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Meeting on Industrial Cooperation
on Production and Application of
Advanced Machine Tools among
Selected Developing Countries
New Delhi, India, 9-14 March 1992

REPORT*

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INTRODUCTION

The Meeting on Industrial Cooperation on Production and Application of Advanced Machine Tools among Selected Developing Countries was held in New Delhi, India, from 9 - 14 March 1992. The meeting was organized by UNIDO in co-operation with the Directorate General for Technical Development, Ministry of Industry, the Confederation of Indian Industry, and the Indian Machine Tool Manufacturers' Association (IMTMA). The event was a further effort in UNIDO's ongoing activity to foster production and application of machine tools in developing countries.

The purpose of the meeting was to:

- Establish specific working agreements to co-operate between enterprises, institutions and government organizations, and to develop technical cooperation among the countries represented, with a view to introducing new production techniques, increasing their industrial productivity and improving the quality of their industrial products;

- Inform participants on current technological trends in machine tools and their implications for developing countries at different stages of development; and

- Identify information sources for developing a data base that could serve future co-operation initiatives.

The meeting took place in conjunction with the Indian Machine Tool Exhibition (IMTEX '92) at which exhibitors from 130 countries displayed their latest products. As part of the meeting programme, participants visited the exhibition both to learn the latest technological advances in the field of machine tools and to establish a mutual understanding of technological and economic basis for co-operation with Indian machine tool and component manufacturers.

I. ORGANIZATION OF THE MEETING

The meeting was attended by 76 participants (21 from overseas) from 15 countries. The list of participants is shown in annex 3.

Opening of the meeting

Mr. N. Biswas, Secretary and Director General, Directorate General of Technical Development (DGTD), Ministry of Industry, formally opened the proceedings. In his keynote speech, he welcomed UNIDO's initiative in organizing meetings to promote direct co-operation at the company-level in the field of advanced machine tools as a continuing programme of interaction by different parts of the world.

The Indian machine tool industry, said Mr. Biswas, had recorded accelerated progress from early eighties when manufacturers embarked a programme of updating their technology. Today, India was able to meet most of its requirements of machine tools both in the CNC range as well as conventional machines. The experience gained by India would be relevant in any other developing industry's situation. India's industrial profile was highly diversified and placed exacting demands on the machine tool industry to satisfy the varied requirements in industrial machinery, power plants, other capital equipment, automobiles etc.

The machine tool industry in India had performed significantly partly because of its ability to absorb imported technology and develop it further. It had also benefited from in-house R & D efforts through which not only conventional machines had been developed but also a wide range of high technology equipment had been introduced into the markets, a number of them having been exported to various parts of the world. Indian companies had successfully manufactured the critical components forming major aggregates of CNC machines, such as CNC systems, drive systems, measuring devices etc.

In that context, Mr. Biswas added, it was an appropriate decision to organize this meeting coinciding with the Indian Machine Tool Exhibition gave an opportunity to see the capabilities of the machine tool industry in India as well as those of a number of advanced countries participating in the exhibition. India recognized that

strengthening international exchange and co-operation, in particularly by exchange of experience and co-operation among developing countries, was conducive to the development of the machine tool industry of all countries. UNIDO had promoted that by sponsoring several beneficial activities. The present meeting was a good opportunity to exchange information and experience and to promote further co-operation. India's machine tools and tool industry wanted to learn from the experiences of other developing countries. Meanwhile, India welcomed the opportunity to develop technical and economic co-operation with all developing countries.

During the opening session, the UNIDO Country Director thanked the Government of India, the Directorate General of Technical Co-operation, the Indian Machine Tool Manufacturers' Association and the Confederation of Indian Industry for inviting UNIDO to organize the meeting. As an important industrial city, and a major centre for machine tool production, New Delhi was a very appropriate setting. The UNIDO representative also placed on record the Organization's gratitude to the Government of India for its generosity in bearing a substantial portion of the international and local costs of the meeting via its special-purpose contribution to the Industrial Development Fund and its funds allocated for promoting economic and technical co-operation (ECDC-TCDC). From UNIDO's standpoint, the meeting continued its support of ECDC-TCDC in the machine tool industry, following on from similar meetings organized in Buenos Aires, Argentina in July 1988 and Shanghai, China in May 1989.

Election of officers

Mr. H.C. Gandhi, Member of the Public Enterprises Selection Board and former Secretary (TD) and Director General, DGTD, was elected Chairman. Mr. Liang Xunxuan, President, China Machine Tool Builders' Association, was elected Vice-Chairman. Mr. Goodluck William Ndesokia, Director, Industrial Development, National Development Corporation of Tanzania, was elected Rapporteur.

Adoption of the Agenda

The meeting adopted the following agenda:

Opening of the meeting
Election of the chairman, Vice-Chairman and Rapporteur
Adoption of the agenda
Presentation of the host country and expert papers
Presentation of international papers
Bilateral discussions on co-operation projects
Discussion and adoption of conclusions and recommendations
Adoption of the draft report
Closure of the meeting

The work programme is attached as annex 4. Formal papers presented or made available for the meeting are listed in annex 5.

Conclusions and recommendations

The meeting adopted the draft conclusions and recommendations at its last session on 14 March 1992.

Closure of the meeting

Addressing the the concluding session, Mr. A.V. Ganesan, Secretary, Ministry of Commerce underlined the major role the machine tool industry was playing the in the modernization of developing countries. Furthermore, productivity and the efficiency of machine tools depended crucially on the way they developed their own machine tool industries. India had made great strides in this respect, reflecting the attention given to raising the technology and design standards of the machine tool industry. But it required a constant and determined effort, he emphasized, to stay abreast of the latest technology in the world. There was great potential for cooperation among developing countries and therefore the meeting had been timely and crucial. UNIDO had played a vital role in bringing together the exchange of ideas and experiences to bridge the technology gap between the developing and developed countries. He hoped that in the years to come, such meetings would prove more beneficial to developing countries.

Mr. Bhogilal, Chairman of IMTMA, said that India's machine tool industry had grown rapidly over the years and was in a position to offer its expertise to other developing countries. It had adopted technology from the world leaders in machine tools, assimilated it, improved it, and adapted it further to make it more suitable for India's environment. The needs of a developing country were different, he explained, the problems unique, and they faced constraints as well as having strengths. Nevertheless, the Indian industry had embarked on export of machines whose high quality reflected adoption of quality management. Already one IMTMA member had received ISO 9000 approval; others were preparing for similar approvals. Some already had the German TUV certification.

The present meeting had been timely also because Indian industry was at the crossroads of various new developments reflecting a focus on market orientation. The machine tool sector therefore sought newer technology from various sources. While offering Indian technology to other developing countries, machine tool manufacturers would seek support and cooperation with others to improve production facilities and the quality of machines. In this context, the cooperation agreements signed during the meeting were most appropriate.

Mr. Bhogilal concluded with four suggestions for continuing the effort of developing South-South cooperation:

(a) A follow-up meeting similar to the present one, particularly to take stock of the progress of the signed cooperation agreements, and to examine the status and focus attention on specific issues;

(b) With UNIDO assistance to establish linkages among machine tool manufacturers' associations in order to exchange information, data and to assist each other to develop bilateral cooperation;

(c) To establish, with UNIDO support, linkages between research institutions in developing countries, in order to benefit from each other's R and D efforts;

(d) To organize group visits of manufacturers to different countries for bilateral discussion at the industry level, again with UNIDO support.

