comparison is to be made between numerical results and the experimental results obtained by Klaseboer et al. (2005)[1]. Hexocire (55g) was placed at a depth of 3.5m. The pond sidewalls were designed to diffract the shock waves induced by the explosion and absorb the bulk of the explosion energy. This numerical simulation focused on the dynamic process of bubbles in a free field, especially the bubble collapse phase. The numerical analysis was conducted using an Eulerian-based finite volume program. The entire Eulerian domain includes three regions of material as water, air, and highly compressed detonation gas as Figure.1.

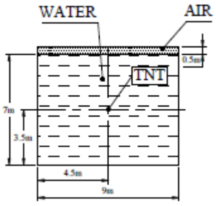

Figure 2. Set-up numerical model

The air domain and explosive gas were modeled using ideal gas Equation of State (EOS), whereas the water domain was model using the U_P-U_S EOS. The physical parameter details of the numerical model were presented on the Table 1.

All faces of the Eulerian domain were fixed to prevent materials flowing out, and a non-reflecting Eulerian boundary was used for the side boundaries of the Eulerian domain to eliminate the reflection of pressure waves that may affect the simulation result accuracy. To obtain accurate results and conserve computational resources, the initial bubble region was meshed at the small size of 5mm. The region of 700 mm from the bubble center had a mesh size of 20 mm, and the remaining model region had a large mesh size. Figure.2 and TABLE 1 shows half of the model and an enlarged view of the mesh surrounding the original bubble.

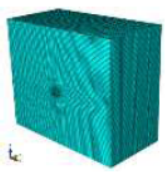

Figure 3. Mesh solution of the numerical model

The overall model element mesh consisted of 1,173,872 EC3D8R elements.

If the charge is a sphere, then the charge radius is calculated using

$$r_{ch} = \left(\frac{3}{4} \frac{W}{\pi \rho_0} \right)^{\frac{1}{3}} \quad (3)$$

Where W is the charge weight, and ρ_0 is the charge density. Based on the calculations by Cole [19], the relationship between pressure and specific volume is shown in Figure.3.

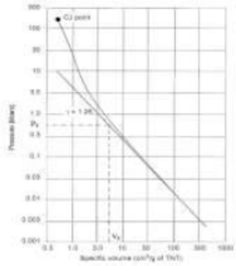

Figure 3. Cole calculation for TNT on the logarithmic plot [19]

The heat exchange between the detonation gas product and the water domain can be negligible in studying the UNDEX bubble, the expansion and contraction of detonation gas are considered to be an adiabatic process. Thus, the ideal gas EOS in ABAQUS is applicable for simulating the properties of air and detonation gas. The water domain in the numerical model was simulated using U_P-U_S EOS in ABAQUS. On the TABLE 1, the details of physical parameters are showed.

TABLE 1. Physical Parameters of Numerical Model

Material	Parameter	Symbol	Value	Unit
Water	Density	ρ_w	1000	kg/m^3
	Sound speed	C_w	1500	m/s
Air	Density	ρ_a	1.17	kg/m^3
	Ratio of specific heat	γ_a	1.4	-
	Initial pressure	P_a	1.0x10^5	Pa
Explosive (TNT)	Weight	W	0.055	kg
	Density	ρ_{ch}	1630	kg/m^3
	Charge radius	r_{ch}	0.02	m
Gas Bubble	Density	ρ_g	203.75	kg/m^3
	Ratio of specific heat	.	1.25	-
	Bubble radius	r_g	0.04	m
	Initial pressure	P_g	5.672×10^7	Pa

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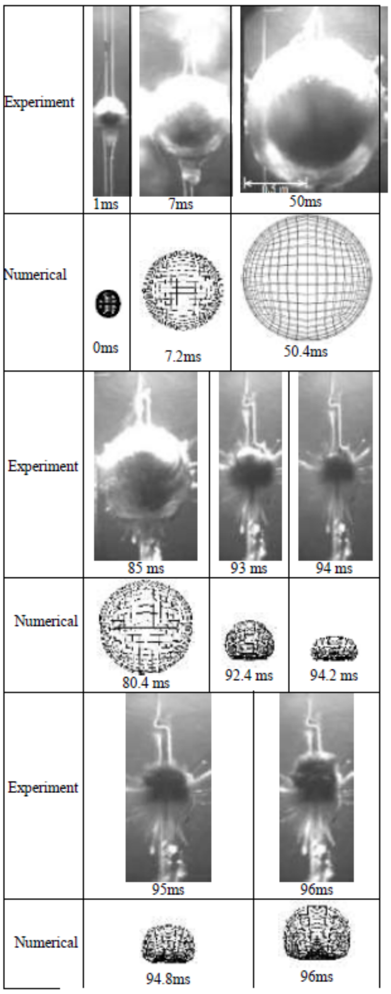
B. *Comparison the results between live experiment and simulating*

Simulated and experimental bubbles show similar bubble radials at different intervals as TABLE 2.

