STUDY MEETING ON
ADVANCED MANUFACTURING TECHNOLOGIES AND SYSTEMS:
PRECISION ENGINEERING INDUSTRIES

25–28 October 2005

Daegu, Republic of Korea

Introduction

The precision engineering (PE) industry comprises predominantly small and medium-sized enterprises (SMEs) serving largely as contract manufacturers and component suppliers for product manufacturers. Being at the end of the manufacturing chain, PE companies face tremendous challenges in an increasingly dynamic environment of globalization, product proliferation, and shortening product life cycles. For PE companies to succeed under such circumstances, they must be lean, agile, and technologically competent.

There is a progressive trend for product manufacturers to outsource more of their operations so that they can concentrate on their core strengths of design and development. This provides excellent opportunities for the more enterprising PE companies to move up the value chain. A business model that is becoming increasingly common is one in which the product manufacturer nurtures of pool of supporting companies to form a manufacturing ecosystem. There are a number of important considerations for PE companies to adapt to such a symbiotic relationship.

The study meeting was aimed at understanding the extent to which advanced technologies and systems have been adopted and the associated issues faced by PE industries in APO member countries to meet the demands of the rapidly changing manufacturing landscape and market conditions.

The specific objectives were to:

a) appraise the challenges faced by the PE industry in an environment of rising consumerism and globalizing markets;
b) examine the extent to which advanced manufacturing systems and technologies are relevant and vital to the continuing competitiveness of the PE industry; and
c) compare the experiences in the adoption of advanced systems and technologies by the PE industry in the participating APO member countries.

The scope of the study covered:

(i) national priorities and policies, infrastructure support, human resources development, intellectual property rights, etc.;
(ii) industry initiatives and programs;
(iii) experiences of PE companies in systems and technology upgrading;
(iv) specific topics in manufacturing systems and technologies; and
(v) other factors such as legislative and cultural issues when PE companies relocate to foreign countries.

The four-day meeting included presentations by resource persons, country paper presentations, syndicate discussions, and a company visit to LG Micron. The meeting program and list of participants and resource persons are given in Appendices 1 and 2, respectively.

Overview

In the opening presentation, Dr. Lee Loke Chong identified a number of key drivers for change. Globalization is reflected in a proliferation of free trade agreements, double tax agreements, investment guarantee agreements, mutual recognition, and special economic zones. More economies are pushing to raise their competitiveness quotient, in which the technology index represents a significant component. Dr. Lee highlighted innovations in technologies and systems which have allowed miniaturization, greater precision, new functionalities, new materials, shorter life cycles, and higher productivity.

The strategic importance of SMEs in general and in the PE industry in particular is widely recognized, as they make a significant contribution to the economy and to employment. Often hindered by limited resources, PE companies require assistance in the five Cs: competencies (know-how and intellectual properties); capital (for investments and expansion); connections (to markets and alliances); conditions (government policies and macroeconomic environment); and culture (attitudes and mindset of the workforce). The experience of the SME21 initiative, which was introduced in 2000 in Singapore, has shown that a holistic approach is more likely to produce the desired results. SME21 covers broad-based national, sectoral, and enterprise-level strategies to develop entrepreneurship and manpower, design new business models, harness technology and knowledge, facilitate market access, and accelerate the use of e-commerce. Another program that has a successful track record is the Local Industry Upgrading Programme (LIUP), which was started in Singapore in 1986. In the LIUP, a large local or foreign company acts as the “big brother” to a group of SMEs to help them upgrade their technologies, operations, and management. Funding is provided for the LIUP manager and the upgrading projects. A more recent effort to help SMEs to move up the technology chain has been the Growing Enterprises with Technology Upgrading Program (GET-UP). Within GET-UP, there is (i) T-Up, under which staff from research institutes are seconded to the companies for up to two years; (ii) OTR, which helps companies to devise roadmaps that align technology with business strategy; and (iii) TA-S, under which senior researchers are assigned to advise companies on technology-related matters.