II. SUMMARY OF STATEMENTS AT THE PLENARY SESSION

The host country's experience in building up an effective machine tool industry was detailed by national experts with emphasis on three main aspects: (1) the criteria developing countries may use for economic manufacture and use of advanced machine tools; (2) experience in transferring machine tools technology to other developing countries (South-South cooperation); and (3) issues and guidelines for choosing between CNC and conventional machine tools. These are summarized respectively in chapters III, IV and V. All the overseas participants presented short summaries of their formal papers (listed in annex 5) outlining the situation of the machine tool industry in their countries. The presentations highlighted the present status of the development of the sector, the problems encountered by machine tool manufacturers and users, and the possibilities for solving some of these problems by means of cooperation with other developing countries.

Common difficulties for manufacturers were endemic uncompetitiveness due to limited scales of operation and high overheads. Many countries faced shortages of skilled personnel and access to technology. One delegation warned that acquisition of technology remained an uphill task. Successful collaborations depended on the mutual trust and association formed between the two companies. In contrast, there were many cases where the recipient of the technology had been denied access to critical drawings, process know-how and other vital information. Some joint ventures had collapsed when the collaborator hindered the pace of progress in order to assure its own continued production. In addition there were many other obstacles to technological autonomy: wrong choice of products reflecting foreign consumption patterns, training courses geared to Western-oriented curricula, lack of analysis of imported technology as the first

step in its adaptation, prohibitions on further use and adaptation, unnecessary tied purchases of goods and technical processes, lack of criteria for effective selection of technology, unrelated development of national technological institutions, ill-defined or non-existent purchasing policies for the public and private sector, and lack of consultancy extension. UNIDO could assist in securing meaningful collaborative arrangements for their machine building projects to materialize.

On the basis of its own country's experience, another delegation recommended the following types of cooperation under which large, well-equipped manufacturers and engineering and financing institutions would assist smaller ones:

- Assistance in design and development, subcontracting/hiring of advanced machining capacities, advice by qualified and foreign-trained engineers, subcontracting and or advice on heat and surface treatment and other special facilities for finished components, training support in quality control (including use of physical facilities)
- Standardization and production by large manufacturers of long, efficient, silent and accurate components for power and motion transmission (e.g. hardened and ground gears, shafts for mandrels or lead screws)
- Expansion of research facilities for machine tools in government agencies and/or establishment of a national machine tool research and development institution
- Establishment of at least one institution for highly-skilled technicians in each main machine manufacturing centre
- Assistance in selection of correct materials and establishment of material banks or godowns;
- Development of simple, low-cost special-purpose attachments for specific purposes on different machines
- DFI policies favouring small-size engineering firms with small loans and simplified procedures and concessional terms, recognition of creative ability as collateral
- National bank encouragement of commercial banks to develop small-firm-friendly policies including terms such as firm orders as security for supplies from material banks; simpler financing policies with respect to exports
- Governments and agencies to give top preference to locally-manufactured machine tools; discouragement of indiscriminate imports (especially used/second-hand machines)
- Financial and other incentives for where the banking and finance system could not help, e.g. rebates on income tax, on imports of raw materials and special equipment, and for foreign experts where local expertise was lacking
- Compulsory local manufacture, where possible, in the context of foreign collaborations.

Algeria

Algeria began production of machine tools in 1973 with the aim of mastering the basic technology, gradually meeting domestic demand and, eventually undertaking exports. The sector was dominated by the state-owned Enterprise National de Production de Machines-Outil (En-PMO) whose activities covered R and D as well as manufacture of machines, accessories and components, including sheet cutting and forming, and tools. The main factory turned out 1,200 machines annually with a workforce of 500, a turnover of approximately $20 million and a local content level of 70 per cent. The product range included knee-type milling machines, lathes, drilling machines, saws, shaping machines, universal sharpeners and grinders. A second unit was starting in early 1992 to make tools bodies (initially with imported inserts). The workforce would be 250 and the expected turnover around $5 million. Also starting in 1992, a subcontracting unit would make machined parts and accessories. En-PMO's development strategy would emphasize sheet metal cutting and forming machines, give priority to higher-value products, introduce numerical control and

start up a foundry.

En-PMO was following a development programme featuring:

- Introduction of numerical controls on milling machines and lathes;
- Creation of a unit for production of tungsten carbide inserts for incorporation in tools;
- Planning of a drill manufacturing unit, size range 6 - 13 mm;
- Study and realization of a foundry with 1,000 tons/year
- Establishment of a factory to build sheet metal cutting, forming and rolling machines;
- Establishment of a unit for renovating machine tools.

Six specific projects had been prepared:

(1) Establishment of an R and D Centre to develop new products, and acquire know-how in the field of machine tools, accessories. Estimated investment cost was $1.47 million, of which 56 per cent was in local currency, the rest in convertible currency.
(2) Factory for machining parts and manufacture of machine tools accessories. Estimated investment cost was $2.5 million with a turnover of $1.3 million.
(3) Production of HSS tools, drills, milling cutters, taps and threading dies, with a capacaity of 1.7 million items per year. Estimated investment was $12.4 million, including $5.05 million in local currency, and a turnover of $9 million annually.
(4) Production of cast iron parts for machine tools (1,000 tons/year).
(5) Production of tungsten carbide inserts (3 million/year - approx. 30 tons. Estimated investment: $11.3 million of which one third was in local currency; estimated turnover: $6.52 million.
(6) Production of metal shearing and forming machines - bending presses, shearing presses, roll bending machines and unversal bending machines.

Bangladesh

Bangladesh had six factories engaged in machine tools manufacture covering different types of lathes, column and bench drills, power saws and shaper machines. None of the factories made either NC or CNC machines. Hand and cutting tools were not manufactured because of low-cost supplies in the market from China. Output covered 15 per cent of local demand, the remainder coming from India. Local production was originally based on CKD kits; today all parts were made in Bangladesh.

The country's largest machine tool company, Bangladesh Machine Tool Factory (BMTF) employed 1,560 out of the 2,600 engaged in the machine tool sector. Its output in recent years had been erratic, rising from a value of 2.69 million taka in 1987/1988 to 4.62 million taka in 1988/1989, and falling to 1.2 million in 1989/1990 (around 15 per cent of demand. BMTF had a well-equipped design department and good engineers with access to research and testing facilities of Bangladesh University of Engineering and Technology and those of the Bangladesh Standards Testing Institute. Nevertheless it faced a downward trend in the demand for machine tools owing to its high prices--a reflection of high overhead. Other problems were the need for complex jigs and fixtures, human error induced inaccuracy, costly product inspection, operator safety, high rejection rates, high lead time and high inventories of spare parts.

In the view of BMTF's general manager, Bangladesh machine tools industry could make great headway by adopting advanced technology on the basis of international cooperation, i.e. technical collaboration agreements and joint ventures. A related problem however was the lack of an institution to help spread the use of advance machine tool technology. Insufficient local investment was a further bar to selecting advanced technology.

