MPI DELEGATION VISIT TO CHINA’S RESEARCH & EDUCATIONAL CENTERS IN METAL PROCESSING

DECEMBER 8-17, 2004
I. **Purpose of trip:**

1) Renew and nurture friendships with key Chinese university professors and industry leaders, 2) Introduce MPI delegation to leading Chinese researchers and 3) Plan for future cooperative and collaborative research between MPI/WPI and Chinese Universities.

II. **MPI Delegation Members:**

**At Beijing - Tsinghua University:**
Professor Diran Apelian, MPI/WPI, Worcester, MA
Professor Makhlof M. Makhlof, MPI/WPI, Worcester, MA
Dr. Qingyue Pan, MPI/WPI, Worcester, MA (China-USA)
Dr. Libo Wang, MPI/WPI, Worcester, MA (China-USA)
Mr. John Jorstad, JLJ Technologies, Inc., Richmond, VA
Professor Andreas Alexandrou, University of Cyprus, Limassol, Cyprus
Mr. Max Hoetzl, Surface Combustion, Inc., Maumee, OH
Mr. Fredric (Rick) A. Woldow, Caterpillar Inc., Peoria, IL
Mr. Michael Lovis, N-Tec Ltd., Redditch, UK
Mr. Gek Leng (Steven) Sim, International Copper Association, Ltd. (ICA), Singapore

*Key Contacts at Beijing/Tsinghua: Professor Baicheng Liu (Academician, Chinese Academy of Engineering) and Dr. Jinwu Kang*

**Additional MPI delegate joining at Xi’an – Northwest Polytechnic University:**
Dr. Jean C. Lynn, DaimlerChrysler Corp., Auburn Hill, MI

*Key Contacts at Xi’an/NPU: Professor Weidong Huang and Dr. Meng Wang*

**All MPI delegates present for Shanghai Jia Tong University:**

*Key Contacts at Shanghai/Jia Tong: Associate Professor Jinfu Li (Casting), Associate Professor Jingquan Liu (Director of Micro/Nano Science & Technology Lab) & Jianfeng Gu, Associate Professor (Heat Treatment).*

III. **Thursday, December 9, 2004, Beijing: Sino-American Seminar on Materials Processing; Tsinghua University Unicenter Conference Room:**

- **8:30 Welcome** by Professor Baicheng Liu and introduction of Tsinghua delegation *(See Liu Attachment 1 for details on Tsinghua University)*; **Opening remarks** by Professor Diran Apelian, introduction of MPI delegation and statement of objectives for the trip *(See Apelian Attachment 2 for details).*
- **9:00-10:20, Presentations by Tsinghua Delegation**
  - Professor Shoumei Xiong, Director Tsinghua-TOYO R&D Center: Al & Mg Die Casting R&D @ Tsinghua *(See Xiong Attachment 3)*
  - China produces 48% of the world's Mg - 354 thousand metric tons in 2003.
Mg die casting in China is 18% of world production; growing @ 10% per year.

Significant work has been done in Al & Mg die casting, correlating casting parameters with casting quality.

Good potential for MPI/ACRC+Tsinghua collaboration on practical items that can be published by NADCA and/or other journals; perhaps another NADCA book combining information from latest WPI/NADCA book and/or i-Select-Al for shot parameters versus casting quality and properties in Al & Mg, liquid and semi solid.

**Associate Professor Quinyan Xu** (with Professor Liu): *Numerical Simulation of Microstructure Evolution R&D @ Tsinghua* *(See Xu Attachment 4)*

- Developed a mathematical simulation of 3-D free dendritic growth and grain development based on CA methodology.
- 3-D model has proven reasonably accurate based on comparison with microstructures of experimental castings -- it also correlates well with 2-D models.