TABLE 2. The Comparison of Experimental and Optimal Bubble with similar Radials at Different Time



C. *Bubble pulse damage to steel plate used CEL*

The CEL technique embedded in the ABAQUS is applied for solving the interaction between the fluid and the structures. In this section, we apply the CEL method to the numerical study of the bubble pulse impact to a rectangular plate (the same model in section III, had dimensions of 0.3×0.25×0.002m) subjected to UNDEX. This numerical simulation focused on the examining the behavior of a rectangular plate. The interaction between a high-pressure bubble and an elastic–plastic round plate is examined in this area; the experimental data are from reference [2]. The test was completed in a pool: an explosive charge of 55 g detonated under the roundabout steel plate of thickness 2 mm. The steel plate was settled at first glance, one side experienced the impacting load and the opposite side was exposed in the air. The mass density of the plate is 7800 kg/m^3; the yield stress is 240 MPa; the shear modulus is 80.7 GPa while the Young's modulus is 210 GPa; and the Poisson's proportion is 0.3. Expected the model was perfect elastic–plastic and the dimensionless damping proportion was taken as 0.05. The steel plate had been settled at its boundaries for each of the six degrees of freedom and it was sufficiently thick to permit moderately extensive large deformation of the plate to happen. The standoff separate had been 1.2 m underneath the plate (or 2.2 times of the most extreme air bubble span). The separation between the explosive charge and the floor of the lake was 3.5 m (the charge depth was likewise 3.5 m). The diagram of Finite Element (FE) model for simulation of bubble pulse damage to a rectangle plate used CEL as Figure. 4. Since the standoff separation was far bigger than the bubble radius, the bubble carried on to some degree, similar to a free-field bubble. The numerical outcomes are appeared in the Figure.5, the vertical removal of the plate is appeared in Figure.6.

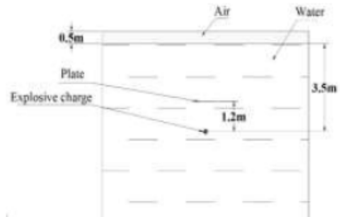


Figure 4. Schematic diagram of FE model for simulation of bubble pulse damage to steel plate used CEL

The numerical analysis was conducted using an Eulerian based finite volume program. The entire Eulerian domain includes three regions of materials: water, air, and highly compressed detonation gas. The air domain and explosive gas

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were modeled using ideal gas EOS, whereas the water domain was model using the U_P-U_S EOS.