Specific needs of BMTF included:

(1) Consultancy: training and expertise, joint venture, technical agreements and co-operation for transfer of

advanced machine tools technology in particular NC and CNC machine tools.

(2) Partner to rehabilitate machine tool factory (BMTF).

China

China currently had over 1,000 factories devoted to machine tools and employing over 650,000 people. The product range covered metal-cutting machinery (170,000 units annually), metalforming machines (50,000 units), measuring tools (5 million pieces), cutting tools (40 million pieces), foundry machinery (10,000 units), large-size measuring instruments (500 units), abrasive and grinding tools (300,000 tons), machine tool accessories (4.5 million pieces), and machine tool electrical apparatus (20 million pieces). Alongside general purpose machines were CNC vertical turning and boring mills for workpieces up to 16-m diameter, CNC planer boring and milling machines with a 5-m wide work table and 17-m travel length. Heavy-duty lathes could machine workpieces up top 2.5-m diameter and 10-m long. Floor-type boring and milling machines offered boring diameters up to 260 mm; roll grinding machines handled components up to 1.6 m diameter. Precision cylindrical grinders machined roundness up to 0.1 μm; surface grinders and other grinders yielded flatness and straightness to 3 μm/m; ultra-precision lathes delivered roughness of Ra < 0.008 μm. CNC machines included horizontal and vertical machining centres, FMCs with worktable widths up to 1,200 mm, FMS for box-and rotator-shaped parts, and robots. EDMs machined workpieces down to 0.03-mm diameter or specialized in large-sized moulds. Alongside mechanical presses up to 3,000 tons were CNC turret punching presses, NC three-point press brakes, forging machines and FMC. Cutting tools included many kinds of coated, carbide, ceramic, PCD and CBN tools.

Under the eighth five-year plan, China would equip automobile and bearing manufacturers with high-automation, high-efficiency metalworking systems involving development of 200 items of technology. CNC would feature in 200 new metalcutting machine designs, 54 metalforming machines and 10 varieties. A leading role in these developments would be played by China's eleven comprehensive research and nine institutes for the machine tool sector. Relations between individual enterprises, research institutions and the outside world were also the province of the China Machine Tool & Tool Builders' Association. In recent years, China had concluded over 150 agreements to introduce manufacturing technologies for machining centres, large-size/high efficiency/precision machine tools, metalforming machines, CNC systems and others. Over 40 enterprises were engaged in coproduction with foreign partners and as a matter of policy were specially supported by the Government. Exports meanwhile had grown to $350 million (in 1990), with especially rapid increases in trade with the Middle East, Africa and South America. Technology was also exported, particularly in the field of metalcutting machines, measuring and cutting tools -- all the subject of joint ventures in other countries. In general, China offered machine tools that were technical adaptive, easy to operate, simple to maintain and well-suited to the conditions of developing countries.

Indonesia

Indonesia's machine tool industry dated from 1985, when 11 companies were encouraged by the Government to manufacture machine tools. Since then the number increased to 16 companies, with production activities generally based on the licence/foreign technical assistance to meet the domestic demand. Total investment through to June 1991 amounted to $21 million. Locally-made components accounted for more than 75 per cent for bending and rolling machines and presses; more than 75 per cent for bench, drill and sawing machines; 47 per cent for standard lathes (small and medium size) and 15 per cent for standard milling machines. Despite this, imports of machine tools rose sharply in the last two years, reaching a value of $522 million in 1990—nearly half supplied by Japan, 26 per cent from China (including Taiwan Province), Singapore and Hong Kong.

The factors acting as barriers to entry into the machine tool industry in Indonesia included shortage of skilled personnel, insufficiency of supporting industries,

difficulties in technology acquisition and financing. The main channel for technology transfer in the machine tool industry was reverse engineering, i.e. using imported machine tools and developing replicas or adapted models. The lack of access to blueprints made this difficult, however. Thus transfer of technology from abroad needed to be put on different footing in order to develop the machine tool industries. It was partly to support the development of machine tool technology in Indonesia in this sense that The Machine Tool Design and Development Centre (MTDDC) was established with the UNDP/UNIDO technical assistance in August 1991.

Specific needs of Indonesia included:

(1) Short-term experts for a factory expansion and modifying conventional to CNC machines.
(2) On-the-job training in manufacturing/assembling of CNC, lathes, CNC milling machines and machining centres.

A further opportunity to discuss these requirements would be at Indonesia's first international machine tool, metalworking and allied industries exhibition -- Machinetool Technology Indonesia '92 -- to be held from 12 to 15 August 1992 in Jakarta.

Islamic Republic of Iran

Iran was a major user as well as manufacturer of machine tools. At the peak in 1985, demand amounted to $90 million and had been growing by 15 per cent annually. Many recently built factories had the most advanced machines, including large vertical lathes, boring machines, machining centres and special purpose machines.
Iran's first, and still the main manufacturer of machine tools, the Tabriz Machine Manufacturing Company, was founded in 1971 with a production programme comprising 14 types of machines. Because external factors limited this to only three types of machines including lathes, drilling, and milling machines, the company could never meet industry's requirements. Today, under new development plans and policies from the Ministry of Heavy Industries, other private and state-owned companies were being licensed to manufacture machine tools in several phases. These would be located in Tabriz, Tehran, Isfahan and Khorasan provinces.

Iran's major policies for production of machine tools were as follows:

- new projects for production of conventional machine tools,
- projects having flexibility to manufacture unconventional machines in later stages;
- design and manufacture of special purpose machines through specialized engineering centres;
- establishment of a technical information centre;
- research activities to include design and production of CNC machines and industrial robots;
- small workshops and training courses to improve application and maintenance;
- expansion of training centres;
- production of machine tools in cooperation with foreign companies as joint ventures and with buyback arrangements.

A key problem was the shortage of qualified engineering manpower, especially in the fields of product design, technology and production processing. Although there were relatively good capabilities in Iran's engineering and research centres to provide electronic maintenance of machine tools, replace electronic boards, design and production of digital read outs, and making spark erosion machines, robots etc., shortages of expertise were still evident. Although NC and CNC machines were used for die making and production, it was not possible to optimize productivity from the computerized machinery because CAM and CAD were neither well known nor accepted.

Considering the present potential and the $100 million annual demand for machine tools, Iran would welcome any cooperation with developing countries to benefit mutually with respect to experiences and capabilities.

Specific needs included:

(1) Technology transfer of advanced

machine tools (CNC machines) and engineering design on new products.

(2) Short-term experts as well as long-term experts, on-the-job training for designers and study tour in all these areas.

(3) CAM/CAD machine tool products.

Kenya

Although development of a sound engineering and machine tools industry had been on the Government agenda since the late 1970s, the pressure on foreign exchange and the importance of machine tools as the mother of production and modern industry had given new urgency to project and establish a machine tool factory. Several studies had indicated the scope for manufacture of machine tools, parts and components. The latest proposed seven metal cutting machines (for turning, sawing, grinding , milling, drilling and shaping, along with universal lathes) and five wood-working machines. Separate manufacturing facility had been suggested for metalforming machine tools. Currently one factory made lathes using scrap materials; others produced simple metalforming machine tools, and components for repair and maintenance. A number of machine shops manufactured presses, shears, roll benders and grinders, largely for their own use. Others specialized in dies and moulds.

