



# THERMAL HYDRAULICS DIVISION NEWSLETTER

## Fall 2013

### Message from the Chair



Dear Colleagues,

As I start my term as ANS THD chair, I have to take a few minutes to reflect on the all of the hard work that continues to improve THD. I want to thank all of you that have chosen to be a part of THD. Additional

thanks to all of you that have taken the time to serve in ANY role in THD.

Thanks to all of the efforts, THD continues to grow in terms of membership and conference participation. Professor Sun detailed the membership statistics in his report in the last THD newsletter. Regarding conference participation, for the ANS Winter Meeting, the almost 100 papers were submitted to THD sessions. In my years in THD, I do not remember an Annual or Winter Meeting with this number of papers! As a result of the number of papers to be presented, two evening sessions will be required. Please be sure to check the program and support all of the THD sessions!

I would like to thank the organizers of the NURETH-15 conference held last May in Pisa. In addition to hosting a successful conference in terms of technical interchange and fellowship, the organizers have recently made a donation of \$10,000 to THD. These funds will be used to endow Technical Achievement Award.

In 2014, THD will provide two different opportunities for authors to prepare full-length papers. The Advances in Thermal Hydraulics (ATH-14) embedded topical meeting will be held in conjunction with the ANS Annual Meeting to be held Reno, NV from June 15-19. I am excited for opportunity to see more full-length papers being presented. The format of ATH is such that sessions will be available for all aspects of thermal hydraulic research. The second THD sponsored conference in 2014 will be the NUTHOS-10 to be held in Okinawa, Japan from December 14-18. More information on both of these conferences can be found later in the newsletter.

While there is much good news to report, I need to report on

the passing of two people that have had a significant impact on thermal hydraulics and THD. On August 7<sup>th</sup>, former THD chair, Dr. Chang Oh, passed away. I was first introduced to Dr. Oh as a result of his research. Dr. Oh was invited me to participate in THD activities. His leadership served the division well. His technical and division contributions will be missed.

On October 3<sup>rd</sup>, Dr. Novak Zuber passed away. It would be difficult to overstate the impact that Dr. Zuber had on the arena of thermal hydraulics. His contributions include creating the first, workable drift-flux formulation and creating the scaling techniques that are still considered to be state-of-the-art. I am sure that Dr. Zuber's ideas will be used in thermal hydraulic analyses for decades to come.

More detailed articles on both Dr. Oh and Dr. Zuber can be found later in the newsletter.

I recently had the opportunity to discuss the operation of THD to the staff of ANS. As part of that conversation, I realized that the focus of THD has traditionally been focused on providing a means for researchers to present their current work to an interested group at venues such as THD sponsored topical conferences (NURETH and NUTHOS) or at THD sponsored sessions at the ANS Annual and Winter Meetings. While I have personally benefitted greatly from these opportunities, I realized that only a small fraction of our members participates in these events. As such, I started thinking about how to make THD more relevant to a larger group. As part of this process, I'd like to hear from you. Are there services that THD could provide that we are not? If you have ideas, I'd appreciate an e-mail at the address provided at the end of this article.

David Aumiller, Bettis Laboratory  
2013-2014 THD Chair  
[dla12@pitt.edu](mailto:dla12@pitt.edu)

### Upcoming THD Conferences

2013 ANS Winter Meeting (Washington, DC) – Nov. 10-14  
2014 ANS Annual Meeting and ATH '14 (Reno, NV) – Jun. 15-19, 2014 (Papers due Jan. 10, 2014)  
NUTHOS-10 (Okinawa, Japan) – Dec. 14-18, 2014  
NURETH-16 (Chicago, IL) – Aug. 30-Sept. 4, 2015

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## Treasurer's Report

**The following 2013 Division Financial Report** is based on the actual spending through August 31, 2013.

### **2013 Income / Balance**

- Revenue from 2013 THD member allocation: **\$1,621**
- Balance forward from 2012: **\$18,790**
- The balance for THD fund as of August 31st, 2013: **\$17,967**

### **2013 Division Budget (\$5,550)**

The THD Executive Committee approved the following budget at the 2012 Winter Meeting:

- Awards and plaques: **\$1,800**
- Donation to Scholarship/NEED: **\$500**
- Student support: **\$3,250**  
Student support includes: \$750 for ANS-national directed support of student travel to Annual/Winter meetings; \$1,000 for 2013 ANS Student Conference; \$1,500 of THD-directed student travel support for 2013 Annual and Winter meetings (including the embedded topical in at the Winter 2013 meeting).

