Advanced Materials for Developing Countries*

A group of materials scientists met in Vienna this past December to exchange views and to advise the United Nations Industrial Development Organization (UNIDO) on a program to help introduce new materials and related technologies into the economies of developing countries. The following report summarizes some of the more important discussions and recommendations resulting from this meeting.

The Vienna meeting was chaired by Klaus M. Zwilsky, the executive director of the U.S. National Materials Advisory Board. The meeting objectives were to:

- Look at current new materials and related technology developments in some developing countries;
- Discuss the role of materials in developing countries;
- Discuss the infrastructure needed to introduce new materials into developing countries on a wide-scale basis; and
- Make recommendations on these subjects for national and international action.

National Actions

The group recommended that developing countries initiate a number of actions on the national level. As a matter of policy, it was recommended that analysis of materials be included in all national planning efforts. Such analyses are specifically to consider any abundant local resources—renewable and nonrenewable—which might be unique to the country, and where materials science might play a major role. The use of anatase for titanium production in Brazil, laterite for the development of improved brick in India, and coconut leaves and fibers for roof thatching and rope in some Asian countries were cited as examples of the development of local resources through materials-based science and technology.

It was also recommended that the buildup of a materials science and technology infrastructure be a high priority to provide a foundation for natural resource development and value-added manufacturing. Essential to this buildup are the interacting roles of government, universities, and industry.

It was also felt that developing countries should encourage the formation of local professional societies in materials science and engineering, and should encourage scientists and engineers to join existing national and international technical societies. Such associations were recognized not only for facilitating exchanges between the technical personnel of government, universities, and industry, but also for providing course materials, handbooks, abstracting services, and materials-selection software, all at reasonable costs.

A special coordinated infrastructure effort was called for in the development of human resources at the plant operation/manufacturing technician level. Specifically mentioned was the need for continuing education, special seminars, and professional society courses.

International Cooperation

It was recognized that technology transfers between countries can be accomplished bilaterally or multilaterally, the impetus for the exchange coming from either a developing or developed country. Technology transfer is also deemed possible through international organizations such as UNIDO, or through professional societies, laboratories, or institutes. Several exchange mechanisms were specifically cited.

Workshop and exchanges, such as the UNIDO/Czechoslovakia Joint Program for International Cooperation in the Field of Ceramics which provides both technical workshops and short-term study tours, were cited. Similarly, the OKTEN program of transferring know-how through expatriate nationals was cited as a valuable exchange. Experts working in advanced countries go back to their less developed countries-of-origin for short visits to give technical advice. It was also suggested that opportunities for the short-term training of scientists and technicians in developing countries be increased through such means as the International Center for Theoretical Physics in Trieste. Laboratories in developed countries could also be funded to encourage the inclusion of developing countries in cooperative activities with other developed countries. Also recommended was that courses be taught by members of professional societies in the developing countries.

Existing data bases need to be more accessible to developing countries, and data bases which could be most beneficial to the technical needs of specific developing countries could be identified, according to the group.

The Role of UNIDO

It was recommended that UNIDO expand its materials sciences role/programs in a number of ways, such as establishing an International Materials Assessment and Applications Center (IMAAC) for the analysis and promotion of the rational use of materials. An IMAAC would be the focal point of, and protagonist for, international materials science cooperation. A proposed IMAAC nine-point program was defined, including such activities as: (1) becoming the international clearing house for the collection, analysis, and dissemination of all materials science information, particularly related to unique resources not likely to be studied by others; (2) promoting R&D of materials-related problems of developing countries; and (3) establishing an international network of cooperating laboratories to undertake problem-oriented studies in specific areas of technical need.

UNIDO's Industrial Technological Information Bank (INTIB) likewise could develop specialized data for new materials and technologies not now covered, especially for materials unique to a region where little or no data exists. UNIDO was also encouraged to include more information on new materials in

*This is a summary discussion of a report prepared by the UNIDO Secretariat on a meeting held in Vienna, Austria, in December 7-10, 1987. This was one of a series of similar meetings initiated by the Secretariat in conjunction with its new program for the development and transfer of technology.

its existing technical publications. Particularly helpful would be an INTIB Guide to Information Sources on specific materials, and a directory of R&D institutions in developing countries that are working in the field of materials.

The group further suggested that UNIDO look into the possibility of establishing a network of R&D institutions in the field of new materials to cooperate in research and training programs, and to exchange technical information.

UNIDO was further encouraged to implement its proposed program on new materials and to include monitoring and analysis of technology trends in selected materials, the establishment of materials testing laboratories in developing countries, and implementation of various programs for international materials science cooperation. Also cited as fundamental to these overall efforts was increased interaction among UNIDO and the professional societies in order to present a coherent worldwide view of the needs of developing countries in the materials area.