The establishment of a significant machine tool industry in Kenya would require setting up of several interrelated and interdependent facilities as well as feeder industries. Because of machine tools industry's strategic nature and the capital intensive nature of the project, the Kenyan government would be directly involved through one of its financial institutions. Because of the level of technology involved there would need to be collaborating partner.

Specific needs of Kenya included short-term experts for foundry/metallurgy technology including manufacturing technoiogy of machine tools.

Malaysia

The Malaysian delegation discussed the role for advanced machine tools in the context of its country's need for advanced technologies of all kinds. With technological developments progressing so fast, and the technological gap between developing and industrialized countries widening rapidly, drastic corrective action was called for.

Embracing broader aspects of manufacturing, including cost justification and practicality of the system, advanced manufacturing technology (AMT) encompassed aspects of both scientific and engineering disciplines. Current areas covered included CAD/CAM, computer-controlled machine tools (e.g. CNC), flexible manufacturing systems and information technology.

Malaysia's structured AMT programme, coupled with a fully equipped R & D centre, was intended to enhance the dissemination of advanced manufacturing technology to the local industries. Such a programme would provide research and development in AMT related activities, promotion of advanced manufacturing concept and practices that would improve productivity and also enhance the competitive power of local entrepreneurs in the domestic and international markets, and to serve as a technology transfer agent.

With the current facilities, manpower and expertise available, the Centre was engaged in three major areas: research and development, design and analysis, and precision machining services.

The R and D activities undertaken with local industries in new technologies included simple machine tool control software, manufacturing systems such as CAD/CAM, simple robotics and automation using motors and digital controllers, and process control development incorporating intelligent knowledge based systems.

The main activities conducted were basically advisory/consultancy services to provide precision product machining. These included complex machining using CNC machines such as turning centres, machining centres and EDM wire-cutting, development of jigs and fixtures for ease of manufacture, simple process-planning software.

The R and D activities to be undertaken with industries in developing new technologies would include:

- software development as interfaces and postprocessors for CNC machines and machining centres to coordinate measuring machines, for robots, and for dedicated expert systems for production scheduling;
- hardware development and modification, including retrofitting of conventional machines to upgrade them into NC and CNC machines;
- moulds and dies, jigs and fixture designs using computer-aided design facilities to increase reliability of end-products;
- introduction of flexible automation/manufacturing production systems incorporating computer-aided production management software, such as MRP II, JIT, CAQC etc.

Although the basic infrastructure, staffing and equipment, would be funded under the Sixth Malaysia Plan, AMTC required further upgrading. Expertise in various fields of specialisation was needed in order to upgrade the technical capabilities of AMTC and its staff in the following areas of advanced manufacturing technology: advanced manufacturing systems expert to advise the head of AMTC in the evaluation of the ongoing projects, to propose corrective actions and a future plan of action; experts in precision machining, machine tool technology, design and manufacture of forming dies and plastic injection moulds, mechatronics, CAD/CAM, CAPM, FMS and CIM. Technical training of the staff was required in the following fields: CNC technology, CAD/CAM interfacing, machine tool design, computer simulation, precision machining, jigs and fixtures design, machine tool retrofitting, robotics technology, automation, mechatronics, control engineering and plastic injection mould design.

Nepal

As in other countries, where economic policy changes in favour of market economy were being adopted, the Nepal government had given top priority to the following areas:

- privatisation of the various public enterprises,
- packages to attract foreign investors,
- delicensing of various industries,
- attractive tax holidays.

Positive reactions from investors indicated that these measure had created a good climate for investment.

Nevertheless, because of the low level of industrialisation, demand for machine tools in Nepal was mainly confined to general purpose machines such as lathes, milling machines, shapers, presses etc. The size of demand for machine tools was much smaller than the economic scale of production. Therefore, Nepal would remain for the foreseeable future a consumer of machine tools rather than a producer.

Specific needs of Nepal included representation of Indian manufacturers.

Nigeria

The Federal Government established the Nigerian Machine Tools Ltd (NMT), Oshogbo, as joint venture with India's Hindustani Machine Tools Limited (HMT) in 1980. The equity base of the company was later raised and the Federal Government's share increased to 99.994 per cent. NMT's objectives included establishing local manufacturing and marketing of machines, aiding/developing auxiliary units and assisting downstream user industries, imparting technical skills and developing trained manpower, conserving foreign exchange through import substitution, and assisting local entrepreneurs and user industries with consulting service. Users today were found in six sectors: transport, agricultural machinery, manufacturing, power and energy, defence and engineering. Manufacturing started with assembly of SKD kits (mainly centre lathes, milling machines, grinding machines, power hacksaws and drilling machines) supplied from Indian. Since 1987, import of SKD and CKD machines had been replaced by design and manufacture of machines from scratch.

Today, further growth was seen through production of high quality machine tools. Emphasis was therefore on management and

other skills required by a production programme with a high value-added content. NMT had a fully established training school with the capability to train personnel in machining, maintenance and servicing of machine tools and to conduct management and supervisor training. There was a light machine shop to manufacture spare parts.

In order to ensure full fledged manufacturing operations, NMT was now setting up a heavy parts shop and a captive foundry. However, some basic raw materials, e.g. alloy steels, were still being imported. R and D efforts were also to be intensified with a view to diversification into special purpose presses, benders, and equipment for agricultural machinery. In addition, NMT needed an R and D Centre having the following main objectives:

- study of basic phenomena and their effects (a contribution to Nigeria's product-oriented applied research work);
- ability to undertake large, complex and sophisticated design and development assignments in electrical engineering. hydraulic power and electronics,
- development of indigenous technical know-how especially with respect to hydraulic, electrical and electronics products;
- development and assessment of special materials for use in products manufactured or planned for manufacture by the company;
- stimulation of commercially sound technical innovations;
- promotion of research and development, scientific and technical work, including technical information, advisory, consulting and engineering services;
- raising the level of industrial practice through more effective application of the knowledge and techniques of products and processes;
- contacts with efficient and technical institutions in Nigeria and overseas, in order to follow developments elsewhere and to judge their relevance to the company. The work of the centre would thus cover basic research, applied R and D.

The Nigerian Machine Tools Company needed to establish a research and development centre, with the following main objectives:

- capability to undertake complex and sophisticated design and development assignments for machine tools, including electrical and electronic engineering, and relevant hydraulic systems;
- extension services, i.e. consulting services to the machine tool and related metalworking and machine building industry.

In order to design such a Centre it would necessary to assess existing NMT and related institutions' facilities with a view to strengthening them in areas of engineering research. A study of this nature, to be undertaken by UNDP/UNIDO within six months of project approval, was urgent. Costing an estimated $50,000, it would involve, under UNIDO subcontract, two consultants for around six weeks in the field followed by four weeks to finalize the report.

Pakistan

Pakistan had 200 machine tool builders, two classified as large, ten medium-sized and 188 small as very small. Their installed capacity was estimated at 9,000 units/year, their capacity utilization around 55 per cent. Total employment was over 2,200, one third in the two large units, one fifth in the medium-size plants.