### **2013 Expenses: Actual as of August 31, 2013 (\$2,444)**

THD expenses as of August 31, 2013 are as follows:

- Awards / Plaque: **\$182** (Three Crown Trophies)
- Donation to Scholarship/NEED: **\$500**
- Student support: **\$1,750**:  
Student support includes: \$750 for ANS-national directed support of student travel (\$150 each for five students); \$500 for 2013 ANS Student Conference; and \$500 for THD-directed student travel support for 2013 Annual Meeting (\$100 each for five students)
- Other expenses: **\$12** (Shipping)

Seungjin Kim, The Pennsylvania State University  
2013-2014 THD Treasurer

[skim@psu.edu](mailto:skim@psu.edu)

## Honors and Awards Committee Report

### **TAA Award**

The recipient of the 2013 Technical Achievement Award has been selected as Dr. Chang Oh.

The award citation reads "In recognition of his exceptional contributions to enhancing thermal hydraulic technologies of advanced reactors, and for his impact as a researcher, practitioner, designer and leader."

TAA is an ANS National award and therefore, the recipient will be recognized in the plenary session of the 2013 ANS Winter Meeting in Washington DC.

The Division will host our own Technical Achievement Award Ceremony at the conference on Monday afternoon, Nov. 11, immediately following the technical session "Experimental Thermal Hydraulics – I: Dedicated In Memory of Dr. Chang H. Oh". As the session title implies, our recipient unfortunately passed away in August. Family members will be present to accept the award on his behalf. Dr. Jong Kim has graciously organized a remembrance for the ceremony. Any and all are welcome to attend and honor our dear colleague and friend.

### **2013 Best Paper Award**

The 2013 Best Paper Award will be presented at the June 2014 Annual Meeting.

Karen Vierow, Texas A&M University  
2013-2014 THD Honors and Award Committee Chair  
[vierow@tamu.edu](mailto:vierow@tamu.edu)

## Young Professionals Report

The Thermal Hydraulics Divisions has organized its annual "Young Professional Thermal Hydraulics Research Competition" to be held during the 2013 ANS Winter Meeting. This competition presently includes nine accepted transactions from four unique organizations, demonstrating continued strength and continued support with regard to this event.

Wade Marcum, Oregon State University  
[Wade.Marcum@oregonstate.edu](mailto:Wade.Marcum@oregonstate.edu)

## Program Committee Report

The strong THD presence at the ANS national meetings continues. The interest and participation to the sessions organized by our division reached a new high: We received the record number of summaries for the upcoming 2013 Winter Meeting in Washington, DC. Thanks to the support of the session organizers, reviewers, contributing authors and panelists, the program committee has put together another strong arrangement of sessions for the meeting.

At the 2013 Winter Meeting, THD is organizing a total of 14 sessions: 12 contributed paper sessions and two panel sessions. This meeting also marks the highest number of summaries for THD sessions, to date. We received a total of 96 summaries, out of which, based on the reviewer recommendations, one summary was rejected and 18 were rated as "Rejected Unless Revised". A total of 86 summaries are expected to be presented at this Winter Meeting. Again, let us take this opportunity to thank the session organizers and the reviewers for their wonderful efforts: Nearly 300 reviews were completed for this winter meeting. These sessions, in chronological order, are:

Experimental Thermal Hydraulics–I: Dedicated in Memory of Dr. Chang H. Oh [Mon. p.m.]

Computational Thermal Hydraulics–I [Tues. a.m.]  
Thermal Hydraulics: General–I [Tues. a.m.]  
Highlights of NURETH-15–Panel [Tues. 1:00 p.m.]  
Thermal-Hydraulics Code Verification and Validation–I [Tues. 1:00 p.m.]  
Experimental Thermal Hydraulics–II [Tues. 7:00 p.m.]  
Thermal-Hydraulics Code Verification and Validation–II [Tues. 7:00 p.m.]

Computational Thermal Hydraulics–II [Wed. a.m.]  
Young Professional Thermal-Hydraulics Research Competition [Wed. a.m.]  
Thermal-Hydraulics Reactor Analyst 2.0–Panel [Wed. 1:00 p.m.]  
Computational Thermal Hydraulics–III [Wed. 4:00 p.m.]  
General Two-Phase Flow [Wed. 4:00 p.m.]

Experimental Thermal Hydraulics–III [Thurs. a.m.]  
Thermal Hydraulics: General–II [Thurs. p.m.]