**Professor Yanxiang Li**: *Directional Solidification of Metal-Gas Eutectic R&D @ Tsinghua* *(See Li Attachment 5)*

- Interesting work generating controlled, elongated-pore structures based on GASAR technology (unidirectional solidification)
- Might be useful as infiltration substrate for special MMC concepts, or
- Reduced-weight, directional-property structural members.

**Associate Professor Wenzhen Li**: *Direct Preparation of SSM Billets R&D @ Tsinghua* *(See Wenzhen Attachment 6)*

- Semi solid processing R&D has been on-going in China since 1970s based on Thixo (billet) methods, but has not made significant progress because of high costs.
- Interest in semi solid processing is high in China because of perceived potential for low-cost production and high casting integrity.
- Tsinghua began SSM R&D in 1990s and has concentrated on reduced-cost billet manufacturing.

- Developed a PLC controlled vertical continuous casting system using vibration in a pre-mold to develop the desired microstructure together with synchronous billet cutting and handling. Is ready now for commercial introduction if industry shows interest.

**Professor Houfa Shen** (with Professor Liu): *Numerical Simulation of Continuous Casting Process R&D @ Tsinghua* *(See Attachment 7)*

- Modeling of macroscopic transport during continuous casting of steel.

**Professor Tao Jing**: *Internet Based Simulation Service to Industry* *(See Attachment 8)*

- Has developed the methodology to provide on-line, web-based simulation services in a timely fashion to small foundries throughout China
- As with Professor Xiong’s work, this is another potential opportunity for collaboration between Tsinghua and MPI/ACRC – offer web-based simulation as a service to industry in USA/North America/Europe, perhaps also tied into i-Select-Al alloy optimization. Could offer the service to government R&D programs as well as to foundry and die casting industries.
10:20-10:50 Tea Break

- 10:50-11:20 Lectures by USA delegation
  - Professor Diran Apelian: Metal Processing Institute – Research Opportunities and Challenges.
    - Provided an overview of visit goals, MPI programs and projects and opportunities for Tsinghua/MPI collaboration
  - Mr. John Jorstad: Aluminum: Trends and Opportunities (See Attachment 9).
    - Provided an overview of the North American foundry industry, current status, future trends and new opportunities.
    - Reviewed challenges faced by the aluminum foundry industry re large, thin-walled castings and offered possible solutions via semi solid processing.
  - Mr. Fredric (Rick) A. Woldow: Caterpillar Materials Technology (See Attachment 10).
    - Provided an overview of Caterpillar materials technology, developments and technical capabilities as well as materials requirements.
  - Mr. Max Hoetzl: Heat Treating and Thermal Processing Opportunities (See Attachment 11).
    - Provided an overview of Surface Combustion’s equipment offerings.
  - Mr. Steve Sim: Technology and its Impact on the Future of Copper (See Attachment 12).
    - Mr. Michael Novis: Molten Metal Quality Assessment (NTec) (See Attachment 13).

11:30-12:00 Tour of Tsinghua Labs

12:00 Lunch, the combined delegations at Uniscenter Restaurant
Afternoon: visits in and around Beijing.
Evening: Welcome banquet hosted by Tsinghua University.

IV. Friday, Dec. 10, 2004; Tsinghua University Guest House Conf. Room

- 9:00-12:30: Round table discussion with delegation representing the Chinese Foundry Association, the Chinese Foundry Society, the Chinese Association of Heat Treatment and the Beijing Institute of Mechanical and Electrical Engineering.
- Co-Chaired by Professors Baicheng Liu and Diran Apelian.
- Welcome by Professor Liu and introduction of Chinese delegation; welcome by Professor Apelian, introduction of MPI delegation and statement of purpose of visit.
- Key Chinese delegation attendees and their comments:
  1) Chinese Foundry Association, Mr. Yong-sheng Li, First Vice-President (in charge of the association’s day-to-day business) with Ms. Yan Gao, his staff associate.
    - Serves primarily foundry executive and operating managers
    - Provided an overview of the Chinese foundry industry:
1. 20,000+ foundries (many of them very small).
2. since 2000, #1 producer of castings in the world.
3. Dominates in ferrous and copper, needs additional capacity for aluminum and magnesium.
4. Is currently in process of completing 2003 Chinese foundry statistics and will send a copy to WPI for re-distribution to delegation as soon as ready.