At the industry level, there is much that associations can do for their member companies. Compared with the other manufacturing sectors such as electronics and chemicals, the PE sector lags significantly behind in the value added per worker. The Singapore Precision Engineering and Tooling Association (SPETA) and Singapore Industrial Automation Association have been proactive in advancing the interests of their members in technology, markets and manpower. For example, SPETA has linked up with the Thai Automotive Parts Manufacturers Association to help access the automotive market and is collaborating with the National Trades Union Congress on the Skills Redevelopment Programme to increase the employability of middle-aged and undereducated workers. The government bodies find that it is more effective to channel resources through the trade associations. The Singapore Economic Development Board has set up the Local Enterprise and Association Development program and International Enterprise Singapore has introduced the International Marketing Activities program to provide financial support for industry associations for technology upgrading, organization of trade fairs, and business missions.

Dr. Lee rounded off his presentation with case studies of two PE companies that have successfully leveraged investments in technologies and systems to grow into global players. In both cases, the companies have carefully balanced market needs with technology acquisition. Nevertheless, the inherent risk in stretching a company's resources should not be underestimated, as seen from the experience of one of the companies, where an untimely downturn in economic conditions nearly sent it into liquidation.

Precision Industry Status in the Republic of China

Professor Benjamin Yuan stated in his presentation that the PE industry has made a major contribution to Taiwan's economic miracle. He provided insight into how the machine tool, tooling, and automotive parts industries underwent successful transitions from initial development through the growth period and finally entered the mature phase of mass production. From relatively modest beginnings, these three industries now command a significant share of the domestic and export markets. The precision machine tools and precision tooling industries have been identified as key industries, together with intelligent robots, flat-panel manufacturing equipment, and industrial machinery, in the 2008 six-year National Development Plan. Under this plan, greater investments will be made in human resources, R&D, innovation, logistics networks, and the living environment to create a steeper "smile curve" and ensure future prosperity.

According to Professor Yuan, Taiwan has good manufacturing skills and efficiency and is regarded internationally as a "professional maker." However, the management of sales channels is comparatively weak. He opined that priority should be given to the establishment of a global marketing strategy and there should be greater use of e-commerce as a means to facilitate the upgrading of Taiwan's enterprises.

Government initiatives to support the tooling industry came as far back as 1963 when the Metal Industries Research & Development Centre was set up to assist companies in technology and management system development. The tooling companies have grown from establishments with fewer than 20 employees to companies employing more than 30 staff. At the industry level, some regions have formed themselves into clusters. The Taiwan Mould and Die Industry Association has been instrumental in assisting its member companies to upgrade their technologies, own intellectual property, expand sales, improve production techniques, develop manpower, and forge corporate alliances.

PE as a Basis for Japanese Industrial Competitiveness

Professor Fumihiko Kimura identified the factors that influence technological competitiveness to be innovative products and processes, high quality, environmental awareness, product life cycle support, adaptability to change, error-free engineering, and manufacturing knowledge management. He elaborated on each of these factors with examples. Professor Kimura then traced the influence of IT systems on manufacturing from the 1970s to date with respect to themes, actors, and methods and tools. In the 1970s, manufacturing was process driven, in the 1980s technology driven, in the 1990s integration driven, and currently is business process and innovation driven. To meet the current challenges, Professor Kimura suggested strong leadership in decision making, giving priority to process innovation, and digitizing competitive knowledge. The emerging technologies that will be significant are life sciences, information and communications technologies, environmental technology, and nanotechnology. Manufacturing technology, infrastructural technology, and energy are important enablers. For SMEs, Professor Kimura suggested support for digital innovation, the capture and standardization of knowledge, generic IT, and a manufacturing process database.

Role of Korean Education in PE

Professor Joo Sang Woo commented that the success of the high-technology industry in Korea can be attributed largely to the weight that has been placed on education. However, to keep this competitive edge in a rapidly changing environment, the education

system may have to be reformed to be more flexible and decisive. He expressed concern that the science and engineering disciplines are facing problems with enrollment and the quality of students. To overcome this problem, Professor Joo suggested that there is a need to build better programs for PE and to attract better-quality students.

In 1999, the Accreditation Board for Engineering Education in Korea (ABEEK) introduced a system modeled after the American Accreditation Board for Engineering and Technology (ABET) program. ABET accreditation ensures that a college or university program meets the standards established by the profession. Some salient reasons for ABET accreditation are (i) students and their parents can choose quality programs; (ii) employers know that they are recruiting students that are well prepared for their jobs; (iii) registration, licensing, and certification boards can use them for screening; and (iv) colleges and universities have a structured mechanism to assess, evaluate, and improve the quality of their programs. Two mechanical engineering departments have received ABEEK accreditation. The program is still too new to arrive at firm conclusions on its effectiveness.