Monday afternoon's Experimental Thermal Hydraulics–I session is dedicated in memory of Dr. Chang Oh, long-time member and former chair of the division, who passed away in August 2013 (See Prof. J. Kim's article in this Newsletter). This session will be held in Room Congressional B. Immediately following this technical session (expected to be

around 5:30 pm), there will be a Technical Achievement Award Ceremony in the same room to honor this year's award recipient.

For those members who did not attend the NURETH-15 in Pisa, Italy in person, the panel session in Tuesday afternoon will be a good opportunity to learn the meeting highlights.

To accommodate large number of technical sessions in the general meeting as well as the four embedded topical meetings, this winter meeting is experimenting with evening sessions. To avoid parallel sessions on Thursday, our division will have two Tuesday evening sessions. We encourage our members to attend these sessions and let us know if you have comments regarding having evening sessions vs. Thursday parallel sessions.

The Young Professional Thermal Hydraulics Research Competition session, organized by Dr. Rui Hu (ANL) and Prof. Wade Marcum (Oregon State University), attracted nine summaries. These will be presented in one session Wednesday morning. Thanks to the hard work of our young member representatives, the session turned out to be a strong program with good participation.

The 2014 Annual Meeting will be held in Reno, NV. Continuing with the successful inaugurating embedded topical of Advances in Thermal Hydraulics in the 2012 Winter Meeting (ATH'12), the division is organizing ATH'14 as another embedded topical in the 2014 Annual Meeting. ATH'14 would be a good opportunity for full-length papers and we strongly encourage our members to consider submitting your work to ATH'14. For the general meeting of 2014 Annual Meeting, our division will sponsor only one summary session: General Thermal Hydraulics. The website (<http://epsr.ans.org/meeting/?m=136>) is open for submission of summaries. The website for the full-length paper submission to ATH'14 should be open shortly. The published deadline for the submissions is January 10, 2014.

In addition to ATH'14, the 10th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety (NUTHOS-10) will be held December 14-18, 2014 in Okinawa, Japan. Please see the conference website <http://www.nuthos10.org/> for detail. The published deadline for abstract submission is February 28, 2014.

The 16<sup>th</sup> International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-16) will be held in Chicago from August 30–September 4, 2015. The organizers are working on the call for papers. More details about the conference will be available at <http://nureth16.anl.gov/>.

In Washington, DC next month, the THD Program Committee meeting will be held on Sunday November 10, 2013, starting at 2:30 p.m. (The meeting start time may be moved up to 2:00 p.m. to allow more time for the following THD Executive Committee meeting.) Please refer to the Official Program of the Winter Meeting for the time and meeting location. Anyone interested in the program committee activities are invited to participate.

Finally, we would like to express our gratitude to all of the colleagues who devote your time to the Division's activities. Thanks to your dedicated efforts, we are able to put together strong programs at many meetings. These meetings remain as the prominent venue for scientific information exchange in the thermal-hydraulics community. As always, we would like to encourage our members to actively participate by attending our meetings, submitting papers/summaries, volunteering to organize sessions, and supporting the peer-review of the papers. We look forward to many more successful years.

Xiaodong Sun, Ohio State University  
2013-14 THD Program Committee Chair  
Elia Merzari, Argonne National Laboratory  
2013-14 THD Program Committee Assistant Chair  
[PCChair@thd-ans.org](mailto:PCChair@thd-ans.org)

## Website Report

The official website of the ANS Thermal Hydraulics Division is located at <http://thd.ans.org>. The THD committee membership and minutes, conference announcements, newsletters, and awards are all updated as they change throughout each year. The website is meant to provide up-to-date information on the division's activities.

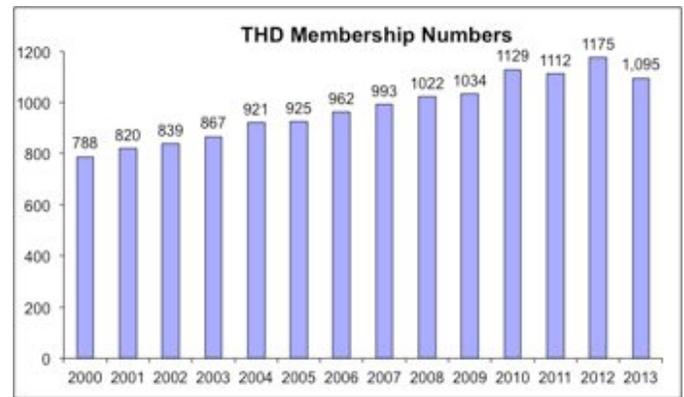
Moreover, the division continues to maintain an online directory of members who are or have been active in division activities at <http://thd.ans.org/people.html>. To update your information or to be included in this directory, please contact the THD Webmaster (see contact information below).