2) Chinese Foundry Society, Professor Shifang Su, General Secretary of the Foundry Institution of Chinese Mechanical Engineering Society and of the Productivity Promotion Center of Foundry Industry of China *(See Attachment 14).*

- Serves primarily the foundry academic interests and technical managers
- Provides the link between universities, research institutes and foundry enterprises.
- Provided an overview of their membership:
  1. About 10,000 strong
  2. Represents more than 600 foundry companies and 50 universities
  3. Has 22 committees
  4. Serves Die Casting, foundries, EPC, tooling, casting machinery, MMCs; virtually all segments of the casting industry
  5. Sponsors or facilitates technical exchanges that draw 100,000+ attendance annually
  6. Member of World Foundry Organization

3) Beijing Institute of Mechanical-Electrical Engineering: Professor Chen Yunbo, member of Chinese Academy of Science, with Professors Dongli Fan and Zailiang Chen.

4) Chinese Society of Heat Treatment: Prof. Sun Dayong *(See Attachment 15).*

- Professor Chen provided an overview of heat treatment in China:
  1. 10,000 heat treat facilities
  2. 120,000 members of heat treating society
  3. 15MMT annual capacity

5) FAMED Machinery Company: Mr. Dongqi Li, General Advisor to Management

- Ferrous foundry, largely making heavy machine parts
- Uses green sand, V-process, resin-bonded dry sand and low pressure
- 50,000+ tons per year

6) University of Science and Technology, Beijing: Prof. Lu Fanxiu,

o MPI delegation comments:
- Professor Diran Apelian: Metal Processing Institute – Research Opportunities and Challenges.
- Provided an overview of visit goals, MPI programs and projects and opportunities for collaboration with Chinese researchers and industry.
- **Mr. John Jorstad**: JLJ Technologies overview.  
  --Provided a brief overview of JLJ Technologies, specialties and capabilities.
- **Mr. Fredric (Rick) A. Woldow**: Caterpillar Materials Technology.  
  -Provided an overview of Caterpillar materials technology, developments and technical capabilities as well as materials requirements.
- **Mr. Max Hoetzl**: Heat Treating and Thermal Processing Opportunities  
  -Provided an overview of Surface Combustion’s equipment offerings.
- **Mr. Michael Lovis**: N-Tec Ltd.  
  -Provided an overview of N-Tec equipment and services
- **Mr. Steve Sim**: Technology and its Impact on the Future of Copper

  - *Lunch at Tsinghua Guest House Restaurant*

V. Saturday evening, Dec. 11: dinner with Tsinghua professors and dignitaries, hosted by MPI Delegation

VI. Monday, Dec 13, Xi’an; Northwestern Polytechnic University, China State Key Laboratory of Solidification Processing:

  **Workshop on Advances and Opportunities for International Collaborative Research and Development in Solidification Processing and in Metal Processing.**  
  *(See Attachment 16 with the full welcoming address and the program of the workshop)*

Workshop Organizing Committee:

  - Weidong Huang and Diran Apelian – co-chairs
  - Yongsheng Li (China Foundry Society)
  - Makhlouf Makhlouf (WPI)
  - Bing Wei (professor, Xi’an University of Technology and editor of Foundry Technical Magazine)
  - Xiufang Bian (professor, University of Shandong)
  - Dantong Chen (China Foundry Society)
  - Libo Wang (WPI)
  - Pan Qingyue (WPI)

Conference Secretary – Asst Professor Meng Wang (SKLS/NPU)