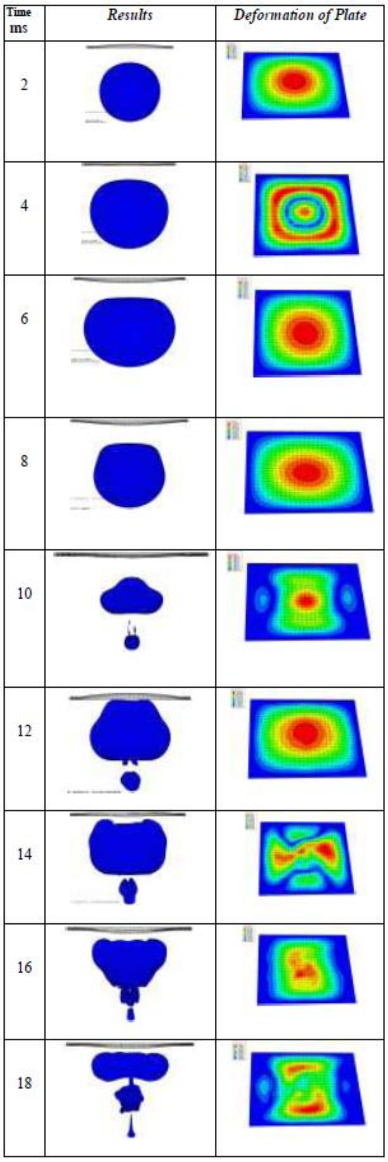

Figure 5. The shape of bubble and steel plate at different time

TABLE 1 shows the physical parameter details of the numerical model. All faces of the Eulerian domain were fixed to prevent materials flowing out, and a non-reflecting Eulerian boundary was used for the side boundaries of the Eulerian domain to eliminate the reflection of pressure waves that may affect the simulation result accuracy. The overall model meshes in EC3D8R element type. The present research focused on studying the influence of the deformation of steel plate on the behavior of bubble. Figure.5 has shown the deformation of the steel plate at different time intervals; deformation was caused by the motion of the flow surrounding the bubble. The effect of the attraction between the bubble and the wall on the deformation of the wall was not clear. Permanent deformation at the center point of steel plate is plotted in Figure 6. There were wild fluctuations in the deformation around 0.02m over 0.02s before a sudden reaching the highest position with deformation is 0.1m.

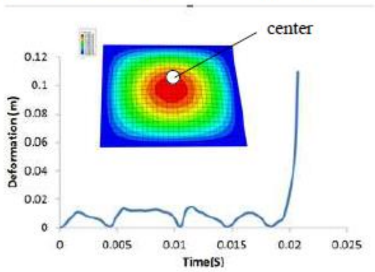

Figure 6- Permanent deformation at the center location of steel plate

IV. The Dynamic Response of Skirt on ACV impacted by bubble

A. Model of simulation

With the same above methods of simulating the damaged bubble dynamic. The same properties of air, water and bubble charge were used (TABLE 1), the new model of ACV was added. Figure.7 shows the position and the size of water, air and explosive charge model. The overall length of the hovercraft is 57m. The beam and draft of the hovercraft are 25.6m and 1.6m, respectively is illustrated in Figure.8. The whole finite element model is shown in Figure.9. The stiffener, the keel are all box steel with the cross section and the specifications are lists in TABLE 2. The body structure was constructed by aluminum

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(7075 Alloy), modeled using the average thickness technique of the hovercraft was 20 mm, meanwhile the thickness of skirt part is 2.5 mm and made by a few kinds of materials. In the fist model, ACV's skirt will make by rubber and in the second model of skirt, it will be checked the response with the coated fabric material [20].

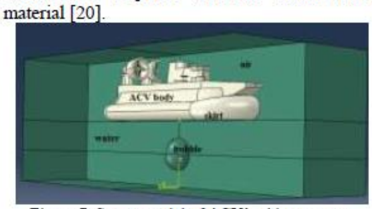

Figure 7. Set up model of ACV's skirt response

The mechanical properties of the hovercraft body and especially skirt properties are shown in TABLE 3.

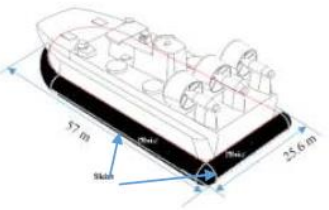

Figure 8. ACV' Skirt model

Figure.9 and Figure.10 show mesh of ACV model including skirt mesh. There are some types of elements in this model including linear quadrilateral elements of type S4R, shell elements, linear beam, line elements, and linear triangular of type S3 elements. The element size is 0.5 m. It includes 380 cell faces, 1135 edges, and 792 vertices.

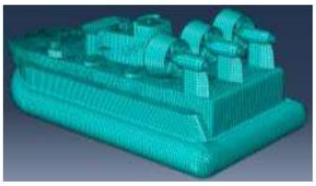

Figure 9. Finite element models of Zubr-class like LCAC

Figure 10. Mesh of skirt model

TABLE 2 shows the parameters of the fabric skirt structure. The properties of them also give in the TABLE 3.

TABLE 2. The parameters of fabric skirt [21]

Skirt fabric designation	Units	Size
Width	mm	830-840
Thickness	mm	2.5
Specific weight	kg/ m^2	2.57
Tearing strength	N	1490

TABLE 3. Mechanical properties of body structure and skirt [21]

Parameters (Units)	*Body Structural*	*Skirt (fabric)*	*Skirt (rubber)*
Density (kg/m^3)	2780	2700	8060
Young's Modulus (GPa)	75.6	70	2.461
Poisson's ratio	0.33	0.3	0.323
Yielding stress (MPa)	300	-	-

For simplicity, the light footprint pressure 3000 Pa is adopted to describe the cushion pressure when the fan speed is increasing further, pressure remains almost constant [20](shows in Figure 11).