Wade Marcum has started officially as THD Webmaster effective at the end of the 2013 Annual Meeting in Atlanta Georgia, stepping in for Elia Merzari (Argonne National Laboratory). I invite all THD members to contact me with any suggestions for improvements, additions, or general comments.

Wade Marcum, Oregon State University  
2013-2014 THD Webmaster  
[wade.marcum@oregonstate.edu](mailto:wade.marcum@oregonstate.edu)

## Membership Committee Report

While the membership in the ANS has been showing some signs of leveling off in recent years, the membership in the THD has been moderately increasing. From 2008 to 2012, the paid ANS membership increased from 10,938 to 11,228, representing a 2.7% increase. For the same period, the paid THD membership had a 15.0% increase, from 1,022 in 2008 to 1,175 in 2012. Currently, our Division's paid membership stands at 1,095, as of the end of August 2013. As a comparison, THD had 1,080 paid members by the end of August 2012. Because the fall season is ANS's membership renewal period, this number is expected to go up slightly by the end of the year. The chart below presents our current growth trends.



\*For 2013, it shows the current paid members as of 08/2013.

The THD cordially invites you to become a member of the Division and participate in the Division's activities. Current activities of the Division include paper review, paper presentation, organizing and chairing technical sessions, sponsoring topical meetings, serving on the various subcommittees, and supporting student conferences. If you are interested in becoming a member, you can contact ANS membership directly. If you are currently a member and interested in any of the above activities, please contact any of the THD Officers.

Xiaodong Sun, Ohio State University  
2013-2014 THD Membership Committee Chair  
[sun.200@osu.edu](mailto:sun.200@osu.edu)

## Nominating Committee Report

Current Division Officers and Executive Committee members are listed below.

### Current Year THD Officers (June 2013 – June 2014)

#### *Division Chair*

David Aumiller, dla12@pitt.edu

#### *Vice Chair/Chair-Elect*

Si Young Lee, si.lee@srnl.doe.gov

#### *Secretary*

DuWayne Schubring, dlschubring@ufl.edu

#### *Treasurer*

Seungjin Kim, skim@psu.edu

### Executive Committee Members

David Aumiller (2014)	dla12@pitt.edu
Fan-Bill Cheung (2014)	fxc4@psu.edu
Yassin Hassan (2014)	y-hassan@tamu.edu
Jong Kim (2014)	jongkim@mail.kaist.ac.kr
Si Young Lee (2014)	si.lee@srnl.doe.gov
DuWayne Schubring (2014)	dlschubring@ufl.edu
Xu Cheng (2015)	xu.cheng@kit.edu
Francesco D'Auria (2015)	francesco.dauria@dimnp.unipi.it
Takashi Hibiki (2015)	hibiki@purdue.edu
Seungjin Kim (2015)	sxk86@psu.edu
Kurshad Muftuoglu(2015)	kurshad.muftuoglu@ge.com
W. David Pointer (2015)	pointerwd@ornl.gov
Chul-Hwa Song (2015)	chsong@kaeri.re.kr
Igor Bolotnov (2016)	igor_bolotnov@ncsu.edu
Lane B. Carasik (2016)	lcarasik@tamu.edu
Elia Merzari (2016)	emerzari@anl.gov
Michio Murase (2016)	murase@inss.co.jp
Don Todd (2016)	donaltdodd@numerical.com
Xiaodong Sun (ex-officio)	sun.200@osu.edu
Hans Gougar*	Hans.Gougar@inl.gov

\*Chair of the ANS Professional Divisions Committee, ex-officio member without vote

### Committee Chairs

#### *Program Committee*

Xiaodong Sun, sun.200@osu.edu

#### *Honors and Awards Committee*

Karen Vierow: vierow@tamu.edu

#### *Nominating Committee*

Xiaodong Sun, sun.200@osu.edu

#### *Membership Committee*

Xiaodong Sun, sun.200@osu.edu

The Nominating Committee is responsible for the nomination of THD members to leadership positions on both the Program and Executive Committees. The THD would like to

encourage members interested in becoming more involved to contact one of the officers listed above. In particular, the division is usually in need of volunteers for technical meeting session organizers and paper reviewers.

Xiaodong Sun, Ohio State University  
2013-2014 THD Nominating Committee Chair  
[sun.200@osu.edu](mailto:sun.200@osu.edu)

## Student Involvement Report

2013 Annual Meeting travel support recipients:

- Nathan Bartel, U-Idaho
- Minghui Chen, Ohio State University
- Alexander Rattner, Georgia Tech.
- Susan Sipaun, MUST
- Muhammad Yousaf, MUST

### New Annual Meeting Student Program Guidelines

No limit on the number of students-- all ANS National student members are eligible. Student members should register for the conference at the student rate of \$150.