Materials Technologies and Development

Currently, the materials situation in developing countries, and in the poorer sections of more advanced countries, is one of low per capita availability and poor quality. Within a development context, materials to fill human needs (i.e., food, housing, clothing, etc.) are far more important than high-tech materials. According to the participants, materials technology geared to stimulating development overall, and better and more materials per capita specifically, need to be based on smaller, lighter, stronger, longer lasting, recyclable materials made from locally available, renewable resources (see Table).

The participants concurred that, ideally, simple processes requiring minimal energy, low capital, and high labor input will be chosen. Therefore, particular emphasis should be on technologies based on plant materials or otherwise abundant resources (e.g., clay, stone, rock, silica, bauxite) and on biological processes. Priority should also be given to solar energy, materials for food production and storage, cloth and paper production, water purification, and health care.

Each country was encouraged to evaluate its own materials options and define its own priorities and approaches. Each materials development option must then be evaluated for appropriateness and suitability, based largely on:

- Location of natural resources;
- Extraction methods and costs;
- Location, method, and costs of processing;
- Impacts on the natural environment;
- Energy impacts;
- Current and future commercial values;
- Export possibilities;
- Impact on imports; and
- Socio-economic effects.

Alternative Routes for Materials Development

The participants recognized that several routes have been taken by countries in developing a materials infrastructure. In western industrialized countries, including the United States and Europe, the infrastructure, production, and consumption of materials evolved over several hundred years. The result is a logical sequence of teaching, research, development, and production.

Unlike U.S. and European experiences, other countries evolved their materials capabilities over a much shorter time. Japan, for example, consciously and quickly imitated U.S. production practices in materials, improved on them, and increased their scale. This was followed by improvements in infrastructure for teaching and research. Today, Japan is viewed as the world leader in research and production of certain advanced materials, such as engineered ceramics.

Some developing countries are taking other approaches. Brazil, for example, set up materials production plants

Important Development Targets for Materials Technology
Genetically engineered plants to absorb nitrogen directly from air
Genetically engineered plants with stronger timber and fibers which can be pyrolized to form high-performance reinforcing fibers and carbon-carbon composites
Microbial processes to extract metals from ores and ocean nodules, and to remove sulfur and silica from coal, bauxite, and other minerals
Microbial processes to extract fibers and ultrafine ceramic particles from agricultural products and wastes
Solar photovoltaic materials with increased efficiencies and reduced costs; solar furnaces for processing materials
Materials for fusion energy
Membranes from polymers, ceramics, and composites offering lower costs and increased performance in water purification
Improved and inexpensive materials for housing based on abundant or renewable resources such as sand, clay, rock, stones, laterites, and plant-based materials
Composites and ceramics with improved performances based on abundant elements such as aluminum, silica, carbon, oxygen, nitrogen, and plant materials Direct reduction of iron and aluminum using low energy processes drawn from solar and biomass energy
Recyclable materials with cascading downgraded applications offering longer life and resistance to corrosion, oxidation, wear, and fatigue
Rapidly solidified materials for reducing energy losses
Surface and interface processed materials with tailored structures and properties to meet specific needs
High performance nano-structured materials, nonequilibrium, and metastable structures
Room temperature superconductors
In situ polymer composites
Tough ceramics
Net-shaped materials fabrication
Parts consolidation through single step moulding of complex shapes.

based on local mineral resources and imported technology, followed by the establishment of a teaching and research infrastructure to meet the staffing needs of these plants.

India, on the other hand, has emphasized the building of an indigenous capability in teaching, research, and development right from the start, while also establishing materials manufacturing facilities in the public and private sectors. As a result, the materials training, teaching, research, development, and testing facilities in India match those found anywhere in the world, even though the production of materials lags behind countries like Japan and the Republic of Korea. India has also established professional societies and over 20 departments in universities and institutes awarding degrees in materials disciplines up to the doctorate level. It has also established several national laboratories (including the National Metallurgical Laboratory, the Central Glass and Ceramic Research Institute, and the Central Building Research Institute) and regional materials research laboratories (at Trivandrum, Bhopal, and Bhusbaneshwar). Planning for materials production is done by the National Planning Commission and the Ministry of Steel and Minerals.

At the other end of the scale, in certain raw material producing countries, like some copper mining countries of Africa, mining is done by foreign companies, or with foreign collaboration. As a result, there is no commitment to building any significant technical infrastructure.

Whatever route is taken in developing a materials infrastructure, the meeting participants concluded that access to modern components, teaching institutes, research centers, professional societies, information and data bases, and mechanisms for materials policy formulation is essential if developing countries are to achieve parity in the production and consumption of modern materials. □