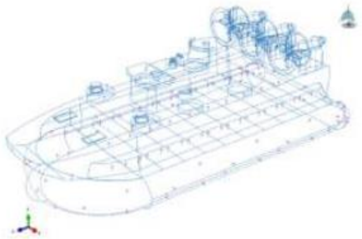

Figure 11. Footprint pressure for ACV [20]

B. Dynamic response of Air Cushion Vehicle with bubble impact

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In this section, we apply the CEL method to the numerical study of the potential damage to a hovercraft's skirt subjected to UNDEX in the different kind of skirt materials: rubber and fabric. The numerical model involves a bubble produced by using 9kg of TNT located under the middle of hovercraft model. The model includes three regions of material, water, air and highly compressed detonation gas. Figure.12 shows a schematic of the numerical model. In the fluid model, the length is 100 meters, the width is 50 meters, and the height is 40 meters.

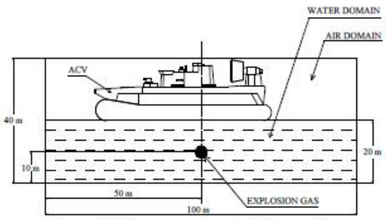


Figure 12. The arrangement of the model

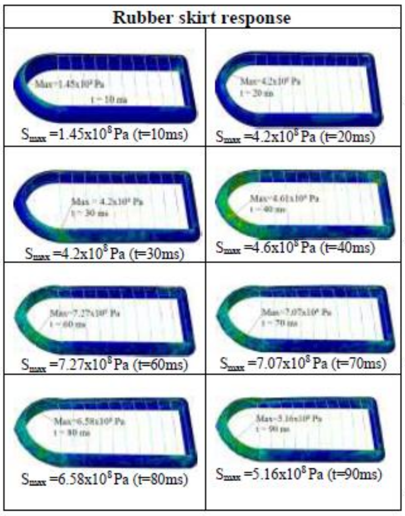
In this study, the near field underwater explosion was simulated which the explosive charge detonates close to the ship hull.

V. Results and discussion

A. Rubber Skirt Response

Dynamic responses of the ACV's rubber skirt model at typical times are showed as the Figure.13.

Rubber skirt response



S_{max} =1.45x10^8 Pa (t=10ms) | S_{max} =4.2x10^8 Pa (t=20ms)

S_{max} =4.2x10^8 Pa (t=30ms) | S_{max} =4.6x10^8 Pa (t=40ms)

S_{max} =7.27x10^8 Pa (t=60ms) | S_{max} =7.07x10^8 Pa (t=70ms)

S_{max} =6.58x10^8 Pa (t=80ms) | S_{max} =5.16x10^8 Pa (t=90ms)

Figure 13. The dynamic response of hovercraft's rubber skirt model under the load of bubble pulse

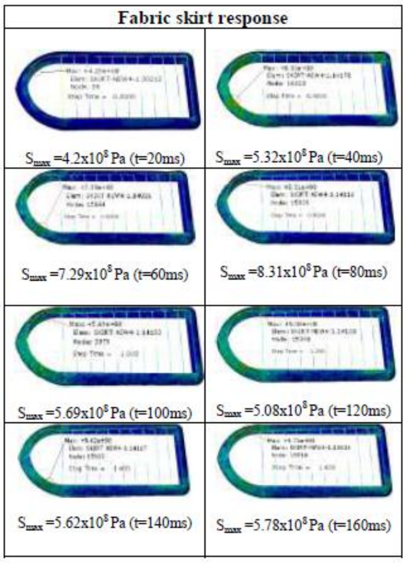
It can clearly observed that the displacement of the hovercraft's skirt model subjected to bubble load is mainly the global response. At the time t = 10 ms, the bubble pulse affect skirt in a small pressure, the shape of skirt from t = 10 ms to t = 70 ms is likely stable. However, we are easy to recognize that at the time t = 80 ms and t = 90 ms the skirt is damaged considerably.