Professor Joo feels that the ability to communicate effectively and efficiently is also important. He described at length the efforts made by his university to promote technical communication skills. Another aspect that he feels requires attention is international programs. These are important in the rapidly globalizing industrial environment. Professor Joo lamented that too often PE is restricted to manufacturing. A more innovative interdisciplinary program for PE would be desirable.

IT and Web-based Services Used by the PE Industry

Professor Park Sang Chan gave an overview of some state-of-the-art precision engineering technologies used in leading international research organizations. These technologies cover processes, automation, inspection, and characterization. Such technologies are important enablers for microelectronics and nano/micro manufacturing. Professor Park examined these technologies when applied to the manufacture of semiconductor probes.

Health Monitoring Technologies for Advanced Manufacturing Systems

In his presentation, Professor Cho Younho covered recent trends and advances in health monitoring and provided insight into the guided wave technique. With capital equipment becoming more sophisticated and expensive, it is necessary to ensure that it is well maintained and downtime is minimized. Health monitoring is now widely accepted as an effective technique to achieve this aim. With increasing emphasis on product quality and

reliability, diagnostic techniques have become an integral part of manufacturing technologies. Professor Cho described various nondestructive techniques such as infrared/thermal imaging, radiography, ultrasonic inspection, eddy current testing, and visual/optical inspection.

Summary of Contributions from Country Papers

(a) Change drivers

Globalization has affected the participating countries in different ways. Countries such as Singapore, the Republic of China, and Malaysia see technology as an important vehicle in their transformations into high-tech, knowledge-based economies, as low value-added manufacturing operations continue to move to lower-cost countries. With the tendency of the original equipment manufacturers to outsource more of their operations, the enterprising PE companies are raising their competencies to position themselves better for such opportunities. Another development that has significantly influenced the modus operandi of PE companies is the need to follow the multinationals to new countries and markets. With production facilities spread across different countries, PE companies must equip themselves with the necessary IT and supply chain management facilities to coordinate their operations.

India, Pakistan, and Vietnam, which have moved to a market economy, look to technology as an enabler to raise product quality to a level that is competitive in the international marketplace. The more appropriate technologies at this juncture pertain mostly to those that enhance productivity and quality. In the case of India, some entrepreneurs have been quick to start new companies to manufacture products with specifications that are comparable with those of their international competitors. The machine tool and automotive sectors have been singled out as having bright prospects for this development. In Vietnam, the shipbuilding industry has received similar attention.

(b) National initiatives/priorities

By and large, governments have adopted a pro-business stance and various measures have been taken to assist the PE industry. India reported on the efforts of the National Competitiveness Council to map out a strategy for manufacturing, with initiatives such as the building up of networks and formation of consortia, reform of labor laws, tax policies and loans to small industries, and the setting up of technology-related infrastructure such as the Central Manufacturing Technology Institute and Precision Engineering Centre. Malaysia actively promotes public-private sector dialogue and partnerships and has

loosened foreign investment and employment restrictions. Other initiatives include the setting up of industrial parks and free industry zones, the development of human resources, and the protection of intellectual property rights. The Republic of China has a long history of supporting entrepreneurship. A number of its companies have successfully established themselves internationally. Taiwan continues to leverage technologies such as e-business and micro/meso mechanical manufacturing to maintain its competitive position. Thailand is working toward a more holistic type of industrial model. For example, for hard disk drive manufacturing, it is broadening the value chain. The next five-year roadmap includes the setting up of a disk storage institute to strengthen R&D on key components and human resources development. The PE industry in Pakistan is still small. In preparation for anticipated growth, the Engineering Development Board has been formed and investments have been made in computer and IT education.