Registration will be reimbursed and a travel grant given upon completion of requirements. After registering for the conference, you may then register for the Student Program online in advance, or upon arrival to the conference. Priority for work preferences will be given to those who register in advance, so plan ahead! Registration is now open:  
<https://ssl.ans.org/meetings/winter/studentreg/>.

Activities and corresponding point values are the following:

- Assist a 1-2 hour session: 4 pts
- Assist a >2 hour session: 5 pts
- Monitor the Student HQ Room for 2 hours: 3 pts
- Stuff registration packets (Saturday or Sunday): 3 pts
- Attend a 1-2 hour division/committee meeting: 3 pts
- Attend a >2 hour division/committee meeting: 5 pts
- Attend the SSC meeting: 2 pts
- Participate in a workshop: 3 pts
- Participate in the mentor program: 2 pts
- Present a poster or paper: 5 pts

Complete at least one work and one participation activity for a total of 10 points to meet the program requirement. Only one poster or paper will be counted, and meetings must be attended in their entirety to earn the participation points.

You will find complete STUDENT PROGRAM INSTRUCTIONS as a PDF in the Documents Section for the 2013 Winter meeting at [www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1)

Lane Carasik  
2013-2014 THD Executive Committee Member  
[lcarasik@tamu.edu](mailto:lcarasik@tamu.edu)



## In memory of Dr. Chang H. Oh

Dr. Chang Ho Oh, a long-time member of the ANS Thermal Hydraulics Division (THD), passed away on August 7, 2013, just one day after he retired from INL. He was 67. He valiantly fought gastric cancer for over two years. He is survived by his wife Theresa, two sons Paul and John, and John's wife Tara. Dr. Oh was born in Pyongyang, North Korea, on April 28, 1946. He graduated from the Dept. of Chemical Engineering at Yonsei University and completed his military duty in the Korean Army. He came to the US with the American dream as so many foreign students do. He received his M.S. in Chemical Engineering from the University of Florida and Ph.D. in Chemical Engineering from Washington State University. He spent the prime of his career at Idaho National Laboratory (INL) where he rose through the ranks as Senior Engineer, Principal Engineer, Advisory Engineer, culminating at the highest technical rank, INL Distinguished Engineer.

Chang was a senior-most active member in the nuclear thermal hydraulics community, well respected by his peers around the world. He was a world-class engineer, scientist, innovator, inventor, and leader with international reputation and influence. Those who knew him held great respect and admiration for his research, dedication, integrity, and leadership. He served as chair of both ANS THD and ASME Heat Transfer Division (HTD), a clear indication of the trust and high esteem placed in him by his peers in the technical community.

During his long professional career, Chang carried out some impactful research and development. His contributions run the gamut from critical heat flux correlations for a very narrow channel mimicking low pressure loss-of-coolant accidents, flow mixing for the conceptual Advanced Neutron Source project, computer code developments such as TPAC (tritium permeation analysis code), GAMMA (gas multi-component mixture analysis), and HyPEP (hydrogen production efficiency calculation program), two-phase flow instability analysis, flow and chemical reaction modeling of supercritical water oxidation, to heat transfer in very-high temperature gas-cooled reactor (VHTR). In recent years, Chang was engaged in enhancing the performance, reliability, and safety of VHTR. VHTR operates at a very high temperature that enhances thermal efficiency as well as hydrogen production. However, the very high temperature in turn also has adverse effects on materials integrity. Chang found a way to reconcile these two conflicting factors by reducing the exit temperature of VHTR by as much as 200oC (thereby alleviating the materials concerns) while compromising the efficiency by only a small fraction. This breakthrough can be achieved by employing a suitable combination of several pertinent technical elements and was verified by a computer code simulation. Chang's innovation will go down in history as one of the most significant technical advancements in the design of VHTR. Chang also proposed a new mechanism for air ingress driven by density-stratified flow as opposed to that due to molecular diffusion. This is a surprising shift in paradigm, as molecular diffusion was accepted as the dominant plausible mechanism for air ingress in VHTR until Chang proposed an alternate mechanism. The new mechanism is much more effective in accelerating air ingress into the reactor core and the lower plenum than the commonly accepted molecular diffusion mechanism. Chang was the first one to raise the possible relevance of density-gradient-driven stratified flow in air ingress process. This new finding is very important to the VHTR conceptual design and developing a mitigation plan for the graphite oxidation. The industrial savings from his contributions are estimated to range in the hundreds of million dollars if his breakthrough inventions are implemented in commercial VHTR reactors, showing that Chang's research is not only of scientific interest but has real practical significance. He holds a number of patents in these areas.