  - *8:30-9:00 Executive reception lounge:*
    - Introduction of NPU/China State Key Laboratory of Solidification Processing professors – Jun Zhang, Yaohe Zhou (Academician of Chinese Academy of Sciences, Honorary Director of Chinese Foundry Society and Honorary Chairman of this Workshop), Weidong Huang -- and other key Chinese dignitaries. *(see Attachment 16 B for statistics on the Solidification Laboratory – a Key State Lab in China)*
- Introduction of MPI delegation by Professor Apelian, and statement of purpose of visit.
- Welcome speech by Yang Shukang, Vice President, NPU

- 9:00-10:00 Workshop of Advances and Opportunities for International Collaborative Research and Development in Solidification Processing and in Metal Processing
  - The audience a mix of Professors from key Chinese universities in casting relates fields from Shanghai, Shandong, Xian and nearby universities; people form Chinese national and local professional societies and professionals from Chinese foundries and related industries – (See Attachment 17 – Attendee List)

- Session I, Chair Professor Weidong Huang
  1. Welcome address by Professor Weidong Huang (See Attachment 16) and opening comments by Professor Diran Apelian, Co-Chairs.
  2. Professor Diran Apelian: Overview of Metalcasting Research in the US and at MPI (See Attachment 18)
  3. Professor Sun Baode: Electromagnetic Separation Principal and Its Application in Materials Processing
     Much work is being done at NPU in this important area. A great deal of common ground between the work R. Ludwig and Apelian have been carrying out at MPI with HEN. This is another area where collaboration between NPU and MPI can take place. In addition to using JxB forces, the potential for purifying scrap Al melts is high. (See Attachment 19)

- Coffee break

- Session II, Chair Professor Diran Apelian
  4. Mr. John Jorstad: Aluminum Casting Trends and Opportunities (See Attachment 20)
  5. Professor Xiufang Bian (Dean of lab, Key Laboratory on Structure and Heredity of Materials, Shandong University): Researches in Structures of Liquid Metals and Casting Heredity. (See Attachment 21).

- Lunch

- Session III, Chair Professor Jun Zhang
  7. Professor Andreas Alexandrou: Research and Applications in Semisolid Technology. (See Attachment 23).
  8. Professor Weidong Huang: Adjusted Pressure Casting Technique and its Application in China. (See Attachment 24).

- Coffee Break

- Session IV: Chair Professor Makhlouf Makhlouf
  9. Mr. Max Hoetzel: Heat Treating and Thermal Processing Opportunities
  10. Mr. Michael Lovis: An Introduction to N-Tec Ltd
  11. Mr. Fredric Waldow: Caterpillar Materials Technology
  12. Mr. Steven Sim: Introduction to International Copper Association
(13) **Dr. Jean Lynn:** *Powder Metal Components for Automotive Applications; Present and Future.* *(See Attachment 25).*

Dinner with Key NPU Professors and visiting guest dignitaries, hosted by MPI Delegation

**VII. Tuesday, Dec 14, Factory Visits in Xi’an area**

- **Visit to Xi’an Aero Engine Group**
  - Manufactures military engine components via investment casting process in cooperation with Rolls Royce
  - Equiaxed turbine blades, vacuum investment cast (no single crystal)
  - Also visited the chemical treatment and plating workshop

- **Visit to Shilky High Voltage and Electric Company**
  - Manufacture pressure tight aluminum high-voltage transmission-tower and power-station connector and isolator castings, ranging in size from under 10 kilograms to 100 kilograms or more.
  - 356-type the predominant alloy
  - Noted that many cores and molds did not properly register, requiring interrupted-cut machining and leaving un-balanced product (heavy walls to one side and thin walls on the other)
  - Claim to be the largest manufacturer of this type of casting in the world (competes with Metal Castings Co., Div. of Electro-Mechanical Corp. in the US).