The large units manufactured lathes, milling machines, shapers, drills and hacksaws to internationally-recognized standards. In addition to these products, the medium-sized units manufactured presses and specialized automobile machinery such as crankshaft grinders, cylinder boring machines, head and valve face grinders, and mechanical/hydraulic presses. Regarded as the successful segment of the industry, the medium firms combined acceptable quality with acceptable prices and sold to manufacturing companies, training institutions, large workshops and export markets. Large firms sold quality machines

at higher cost, mainly to state-owned companies, multinational organizations and manufacturers and training institutions. They competed with imports from ASEAN countries, Japan, Europe, and the United States. Imports share of total demand (around 9,400 machines annually and growing at 2 per cent) was around 46 per cent.

The machine tools industry benefited from reduced customs duties on raw materials, price preference on purchase of local machinery, concessionary financing from the State Bank and institutional support from the Metal Industry, Research and Development Centre (MIRDC) and the Pakistan Industrial Technical Assistance Centre (PITAC). Small manufacturers may benefit from the World Bank supported scheme, Development of Technology in Pakistan, under which facilities could be upgraded.

The machine tool industry had potential for development at a much faster pace. The reasons for Pakistan's present position included: investors had yet to appreciate the potential in engineering industry; financing institutions and commercial banks needed to formulate effective investment policies recognizing local capability and the importance medium and small units; lack of specialized training institutions for imparting training to employees in engineering skills.

In the light of the above problems, recommendations covering the following four areas were: technology, financing, government and export. Specific needs of Pakistan included design of conventional machine tools, transfer of know-how and buy-back arrangements, establishment of supporting institutions (pneumatic, hydraulic and electronic).

Philippines

Although the machine tool industry in the Philippines was still at an infant stage, one company started up in 1988 to manufacture NC machines, turning centres and similar equipment. A largely U.S.-Japanese joint venture, it included a foundry, a parts production shop, a sheet metal shop (for enclosure and body parts) and a machine tool assembly shop. Annual output of 400 units was entirely for export. Apart from this, at least five small companies made metal forming machines (hydraulic and mechanical presses, bending machines, shaping machines and drill presses) to order.

Under the Philippines Metal and Engineering Industrial Plan 1990-2000 (PMEIP), the machine tool industry was supported with R and D in the Design and Engineering Centre, which was linked in turn with the University of the Philippines National Engineering Centre, the Metals Industry Research and Development Centre, the Industrial Technology Development Institute, the Metalworking Industries Association of the Philippines, the Philippine Iron and Steel Institute, the Philippine Automotive Federation, the Agricultural Machinery Manufacturers and Distributors Association, the Philippine Society of Mechanical Engineers, the Society of Manufacturing Engineers, the Philippine Association for Technological Education, and the Philippine Instrumentation and Controls Society.

The development programme for the machine building sector under the PMEIP included the following with respect to machine tools:

- a sectoral study to assess the state of technology, production, capacity, and market potentials of machine tools in the Philippines,
- promoted use of advanced machine tools in parts manufacturing and machine building, primarily through the tax and duty-free importation of capital equipment for new and expanding projects registered with the Philippine Board of Investments (BOI),
- lower tariff rates on machine tools, under the ongoing economic restructuring programme,
- suitable financing schemes for the acquisition of advanced machines from bilateral and multilateral sources,
- development of local manufacture of machine tools needed by the local parts manufacturing and machine/engine rebuilding sectors,
- promote the use of CAD/CAM in

machine-building, including machine tool design and engineering,
- technical consultancy programmes for machine building,
- rehabilitate/modernize/expand metalworking plants,
- special incentives and policy package legislated for the metalworking sector in general and the machine-building sub-sector in particular.

Advanced machine tools had been used in the Philippines since 1978. Experience showed the choice was trade-off between the higher productivity, quality, reduced workpiece rejection, better management control and better return on investment (ROI), and the problems in fully utilizing the machines in view of cycle time reduction. Productivity could be analysed in advance with graphic simulation of cutting movements using CAD/CAM systems. Whereas ROI would determine the choice between CNC and conventional machines, that between different classes of machines reflected the reliability and reputation of the local supplier. More costly equipment could be justified if it was serviced punctually.

The Philippines National Action Plan provided for a technical skills development programme and it was generally admitted that manpower skills needed upgrading.

In the area of machine tool building there was a need to tie-up with machine tool makers from the developed/developing economies. One area of cooperation was in a joint venture project for the local production of conventional and advanced machine tools.

Specific needs of the Philippines included:

(1) Joint venture projects in machine tool building/manufacturing, both for advanced and conventional machines, their parts and components.

(2) Long-term experts in design.

(3) Training in specialised areas in advanced machine tools.

(4) Study tours in relation to potential joint ventures.

Thailand

Because the machine tool industry combined sensitivity to fluctuations in equipment investment with relatively high technology requirements, it was regarded as relatively risky by entrepreneurs and potential investors. In addition, local manufacturers competed with low-priced imports from nearby NICs, as well as cheaper second-hand machine available under easy purchasing arrangements. Local production, by an estimated 30 firms, accounted for only a small share of demand. Most Thai-owned machine tool enterprises produced simple machine tools -- presses, shapers and simple lathes. They were supported by the Metalworking and Machinery Development Institute. Foreign firms, in contrast, were modern businesses with high levels of technology and product ranges featuring top quality metalcutting machine tools. Of the three main companies, two were Japanese-owned. Other foreign firms, including two from China (Taiwan Province) were planning similar operations.

Reflecting the low volume and variety of local manufacture, imports rose sharply in recent years, reaching $32 million in 1989. Generally rated as precision or high-precision tools, they comprised universal machines such as lathes, drills, saws and cutting machines, milling machines, grinders, presses and others.

Current investment opportunities could be summarized as follows:

- alloy steel was an important raw materials used in machine tools and related industries. At present, Thailand did not have a domestic alloy steel industry. Therefore, the large and growing domestic market warrants investment in this sector;
- sophisticated machine tool such as EDMs, grinding machines, machining centres;
- there was an absence of leading firms producing drilling and boring machines despite a large and growing new and replacement market;
- large presses with over 1,000 tons capacity and precision presses were not yet

manufactured; opportunities for investment in their production include significant potential for Thailand to export presses to Vietnam, Laos and Cambodia;
- local manufacturers were also developing skills in converting or refurbishing basic machine tools to meet production requirements. Opportunities existed for the Thai machine tool industry to tap into regional markets for refurbishing machine tools for special purposes.

Specific needs of Thailand included:

(1) Direct foreign investment, alloy steel in sophisticated machine tools, EDM grinding machines machining centres.

(2) Modern machine tools, grinding machines.

(3) Study tour and short-term experts in hot forging and die design and manufacture.

(4) Technology transfer and expertise in the area of precision tooling are strongly required.

United Republic of Tanzania

Like some other countries, although the machine tool industry was still at an infant stage, some users had imported and successfully installed NC and other advanced machinery. The Government had long recognized the strategic importance of such an industry and the late 1970s had sought Indian assistance in the form of feasibility study for setting up a manufacturing company. The objectives were transfer of technology, promotion of rapid industrialization combing appropriate technology and universal machine tools, and an increase in technological know-how through local training. The resulting Kilimanjaro Machine Tools Co. had a machine shop capable of making universal engine lathes, universal milling machines, semi-automatic power hacksaws, column and bench drilling machines and stationary grinders. A captive foundry was being implemented and a training centre planned. At full capacity the plant could produce 970 machines annually in two shifts.