Chang has made significant contributions to ANS THD. He regularly contributed to ANS Summer and Winter Annual Meetings as author, speaker, session organizer, and session chair. Notably, he also served as Chair of ANS THD. His spirit of dedicated service has been an inspiration for his professional colleagues and has set a good example for them to follow. In addition to his activities in ANS THD, he was also highly visible in the ASME HTD affairs and widely respected by his peers at ASME. He chaired ASME HTD, overseeing some 4,000 primary members and 4,000 secondary members of the Division.

Chang garnered numerous honors and awards: he received the Heat Transfer Memorial Award from ASME – the highest recognition bestowed in heat transfer by ASME; he was a Fellow of ASME; served as Associate Editor of the Journal of Heat Transfer; received a Best Paper Award from ANS THD; received the Best Paper Presentation Award at the 8th International Heat Transfer Conference, to name just a few. At his INL, he received the Performance Excellence Award twice and the most prestigious INL Director's Award for Exceptional Engineering Achievement – the highest engineering achievement award bestowed on an individual by INL. He was selected for this year's ANS Thermal Hydraulics Technical Achievement Award (TAA) but sadly he passed away prematurely. The ANS THD Honors and Awards Committee unanimously voted to confer the award to him posthumously.

Much accomplished as Chang was in technical and scientific research, he was also a devoted family man, a warm friend to people around him, and an entertaining and engaging person to his professional associates. His sense of humor, innocent smile, and unassuming laughter were his signature and his passion to help others in need remains his personal legacy. We bid farewell to our beloved friend Chang ---- but will meet him in our garden of memory.

Here are some special words from Chang's colleagues and friends as they reminisce about him:

**Hisashi Ninokata**: Chang and I were of the same age. He let me talk to him as his brother and I did; I tried to do so to an elderly brother, respecting his just a little bit earlier birthday, emphasizing that, in our oriental spiritual inspiration, seniority should precede everything. The time we spent together may be very brief in the scheme of the universe and has gone into my memory, but I sensed that he existed for other people, for those whose smiles and well-being his own happiness depended on. I miss him, who was always found beside me when I needed a friend.

**Karen Vierow**: Chang was a mentor and friend during many years of my interaction on ANS Thermal Hydraulics Division committees. I was one year behind him in the rotation through THD officer-ship. I am grateful to his guidance throughout my officer duties. I am truly pleased to have chaired the Honors & Awards Committee in the year that we selected him as our TAA recipient. On a lighter note, I enjoyed Chang's sense of humor and family devotion throughout our interactions. One of our longer-running jokes was about how I watched a Korean drama series in Japanese (English title: Winter Sonata) and he stated proudly that the popular movie star in the drama looked just like his son! Thanks, Chang, for the good times!

**F.B. (Bill) Cheung**: I was overwhelmed with an immense sense of loss when I learned about the sad news of Chang, a wonderful colleague whom I have great respect for and a dear friend whom I've known for nearly three decades. Our research interests overlapped one another and we had served on a variety of national and international committees and conferences. He was truly a role model particularly in terms of research and service. Not only was he technically strong and capable but also he was always willing to help, ready to encourage, and prepared to get the job done in a timely and perfection manner. His unselfish services, his dedication, his technical impact, his positive attitude, his generosity, his smile, and more importantly, his friendship will long be remembered.

**Yassin Hassan**: I am shocked by the sad news that Chang has passed on. Chang certainly had the knack for making even the most serious things a good fun. He was an optimistic and selfless man who went through his life helping others. I had known Chang for more than two decades. He was chivalrous and a true gentleman. He contributed immensely in the nuclear field. He published in top journals and was a dedicated reviewer. I depended on his technical judgments. He was a lovely man and we thank him for sharing his life with us. His energy will be missed but his memories will live in my heart.

**Xiaodong Sun**: I deeply miss Chang, his laughter, humor, advice, and all the positive energy he brought to us. Whenever I think of him, his smile and laughter come directly to me and I feel he is just somewhere near me.'

**John Luxat**: Chang was one of the most generous persons I have had the honor of knowing. Not only was he selfless in nurturing those individuals who were establishing their careers, but he continued to support them as they progressed to greater achievement. It is the mark of a great individual that one can be so magnanimously supportive of others as he, in turn, achieved constantly increasing recognition. I shall miss him beyond mortal expression.