- **Visit to Qinchuan Machine Casting Company Ltd.**
  - Ferrous – 110,000 MT/year; non-ferrous (mostly Al and Cu, small amount of Zn) – 2,000 MT/year
  - Has keen interest in Weidong Huang’s “adjusted-pressure casting technique” – will likely install a cell.
  - Includes Shaanxi Automotive Group Ltd. – provides gray and ductile iron castings for military heavy trucks – 60,000 MT/year ductile iron differential carriers
  - 30 years experience casting, metallurgy, heat treatment, etc.
  - Would welcome MPI delegation technical cooperation and investments.

- **Visit to Chang'an Special Casting Factory** (private foundry) – (Interpreter - Lily Xu, export manager for Michael Gordon Ltd.)
  - Manufactures a variety of investment cast and Lost Foam cast products such as impellers, pump bodies, power-transmission connectors and engineered hardware (high-alloy steel), automotive chassis and drive-train components (ductile iron) and pipe fittings (stainless).
  - Manufactures and ceramic-coats Pyrotek’s protection tubes
  - Does plaster investment casting and lost foam casting.
  - Melts scrap and alloys own material in induction and cupola-style melters
  - Facility is labor-intensive, relatively dirty, not-safe (by western standards), crowded and disorganized.
  - Average wage rate is 1000 RMB/month ($125/month).
  - Employees live in small dormitories on site.
-Comment was made that Chang’an Special Casting Factory is typical of many of the low-cost Chinese foundries with which Western foundries are now trying to compete.

- Tour of Facilities of Northwestern Polytechnical University, China State Key Laboratory of Solidification Processing
  - Aerospace focus – over 70% of projects directly related to aerospace.
  - Modelling/visualization of solidification (transparent models - similar to John Hunt’s work).
  - Single crystal growth
  - Composites (high temperature)
  - Electromagnetic confinement of molten metals – aluminium and superalloys
  - Direct laser sintering/welding of steel and other powders.
  - Electron beam welding.
  - Foundry: Adjusted Pressure Casting (APC) equipment
    - Magnesium casting – 100kg capacity, treat with flux, SF₆ cover gas
    - Copper single crystal growth apparatus.

VIII Thursday, Dec 16 - Shanghai
  - Early Morning: Visit to Kolbenschmidt Pierburg Shanghai Nonferrous Components Co., Ltd. (www.kpsnc.com)
    - A Joint Venture (50/50) between Shanghai Automotive Industry Co., Ltd. and Kolbenschmidt Pierburg AG
    - Casts aluminum intake manifolds, cylinder heads and other parts for VW and GM
    - Uses low-pressure, gravity permanent mold and high pressure die casting
    - Facility and practices are typical of what might be seen in Germany or in other Western automotive foundries.
  - Mid-morning on: Visit Shanghai Jiao Tong University (note: primary contact and person arranging the visit was not present, and other university personnel filled in at the last moment)
    - Four Institutes of interest; Casting (Associate Professor Jinfu Li; institute includes micro-analytical lab), Welding, Heat Treating (Associate Professor Jianfeng Gu) and Micro-Nano Science and Technology (Associate Professor Jingquan Liu – MEMS lab)
    - Key Laboratories for High Temperature Materials and MMCs
    - Light Metals Casting Center
    - All casting, welding and heat treating activity centers are remote from the main campus and laboratories; the heat treating center could be visited only by the few MPI delegates who visited Ipsen in the afternoon. We heard a presentation on the simulation and modeling capabilities at Jiao Tong – See Attachment 26.
    - Welding Institute
      - Located on ‘old’ campus.
      - Applied rather than fundamental research.
      - Professors: 9, Post Docs: 10, Students:100.
      - Laser beam processing (3kW)
      - Vacuum electron beam welding/brazing
− Robotic welding
− Plasma arc
− High temperature tensile testing.

-State Key Laboratory of Metal Matrix Composites
− Professors: 30, PhD students: >100, Masters students: 80
− A reasonable number of students from this SKL go abroad to Europe and USA.
− Funding from government and industry, focus is on Military applications.
− No real modelling activity.
− Mainly fundamental research on Al, Mg and Ti.