The subsequent problems of KMT reflected neglect of important factors covered in the feasibility study and a poor choice of collaborator. Production volume levels and plant capacity utilization were ignored as were the quality levels needed to compete with PTA and SADCC countries. Testing equipment was not supplied, training programmes were not realised. Skills among Tanzanian workers remained low and poor. There was no preventive maintenance programme. Today the plant was worn out and required massive rehabilitation. The captive foundry had not been completed. Other uncommissioned sections included the effluent treatment plant; heat treatment and galvanizing plant; the laboratory and the heavy duty plant. Spare parts were not available. The design and engineering department was ignored. For this reason it did not have designers. There were no local consultants to assist the industry in quality control, maintenance and service, management techniques in production, finance, marketing and general management.

To remedy the situation, the Government now intended to:

- appoint a consultant to study the industry in detail to advise on the necessary steps to revive it;
- establish the training institute for training specialized staff, meanwhile relying on technical assistance to have staff trained abroad;
- implement the captive foundry;
- develop the design and engineering department with the aid of technical assistance;
- install testing equipment and streamline the product mix.

An initial study indicated that the Kilimannjaro Machine Tools Company was viable and it had a large market within East, Central and South African regions.

It is estimated that Tanzania required $2.9 million to raise the capacity utilization of the existing plant and a further $ 3.5 million to establish the captive foundry. The

training institute would cost $ 1.7 million.

In summary, Tanzania required cooperation in the following areas:

- financing consultants
- establishing the captive foundry
- establishing the training institute
- training staff
- installation of testing equipment
- commissioning the effluent plant, the heat treatment and galvanizing plant, the laboratory and the heavy duty plant
- developing the design and the engineering department and the development of designing engineers/personnel
- developing the existing foundries
- developing the export market
- management of the plant.

III. ASSESSMENT OF DEVELOPING COUNTRY CRITERIA FOR ECONOMIC MANUFACTURE AND USE OF ADVANCED MACHINE TOOLS [1]

The infusion of electronics in machine tools, first in the form of numerical control, later with computers, constituted a major technological development that completely revolutionized manufacturing processes in the engineering industry. Metal cutting machines were more affected than metal forming ones; within the metal cutting group, turning operations, milling, drilling and boring operations were affected most. Today, there were three main categories of CNC machine tools:

- stand-alone CNC machines (NCMT)
- flexible manufacturing systems (FMS)
  - flexible manufacturing modules (FMM)
  - flexible manufacturing cells (FMC)
  - flexible manufacturing systems (FMS)
  - flexible transfer lines
- computer integrated manufacturing (CIM)

NCMT machines were now fairly standarized for turning, boring, milling drilling, grinding and other operations, and some had been mass produced. Adding material handling equipment such as a robot or pallet changer effectively upgraded them to FMM systems. Linking two or more FMMs (or conventional machines plus handling equipment) by means of automatic transport systems created FMCs. In turn, several FMCs (or automated machine tools) interlinked with automatic work flow systems that enabled simultaneous machine of different work pieces passing down different routes created a truely flexible manufacturing system (FMS).

Flexible transfer lines comprised several automated machine tools and work stations, interlinked with automated workpiece flow systems down a line. They were capable of simulaneously or sequentially machining different workpieces with two to eight variants running through the same path. With only one or two variants, FMS fixed transfer lines would be preferred.

Computer integrated manufacturing (CIM) aimed to automate totally and link of the functions of a factory and corporate headquarters. The essential building blocks were NCMTs, robots, FMS and computer-aided design (CAD). Until now, however, only a few islands of such total systems had emerged.

A key determinate in whether or not a country embarks on manufacture of advanced machinery at any of the above levels is its national advantage vis-a-vis the established competitors. Availability of highly-skilled and qualified labour in mechanical engineering and electronics was essential: advanced machine tools had a sizeable electronic content, including computers; introduction of NCMT and flexible automation technologies required skills in application engineering in order reach effective utilization. In-built self-diagnostic systems in CNC machines reduced the demands on repair and maintenance engineers; nevertheless, the level of formal education for building and using CNC machines had to be higher than that for conventional ones. Even for NCMTs, a number of highly skilled people were required in the factory for programming, setting, repair and maintenance. Supervisory and managerial staff also

needed to understand the new technology and adjust to the new ways of working. A strong planning or methods department had to be set up: availability of trained manpower for it could be a major constraint.

In the area of technology, entry could be gained through licensing agreements with foreign firms, but only if it were efficiently absorbed and designers were able to work with limited available data, avoid infringing patents and still come up with technical improvements. Not only had new skills to be acquired and applied, but also accuracy requirements were more stringent, dust-free operations had to be established for manufacturing and metrology operations, sophisticated application engineering capabilities had to be developed. This meant that the industry could not grow on imported technology alone: a strong R and D base was necessary.

A well-developed infrastructure and network of supporting industries was a constraint in many developing countries. For users of advanced machine tools, there had to be continuous availability of good quality power, with voltage and frequency maintained within specified limits. Because of their higher intial cost, NC and other more advanced machines had to be fully utilized to give the desired financial returns. Introduction of 'just-in-time' management and production concepts, quality circles, along with availability of spares, tools and fixtures and supplies of castings and forging of consistent quality and with dimensions close to those of the finished component, required retraining of the workforce and new relationships with vendors. In many developing countries, casting and forging units would need to be modernized.

Machine tool manufacturers faced similar constraints, including the availability of sophisticated standard parts such as linear motion guideway subassemblies, and electrical and electronic components. Japanese experience showed that with advanced machine tools, the manufactured content was lower than with conventional machines. In contrast, absence of a supporting industry left the machine tool plants highly vertically integrated, leading to inefficient plant utilization and high product costs. Here the insufficient volume and lack of available technology to make the highly specialized components and subsystems such as ball screws, drives, electrical control equipment as well as measurement systems, led to dependence on imports and higher final costs.

Industrial policies played a significant role in supporting or deterring entry into advanced machine tool manufacture. Developing countries would need to recognise that in the initial stages of growth, protection in various forms was required. On one hand liberal imports could jeopardize growth of newly established plants; on the other, prolonged protection may lead to inefficiency and stand in the way of machine tool users. However, the Republic of Korea provided an example where the industry was protected from foreign competition but still became internationally competitive because benefits were made contingent on export performance. Experience showed that if protection was offered, close collaboration between producers and users of machine tools was vital for product development.

In summary, developing countries' engineering industries took up advanced machines when they reached a certain volume and technological level. Factors such as price, quality and life cycle of their own products in their national and international markets, and the related need to find more efficient ways of performating certain operations would justify the application of NC machines. In the next stage of development, FMS, combining automation with flexibility would be used if it was commercially attractive.