(c) Issues encountered at the industry/corporate levels

Many of the participating countries reported that PE companies faced considerable impediments due to their limited resources. Technology upgrading represents a major hurdle due to the high cost of capital investment, the need to acquire the necessary expertise, the time required to build up the market base, and the means to motivate the workforce to be more quality conscious. Thailand faces difficulties in sourcing raw materials and precision tools and dies locally. There is also a high manpower turnover in the PE industry. Malaysia suffers from the lack of expertise in design and programming and is hindered by increasing relocation of PE companies to lower-cost countries. India feels that greater emphasis should be given to R&D. The country also faces problems with the procurement of specialized raw materials and the exodus of skilled workers overseas. Other problems areas are poor infrastructure and high tariffs.

Syndicate meetings

Three topics were proposed for brainstorming by the participants, with the resource persons serving as facilitators. The discussions were intense and lively. The salient findings from the deliberations are as follows:

Group 1

Topic: National infrastructure and initiatives for technology upgrading of the PE industry

Members: **Yusufzai**, Mahammad Zakaria Khan (India); **Lim** Kwee Heng (Singapore); **Tanchevavong**, Narong (Thailand); **Chiou** Chyou-Huey (Republic of China). Facilitator: **Lee** Loke Chong.

Constraints identified include low volume/lack of economics of scale; technology gaps pertaining to quality and reliability; poor local support in components and subassemblies; weakness in technology innovations; insufficient cooperation among companies in joint sourcing of materials, capacity sharing, and product/process innovation; poor horizontal integration; excessive tax burden; too little in-house R&D; limited access to new technologies; bureaucratic obstacles; insufficient access to common facilities; high cost of capital and infrastructure; and inadequate applications of e-business and supply chain management.

Recommendations:

(i) Initiate a national program to develop the PE industry.
(ii) Provide institutional support for product/process development.
(iii) Provide access to common facilities in tooling, waste management, fabrication, testing, and inspection.
(iv) Establish training, advisory, and marketing centers.
(v) Provide technology upgrading assistance such as low-interest grants.
(vi) Encourage university/research institute/industry interactions.
(vii) Strengthen industry associations and use them to channel assistance to member companies.
(viii) Improve transport, communication, IT use, and utility infrastructure.
(ix) Reduce trade barriers.

Group 2

Topic: Training and education for technology upgrading of the PE industry

Members: **Makaram**, Singaperumal (India); **Rujikietgumjorn**, Somkiet (Thailand); **Hoa** Ngo Thien (Vietnam); Md Nizam **bin Abd Wahab** (Malaysia); **Goh** Ser Shin, Andy (Singapore). Facilitator: **Kimura**, Fumihiko.

The stakeholders were identified as students and companies. Student stakeholders include skilled manpower, shopfloor management, and design and systems management. Problems associated with this category of stakeholders are the poor image of the PE

industry, unattractive pay, limited career prospects, and insufficient provisions for skills acquisition and retraining. The company stakeholders include the multinationals, SMEs, and industry groups. The problems these stakeholders encounter are unattractive job prospects in the PE profession, low pay, little support for R&D, unhelpful national policies, lack of job redesign to reduce monotony, and poor training levels and standards.

The salient issues that surfaced from the deliberations were:

- ∞ how to improve the image of PE jobs
- ∞ how far PE can be built into the mechanical engineering curriculum
- ∞ whether the management of technology is an increasing trend
- ∞ how well PE training is covered at various levels (skills/technical/education)
- ∞ how much emphasis innovation and entrepreneurship receive

Recommendations:

(i) Project PE as more than just precision manufacturing. PE embraces design, materials, manufacturing, measurements, and control.

(ii) Companies should have a broader perspective of operations to include dynamic control and network linkages between companies and the research and education communities.

(iii) PE companies should invest more in R&D and be committed to skills development.

(iv) Reward staff for continuing education to improve performance and the quality of work.

(v) Educational institutes should tailor their curricula to meet the changing needs of the industry.

(vi) There should be greater emphasis on product-based learning instead of process-based learning.

(vii) Establish strong links between government, academia, and industry to form centers of excellence.