**Si Young Lee**: I was one of those who were fortunate enough to know and work with Dr. Chang H. Oh as a dear friend and a valued colleague. I respected Dr. Oh as a member of our ANS-THD community. Not only will his contributions to nuclear thermal-hydraulics be missed, but also his leadership skills and the great kindness he showed others. He was a worthy role model in every sense.

***Jong H Kim***  
***Past Chair, THD (2002-2003)***  
***Professor***  
***Dept. of Nuclear and Quantum Engineering, KAIST***  
***Daejeon, Korea***



## **In Memory of Our Friend and Colleague, Novak Zuber**

Dr. Novak Zuber was a pioneer researcher in boiling heat transfer and two-phase flow, and one of the founding fathers of the field of nuclear thermal hydraulics. His work spanned seven decades, during which time he made numerous contributions to science and engineering. His many technical achievements, as well as his vigorous passion towards nuclear safety and two-phase flow have inspired many of us.

Novak Zuber was born on December 4, 1922 in Belgrade, Yugoslavia. He immigrated to the United States following World War II, during which he was a member of the Royal Yugoslavian Air Force based in Italy. After the war he took on a number of jobs including that of a merchant seaman until completed his education at the University of California at Los Angeles. His doctoral thesis, "Hydrodynamic Aspects of Boiling Heat Transfer," is widely recognized as a classic scientific work and an example of his research into the

governing mechanisms of boiling and two-phase flow. For this work he received the first ASME Memorial Award. Zuber later derived and developed the now well-known drift flux model relating the void fraction and observable quantities of a two-phase flow. In these and in a wide variety of complex problems he continually used physical insight to obtain simplicity through fundamental physics.

After working for Thompson Ramo-Woolridge (1958-1960) and General Electric (1960-1967), Zuber became a Professor of Mechanical Engineering first at New York University and then at the Georgia Institute of Technology. Dr. Zuber was an exceptional educator who developed many students who became "bright stars" in their technical fields. He taught about the power of rational thinking, the rigorous mathematical treatment of two-phase flows based on physics, and the ability to use those principles to interpret the true driving mechanisms for flow phenomena. Dr. Zuber may have had the strongest influence on the shift to a physics-based analytical approach for analyzing two-phase flows rather than a semi-empirical approach. He emphasized the importance of integrity and honesty in scientific research that remains essential in nuclear thermal-hydraulics. From 1974 until 1991 Zuber worked in the Office of Nuclear Regulatory Research at the U.S. Nuclear Regulatory Commission (NRC). This included the period following the event at Three Mile Island, where nuclear safety and accident analysis took on a new importance. Zuber guided development of several of the NRC best-estimate reactor safety codes including TRAC-P, TRAC-B, RELAP5 and RAMONA, and served on the international committee for the "2D/3D Program" to investigate multidimensional effects during a large break loss-of-coolant accident (LOCA). Zuber was instrumental in development of the Code Scaling, Applicability, and Uncertainty (CSAU) methodology that enabled a revision to 10 CFR 50.46 to permit "best-estimate" LOCA analysis.

Following his retirement from the NRC in 1991, Zuber continued to remain active until the time of his passing. He served as a consultant to the Advisory Committee on Reactor Safeguards and continued to develop improved methods for thermal-hydraulic scaling.

Over the past decades Dr. Zuber has made many contributions to boiling, two-phase flow and nuclear safety. He published over 100 technical papers and was co-editor of several books. He has a long list of awards including the Technical Achievement Award from ANS and a Meritorious Service Award from the NRC, and is a fellow of ASME and ANS.

Novak Zuber was a fascinating character. In addition to his mother tongue Serbian, he spoke fluent English, Russian, Italian and French. He was able to deliver unprepared peppy speeches in these languages as he did in flawless French in Avignon at the 2005 NURETH-11 Conference in front of a captivated audience. Novak was an amazing scholar not only of science and engineering but also of history. He was unbeatable on the Ottoman Empire, Genghis Khan and the Mongol Empire and of course on the Balkans chaotic history. An avid reader of books, he left a library of more than 7000 books, many of them hand-annotated. Novak contaminated many of his friends with his tireless enthusiasm for studying science, history or sociology.

But, perhaps most importantly, he was known as a good friend and inspirational leader to any and all who work in these fields. It has been a great honor and a high privilege to have known him personally. He will be sorely missed.