In the Figure.13, von Mises Stress followed the time were illustrated. It also included the maximum and minimum values at the specific position of the element and node. Base on this data source, we could determine the very dangerous area where will be damaged considerably. From the database, we are easy to see the maximum value is 4.600 x 10^8 Pa at the time t = 40 ms, the node 16013th, the 5th element. At the same period of this time, the minimum value is 1.384 x 10^{-6} Pa in the 1.219th element, the 5th node. It is noticeable at t = 60 ms, in the 1.14100th element and the 3979th node, the value of von Mises Stress peaked at 7.27 x 10^8 Pa.

B. Fabric Skirt Response

The Figure.14 shows the outcomes of impact of high-pressure bubble in UNDEX process to fabric skirt.

Fabric skirt response



S_{max} =4.2x10^8 Pa (t=20ms) | S_{max} =5.32x10^8 Pa (t=40ms)

S_{max} =7.29x10^8 Pa (t=60ms) | S_{max} =8.31x10^8 Pa (t=80ms)

S_{max} =5.69x10^8 Pa (t=100ms) | S_{max} =5.08x10^8 Pa (t=120ms)

S_{max} =5.62x10^8 Pa (t=140ms) | S_{max} =5.78x10^8 Pa (t=160ms)

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Figure 14. The dynamic response of hovercraft's fabric skirt model under the load of bubble pulse

The deformation of fabric skirt follow the different time is illustrated. The span of the time from t = 20 ms to 60 ms, the destroying of fabric skirt is smallish. It is noticeable at the period of time from t bigger 80 ms. Especially, at t = 100 ms the fabric skirt is unprofitable. In the Figure.14, von Mises Stress followed the time were illustrated. It also included the maximum and minimum values at the specific position of the element and node. Base on this data source, we could determine the very dangerous area where will be damaged considerably.

From the database, we are easy to see the maximum value is 1.452 x 10^8 Pa at the time t = 20 ms, the node 1557th, the 130024th element.

At the same period of this time, the minimum value is 1.856 x 10^{-6} Pa in the 1202th element, the 5674th node. It is noticeable at t = 80 ms, in the 1.13617th element and the 15501th node, the value of von Mises Stress peaked at 8.31 x 10^8 Pa. The bottom value at this time is 1790x10^{-6} Pa in the 1276th element and the 5789th node. The most dangerous area on the skirt is concentrated at the head location as the Figure.19. The deformation of skirt with the high-pressure bubble at t = 100 ms was illustrated by the several of colors as Figure.15. The red elements on the skirt gave the high von-mises stress value. It will decrease following the changes of color from dark red to dark blue. It is very simple to observe the high von-mises stress value area. In the Figure.15, the ACV's head is the most damaged location from UNDEX by the high-pressure bubble.

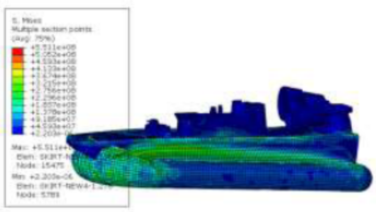

Figure 15. The deformation of skirt followed the changes of color

VI. Conclusions

The purpose of this study is to investigate a procedure to analyze the dynamic structural response of a hovercraft. It shows the possibility of using the Coupled Eulerian- Lagrangian (CEL) method in ABAQUS. Numerical simulations were compared with the results of validated experimental data. The finite element simulation of the ACV's skirt model subjected to high-pressure bubble simulation that were presented. The skirt response of the hovercraft model have been discussed. The consequences of simulated methodology could be an important reference to outline ACV's skirt structure. The calculated results excellently agree with experimental data, which indicates that the numerical model can effectively predict bubble pulse damage.

A numerical model of dynamics of an UNDEX bubble is developed using CEL method and Equation of State (EOS). Crucial effects of bubble on the structure were investigated, such as pressure pulse and water jet attack. The locations in the skirt and main deck sustain the significant effect on gas bubble behavior when a hovercraft damaged by UNDEX. Large global responses take place at the bubble load, followed by the formation of water jet. Bubble generated in underwater explosion has a significant impact on the general strength of hovercraft's skirt, even exceeding the effect of shock wave sometimes. The results show the importance of considering bubble pulsation in estimating the damage of structure induced by the UNDEX phenomenon. Through case studies, it is found that the high precision of the evaluation method. As a result, it can be applied to checking hovercraft's skirt overall capacity against underwater explosion ultimate damage. The analytical results were offering a reference for evaluating the damage of hovercraft's skirt structure under the underwater explosion which is very utility to forebode and adopt a suitable material of skirt for designing a future hovercraft.

Acknowledgements

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