Group 3

Topic: Challenges and issues in technology upgrading from the corporate perspective

Members: **Li** Hsin-Chung (Republic of China); **Katoch,** Rajesh Chand (India); **Butt**, M. Ashraf (Pakistan); **Mao** Chin Tao (Singapore); **Raksiri,** Chana (Thailand). Facilitator: Benjamin **Yuan.**

The challenges pertain to the five Ms: markets, men, machines, materials, and methods. For markets, there are problems of size (or the lack of) and the increasingly shortened life cycles. For men, there is a need to raise skills level and competencies, have suitable trainers, provide budgets and resources, and be able to retain the workforce in the industry. For machines, there are issues such as the high cost of capital, expensive testing equipment, rapid technology changes, restrictions imposed on the export of high-tech machinery, and long procurement times. For materials, there are limitations on the supply of specialized materials, difficulty in obtaining supplies in small quantities, high cost, and uncertain quality. For methods, the challenges are in the use of forecasting techniques such as Delphi and scenario analysis to assess market demands, emerging technologies, and product trends, and the receptivity of the workforce and companies to technology transfer and certification.

Recommendations:

(i) Markets: carry out SWOT analysis, market research, and ROI analysis.

(ii) Men: provide more conducive work environments and better remuneration.

(iii) Machines: acquire more versatile machines to cater to changing and diverse needs.

(iv) Materials: plan for larger volume and longer term supplier arrangements.

(v) Methods: set up standard operations procedures; improve forecasting of markets, technologies, and products; achieve quality standards and certification.

(vi) In the broader perspective, there is a need for:

- ∞ lower taxation
- ∞ decentralization of certification centers
- ∞ nonprofit R&D and technology transfer centers specifically for SMEs/PE companies
- ∞ formation of consortia to purchase capital-intensive equipment and bulk materials
- ∞ use of the “big brother” arrangement to assist smaller companies to access capital-intensive equipment.

Appendix-1

Study Meeting on Advanced Manufacturing Technologies and Systems: Precision Engineering Industries
(25–28 October 2005, Daegu, Republic of Korea)

Program and Schedule

Tuesday, 25 October

09:00–09:30 Registration

09:30–10:00 Opening Session

10:00–10:30 Tea break

10:30–12:00 **Resource Speaker Presentation (1):**
"Advanced Manufacturing Technologies and Systems—Precision Engineering Industries," Dr. Loke Chong Lee, Singapore Institute of Manufacturing Technology, Singapore

12:00–13:30 Lunch break

13:30–15:00 **Resource Speaker Presentation (2):**
"IT and Web-based Services Used by the PE Industry," Dr. Sang-Chan Park, Korea Advanced Institute of Science and Technology, Republic of Korea

15:00–15:30 Tea break

15:30–17:00 **Country Paper Presentation (1)**

18:00–19:30 Welcome Dinner hosted by the KPC
(Granada, 2F, Inter-Burgo Hotel)

Wednesday, 26 October

09:00–10:30 **Resource Speaker Presentation (3):**
"Precision Engineering Industry Status in the ROC," Dr. Benjamin Yuan, National Chiao-Tung University, Republic of China

10:30–11:00 Tea break

11:00–12:30 **Resource Speaker Presentation (4):**
"Role of Korean Education in Precision Engineering," Dr. Sang-Woo Joo, Yeungnam University, Republic of Korea

12:30–14:00 Lunch break

14:00–15:30 **Country Paper Presentation (2)**

15:30–16:00 Tea break

16:00–17:30 **Country Paper Presentation (3)**

Thursday, 27 October 2005

09:00–10:30 **Resource Speaker Presentation (5):**
"Precision Engineering as a Basis for Japanese Industrial Competitiveness," Dr. F. Kimura, University of Tokyo, Japan

10:30–10:40 Tea break

10:40–12:00 **Resource Speaker Presentation (6):**
"Precision Health Monitoring Technologies for Advanced Manufacturing Systems and Product Quality Assessment," Dr. Youn-Ho Cho, Pusan National University, Republic of Korea

12:00–13:00 Lunch break

13:00–16:00 Observational Study Visit: LG Micron

18:30–20:00 Farewell Dinner hosted by the APO
(Salute, 12F, Grand Hotel)

Friday, 28 October

09:00–11:00 Syndicate Discussion by Groups

11:00–11:30 Tea break

11:30–12:00 Syndicate Discussion Outcome Presentation by Groups

12:00–12:30 Summing-up session
Panel of resource speakers led by Dr. Loke Chong Lee

12:30–13:00 Closing

05-RP-GE-STM-23-B Study Meeting on Advanced Manufacturing Technologies and Systems: Precision Engineering Industries
(25–28 October 2005, Daegu, Republic of Korea)

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