***Prepared by Stephen M. Bajorek, Jean-Marc Delhayé, and Mamoru Ishii***

## Hydro-Mechanical Testing for Fuel Qualification and Code Validation

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Since 2008, Oregon State University (OSU) and the Idaho National Laboratory (INL), through the USHPRR program, have been collaborating on a test program which entails the design, construction, and utilization of an experimental facility for the purpose of hydro-mechanical testing of a prototypic fuel. The final outcome of this test program is to yield objective experimental data that demonstrates the mechanical integrity of the prototypic uranium-molybdenum monolithic fuel material compared to existing fuel material. The prototypic fuel material subject to the qualification effort is intended for implementation in the U.S. high performance research reactors.

In 2010 a final design for the experimental facility was identified and in 2011 the experimental facility came to realization at Oregon State University. The Hydro-Mechanical Fuel Test Facility (HMFTF) has been designed to operate under a large range of thermal hydraulic conditions which are elevated well above that of an ambient state as seen in Table 1. Because the HMFTF's purpose is providing hydro-mechanical information, its design is currently limited to sub-cooled, isothermal testing.

Table 1: HMFTF fluid operating range

Parameter	Value
Flow Rate Range [liters/sec]	0 – 100.94
Pressure Range [MPa]	0.101 – 4.137
Fluid Temperature Range [°C]	20 – 238
Conductivity Range [ $\mu$ mhos]	1 – 3
pH Range	4 – 8

In order to yield experimental data that directly supports critical components (fuel elements) within U.S. research and test reactors, all activities associated with this collaborative effort are required to operate within a quality assurance program. Oregon State University has established a quality assurance program that is compliant under applicable parts and requirements of ASME NQA-1 in order to yield all critical data, and has been confirmed to maintain compliance through its inclusion on INL's quality supplier list.

In 2011 OSU began shakedown testing, calibration and validation & verification efforts on all systems of the HMFTF. Presently OSU and INL are initiating the Matrix Testing phase of this program. The test specimen is of a plate-type fuel element form referred to as the Generic Test Plate Assembly (GTPA), having a total of six plates configured adjacent to one another by flow channels of differing widths. The GTPA is housed in the HMFTF test section which is approximately 2.56 m in total length. Discrete locations along the length of the test section pipe are made available for the insertion of electrical wire leads for strain gages, pitot tubes for pressure transmitters, pressure indicating flow transmitters, and other instrumentation as deemed necessary for a particular test.



Figure 1: Picture of HMFTF

The test section is designed to provide an interface for any desired test element which meets overall size criteria. This is achieved by designing individual test section element-specific inserts which mate directly with the element. The purpose of these inserts is to simulate in-core flow conditions. These inserts are fed into the test section pipe and coupled to a universal interface to secure the insert and the element within the test section. A vaned flow straightener resides upstream of the test section providing repeatable and well controlled inlet boundary conditions on the test section. The location of the vaned flow straightener and test section are shown in Figure 1 within the overall primary loop piping system of the HMFTF. Three materials are intended to be tested as a part of this testing program including (1) a roll-processed all-aluminum 6061-O Temper plate, (2) an aluminum clad DU-Mo monolithic foil plate, and (3) an aluminum clad aluminum-stainless steel dispersion plate.

During a given test, the desired material plates are assembled in the GTPA, which is secured into the HMFTF test section.

The test loop is brought to a nominally desired pressure-temperature state, and flow is incrementally increased until plastic plate deformation is observed via strain gage readings. After a test the geometry of the element and plate are fully characterized to identify the full field plastic deformation relative to test initiation. Figure 2 details a viewgraph of plate deformation after a plate has undergone a successful hydraulic test.

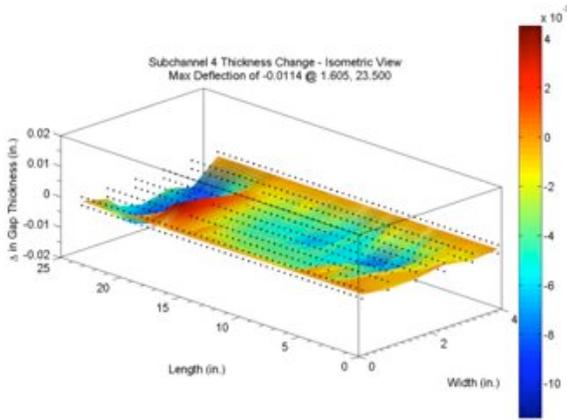


Figure 2: Preliminary plate deformation results

The ultimate outcome of this work will yield a comparison between the hydraulic load required to initiate plastic deformation for plates of each material composition; additionally, this data has been identified to contain sufficient detail to support the validation and verification of multiphysics computational tools that compute fluid structure interactions.