IV. SOUTH-SOUTH CO-OPERATION - INDIA'S EXPERIENCE IN TRANSFERRING MACHINE TOOL TECHNOLOGY [2]

Today's trends in sophisticated systems of metal cutting and metal forming were those predicted at the previous UNIDO meeting on cooperation among developing countries on the production and application of machine tools,[3] namely that modern machine tools would be integrated into manufacturing

systems to achieve the most efficient coordination of design, production, quality and minimizing of timings and costs. The concept of a machine tools as a mere power-driven mechanical device meant for single metal-shaping operation was rapidly changing. Demand for new and better engineering products, buyers markets, high obsolescence rates in consumer products pushed the engineering sector in the direction of batch manufacture –but without sacrificing costs. Machine tools of today were required to meet divergent objectives: productivity and flexibility. A systems approach was being adopted with the goal of enabling manufacture of components nearly completely on one machine with one set-up–thereby significantly reducing throughput time, set-up time, process inventory and handling of work, jigs and fixtures.

The latest technical trends included CNC turning machines with gearless AC spindle drives, high spindle speeds, modular construction, simultaneous first and second operation capability, off-centre milling/drilling/boring facilities, built-in loading and unloading devices and in-process measuring facilities. Machining centres with multi-axis index tables with monitoring and compensation software could give unattended machining of complex shapes in one set-up and could be matched to both in-line and rotary cell applications. Gearless spindle drives, with spindle speeds up to 40,000 rev/min and traverse rates of 30 m/min were realities. Synthetic granite for beds of grinding machines provided high accuracies, CNC laser machining had revolutionized sheet metal working, laser machining centres were taking over from turret punch presses. Multi-wire electro-discharge and jet machining systems exemplified developments in the non-traditional machining area. Lasers were now accepted workshop tools for drilling, welding, scribing and heat treatment, as well replacing conventional cutting tools.

Although, compared to these advancements in industrialized countries, developing countries remained technologically far behind, the technological gap between them even widening year by year, the achievements of the newly industrializing countries (NICs) had brought them to intermediate stage between the advanced world and other developing countries. It was in this context that South-South cooperation between the NICs (a group of countries and territories that included Brazil, China, Hong Kong, India, Mexico, Republic of Korea, Singapore, Taiwan Province of China) and other developing countries in transferring machine tools technology was relevant and advisable.

As a group, developing countries shared a number of difficulties in developing their machine tool industries. These were limited market size, fluctuating demand, high technological and skill requirements, nascent manufacturing base and lack of engineering infrastructure, high cost of project and production inputs, and customer preference for imported brands (especially from industrialized countries). To overcome these and other problems, the concept of complementarity and inter- and intra-regional cooperation among developing countries should be vigorously pursued. Although at different stages of economic and industrial development, such countries represented a considerable concentration of resources, both human and material, they had vast potential markets and many already had considerable technological capabilities.

India's machine tools industry dated back to the 19th century and reached its first peak under the pressure of war during the 1940s. Resurrected by the Government of India in the 1950s, the sector grew especially rapidly in both the private in public sector during the 1960s. Key features in that period were the special technical assistance from the Directorate General Technical Development (DGTD) in the Ministry of Industry, protection in the form of restrictions on imports of machine tool types made in India, numerous collaborations with machine tool manufacturers in Europe, Japan and the United States, and a programme of diversification to build resilience into the industry during spells of recession. To promote absorption of imported technology and upgrade and modernize existing machine tool designs, the Government established the Central Machine

Tool Institute, Bangalore in 1965. India first exhibited an NC machine tool in 1970. Today she was in a position to offer CNC turning centres with automatic turrets, CNC machining centres with automatic tools changers, partially integrated flexible machining systems and also the related software packages for optimum utilization. Production also included EDM, gun boring and deep-hole boring machines. The technology gap between India and Western engineering products had considerably narrowed over the past five years. Current efforts were to raise production of CNC machine tools from their present level of 20 per cent to 50 per cent.

Looking back, it was clear that some of the total packages of the kind India entered into in the early 1950s and 1960s, though technically necessary were very costly. Later, as result of growing maturity, it had been possible to introduce greater selectivity in the seeking technology, and to bargain from a position of relative strength. This strength had to be built up by any developing country over years of experience.

Attention was drawn to India's experience in two particular areas: choice of product design/production technology, and adaptation of designs and technology. In the past, paucity of foreign exchange had led to importation of machine tool designs and technology unsuited to prevailing conditions in developing countries. It was important whether the foreign partner was prepared to modify the designs and technology to suit the conditions of the recipients, or even whether it had the experience to understand their needs in this regard. In any case, the developing country itself should carefully study its needs, make an appropriate choice of design and technology, and select suitable partners to assist in the development of its machine tool industry. India had made mistakes in that direction: it was a matter for other developing countries to learn from countries like India, and not to repeat them.

Nonetheless, intelligent adaptation of designs and technology to suit other requirements was a complex and difficult process. It may include conversion to national standards, such as the metric system, conforming with national electricity systems and regulations, substitution of indigenous equipment, raw materials and purchased items. Over the years, India had accrued considerable experience in transferring know-how and technology to many Asian and African countries. It established a machine tools training centre in Indonesia; tool room and training centres were setup in Malaysia and Singapore. Manufacturing licenses were granted to Indonesia and the Philippines, a large factory was built in Nigeria and a tool unit was modernized in Algeria.

In summary, over the years, India had emerged as one of the important machine tool producing countries among the developing countries of the world, and she was in a position to share her machine tool technology and know-how with many of the developing countries now looking for tie-ups in the form of joint ventures to establish and enlarge the range of their own machine tool activities.

V. CHOICE BETWEEN CNC AND CONVENTIONAL MACHINE TOOLS: ISSUES AND GUIDELINES BASED ON INDIAN EXPERIENCE [4]

India set up domestic capacities to manufacture advanced machine tools because users needed machines that gave improved productivity, consistent quality and held costs within narrow limits. On one hand some sought to meet the stringent quality standards of foreign collaborators; on the other they were moving into areas such as automobiles, bearings, consumer goods and industrial machinery where the emerging quality standards intrinsically favoured CNC over general purpose machine tools. The basic characteristics of CNC machine tools (compared to conventional machines in table 1) were improved cycle time (on average by a factor of four), quality improvement through repeatability independent of human factors, manufacturing flexibility (rapid component changes) and the ability to handle complicated profiles through the interpolation of controlled axes.[5]

The context for assessing the comparative advantages and disadvantages of

conventional and CNC machines were three categories of industry: (1) low technology areas (agricultural pumping sets and implements, slow speed diesels, sewing machines etc); (2) medium-level technology (bicycles, cutting tools, general purpose machine tools, industrial machinery, packaging equipment); and (3) high technology areas (automobiles, aerospace, nuclear energy, CNC machine tools, electronics components, domestic electrical equipment etc. The crossover was in the medium-technology area where CNC may be better depending on the quality parameters and the volumes required.

The major areas where CNC machining had been found suitable were where more than 25 per cent of the parts could (a) be grouped in families, (b) required three or more speed changes, (c) contained contours that were not lines and/or circles, (d) contained compound angles, and/or (e) had dimensional tolerances of less than 0.025 mm; where parts had mathematically definable contours, typical lot sizes were less than 50 pieces; average set-up exceeded three hours; parts were high value and the cost of human error therefore also high; for priority items and/or spares for obsolete designs; for parts having many different operations on different machines, and for parts needing 100 per cent inspection or whose design typically changed more than three times a year. In India's experience if three or more of the above apply, a more in-depth study should be made.