-Research Institute of Micro/Nanometre Surface and Technology
− Independent college within the University.
− Large cleanroom.
− Electronic material, LED’s, electroplating for micro-engineered parts - MEMS for actuators and sensors.
− SEM, Scanning Auger microscope, nano sputtering of films.

-Presentation: Research and Application of Mathematical Model and Computer Simulation of Heat Treatment
− School of Materials Science and Engineering.
− High carbon rollers, die blocks.

Some General Observations and Reflections on the Trip:

1. Air quality in China was generally poor. A combination of dust and smog created a haze most of the time. The air smelled of the fumes from coal being burned to heat apartments. The Chinese government is taking measures to improve the air; like planting trees in urban settings and planning restrictions on future burning of coal.

2. Shanghai is a modern city comparable to NYC. The air quality in Shanghai was the best one, followed by Beijing, and the poorest quality being in X’ian.

3. Labor rates and wages in China today are roughly equivalent to those in the US 45-50 years ago. Workers in remote areas earn ~$100/month and in urban areas as much as $300/month.

4. Apartments buildings are being erected at a fast pace in and nearby large cities. Ownership is costly by Chinese standards; a typical apartment will range in size from 60 to 100 sq. meters, will have three bedrooms, living room, kitchen and bath/toilet and will sell in the city for 3,500 RMB ($400) per m\(^2\), in suburbs for 2500-3000 RMB per m\(^2\) and in more rural areas for 2000 RMB per m\(^2\). In a major city like Shanghai, ownership is even more costly.

5. Major highways into, through and around cities are being built at an amazing rate.

6. We visited one “supermarket” that was billed as “small” in Beijing, but found it to be
very modern and well supplied by anyone’s standards.

7. Chinese move largely on foot and by bicycle, but automobile ownership is becoming more and more popular and traffic jams more commonplace at rush-hour times. The inter-reaction of autos, trucks, busses, bicycles and pedestrians seems to the western eye chaotic but everything amazingly meshes without incident and without horns blowing and without road rage.

8. We saw many investments in the research infrastructure, equipment, and also buildings at the top three leading Universities. At Tsinghua, for example, we witnessed a beautiful granite new building for the Materials Sci. and Eng., another on Nanotechnology, a new well designed (modern architecture) Management School’s building, and another very modern building dedicated to the future of the internet. *(See Attachment 27).*

9. Much investments are being made in China across the board… see the executive summary of the Report prepared by the Asian Intl. Technology Program *(Attachment 28)*

10. The universities have many Professors who are global leaders in their specialty fields, yet it seems that many current studies and student projects are re-visits of work done years ago and little seems to be fresh and innovative by WPI/MPI standards. Our hosts were extremely hospitable, and the meetings we held established the groundwork for future collaborations. The three top Universities we visited will be a rich resource for MPI and our member companies to recruit talent.

11. As manufacturing will move off shore, there is the strong possibility (if not reality) that R&D will also move off shore. The delegation visit established the foundations that R&D can (and should be) done collaboratively – globally- between the leading Universities and R&D Centers in USA and China.

**Specific Action Items:**

1. Contact NSF to establish a Sino-USA bi-annual Conference on the Advances in Metal Processing. This will be similar in format to the one Mert Flemings established 20 years ago for USA-Japan Conferences in Solidification *(In process).*

2. Invite Professors Huang (NPU) and Liu (Tsinghua) to the MPI Symposium on May 26, 2004 on Computational Tools Re-engineering the World of Materials Engineering *(Done).*

3. Send S2P Conference Proceedings to Liu and Huang *(Done).*

4. Send to the Tsinghua University leadership the information we have at WPI on Yi Chei Mei (graduating class of 1914), who then became President of Tsinghua University in 1931 and under his leadership the University doubled its enrollment and established an engineering school *(In process).*