When CNC technology was introduced it brought an entirely new work ethos in the whole organization. Drawings had to be dimensioned so that drawing data was useful for programming. Process planning, tool layouts and tool paths had to be optimized to minimize cycle times. Appropriate inspection systems had to be developed –full and rapid inspection of new components in the proving stage to certify them for production, random sampling and inspect of critical dimensions during production. Full advantage had to be taken in planning, execution, control and management of CNC systems' facilities to store data and produce management reports on a shift-, daily-, weekly-, monthly- quarterly, semi-annual, and annual basis. Installation of CNC machine was more than a technical switchover: it needed a thorough change of mind and skills and competence of all those participating in the production process. Before introducing training Indian companies had to set up training schemes involving project and installation personnel, operators, maintenance personnel. Companies had also had to install the proper infrastructural facilities for trouble-free and efficient service of such machines, i.e. dust-free, temperature-controlled environments, uninterrupted power supply arrangements, facilities for speedy repairs and maintenance, and quality tooling and fixtures.

Selection of particular CNC machine tools required analysis of the components being made, existing production methods, alternative solutions to achieve new targets, different CNC technologies and the available equipment. Following a decision in favour of CNC, the user faced three scheduling and phasing problems: (1) acquiring the hardware and software; (2) developing operational capabilities; and (3) how to operate the system. The particular hardware depended on the components to be manufactured, the volumes required and customers' specifications, especially with regard to tolerances. While the CNC system was provided by the CNC system manufacturer, the interfacing software had to be developed by the machine building and the user-oriented software, i.e. the part programme, had to be developed by the user itself. Thus user required training in development of part programmes –one area in which developing countries generally did not have sufficient expertise.

The most important operational need was capability in setting up CNC machines to machine new components. This was time-consuming and required considerable experience. Similarly maintenance and a supply of essential spares had to be provided for. Even in developing countries that manufactured CNC machine tools, important components such as CNC systems, drive systems, ball screws, bearings and measuring devices were imported for lack of access to the technology involved. The resulting non-off-the-shelf availability of critical aggregates could create production problems.

A training centre equipped with trainee CNC machines to develop operational (i.e. production line) skills was necessary so that workers, who in India came mostly from a rural background, could be made more conversant with CNC machine tools. Otherwise, many had a psychological phobia of handling the high technology involved. Training was also essential in programming, design, production engineering and management.

The management issues included policy decisions concerning the long-term technological organization and managerial structure of the firm. CNC technology was a very powerful and potential technology in the hands of managers, but a new management culture became necessary. If it were appropriately applied and properly managed, it produced high profits. If it were mismanaged, it could cause extensive damage to the organization. The essence of success was to keep the machine running all the time. Utilization rate should be a minimum of 60 to 65 per cent; many had achieved 90 to 95 per cent. Machines should therefore be run with a minimum of two shifts, preferably with three.

Table 1
Characteristics of conventional and CNC machines

Conventional machines	CNC machines
Low investment per unit	High investment but lower part cost
High flexibility	High accuracy and repeatability
Poor productivity	Reduced inspection
No major change in part manufacturing technology	Ease of assembly and interchangeability Less scrap and rework
Delays due to supply problems, especially with vendors	Less material handling
Problems of quality, due to: (a) high human involvement (b) deterioration of tooling (c) administrative problems inherent with a larger in-house workforce	Less lead time Less inventory costs High flexibility for design changes
	Design freedom for complex shapes and contours
Difficulty in locating vendors for small batch quantity, multiple set-up components	Reduced tools fixtures Better machine utilization Better production management and overall management and control Ability for higher levels of integration such as distributed numerical control (DNC), FMS, CAD, CAM, CIM etc.

VI. SELECTED REQUIREMENTS AND TECHNOLOGY OFFERS OF INDIA

Areas for collaboration through technology acquisition, joint ventures and other forms of collaboration in machine tools, identified by India in advance of the meeting, are listed in annex 1. Technology offers included in the presentations of India's largest firms and machine tool support institution are summarized below.

India's Central Machine Tool Institute (CMTI), Bangalore is a Government-supported R and D institution serving both the private and public sector. Its staff of 475 (including 136 engineers and scientists) has developed over 300 products -- from conventional, special purpose and CNC machine tools and control systems to software, accessories, cutting tools and productivity aids. Consultancy services included product development, manufacturing technology and systems, selection and implementation of CAD/CAM facilities, CNC services (machine selection, economics, tooling, programming up to 5-axis machines, retrofitting), production engineering, automation and flexible manufacturing systems, machine structure analysis, metallurgical analysis, manufacturing technology for granite surfaces and modular fixturing. The institute undertook inspection, testing and performance evaluation, vibration analysis and condition monitoring for preventive maintenance and is moving into areas such as robotics research, laser machining and precision engineering. A project on computer integrated manufacturing was being implemented with UNDP assistance and a centre for cutting tool R and D is planned.

CMTI's technology offers included: CNC machines, unit heads, cutting tools, ball screws, PC-based CNC systems, microcomputer-based NC tape preparation systems and CNC system software. The current training programme comprised 24 courses for sponsored candidates from the engineering industry. In addition, customer-oriented courses were mounted in related fields and CNC courses were conducted on the premises of sponsoring organizations. During IMTEX '92, CMTI demonstrated a CNC trainer lathe with a PC-based CNC control system featuring simultaneous control over two axes.

HMT, Bangalore, India's largest machine tool manufacturer, accounts for two thirds of the country's production and covers nearly the complete range of machine tools from simple lathes through CNC machines to computer-integrated manufacturing systems. Its workforce of 30,000 includes 4,600 engineers. Through HMT (International) collaboration possibilities included manufacturing know-how for general purpose and CNC machines, training and development of technical skills, technical services to machine tool plants, reconditioning of machine tools and feasibility studies for machine tool plants. Turnkey projects implemented by the HMT(I) projects division included a hacksaw blade foundry (Kenya), reconditioning of machine tools (Algeria), advanced training centre (Malaysia), supply of machines, equipment and training software (Islamic Republic of Iran), common facility centre (United Republic of Tanzania), training centre/toolroom (Indonesia) and a defence facility (Ethiopia).

The collaboration possibilities with the engineering firm Batliboi & Co. were found both in its machine tool division and related supporting divisions concerned with industrial equipment, industrial controls, foundry, hydraulic and electromechanical projects and instrumentation, inspection and special equipment. Technology offers included conventional and CNC drilling and milling machines (including universal pattern and bed-type vertical machines), a universal portable radial drilling machine, several special purpose machines and CNC turning centres. These were also available in conjunction with CKD and SKD kits. A modernized foundry could supply high-grade grey iron castings, alloy casting with 2.5 per cent nickel, SG iron castings and non-ferrous/non-ferrous alloy castings. Batliboi undertook turnkey projects, training at is own plants and erection of training centres overseas, consultancy services and supply of expertise.

Bharat Fritz Werner (BFW), Bangalore, is an Indo-German company with a world-wide

market in horizontal and vertical machining centres, CNC production milling centres, special purpose machines and milling machines. Designed primarily to cater for India's industrial needs and conditions, the product range together with BFW's experience and expertise was offered especially to other developing countries. BFW's own R and D yielded a series of boring and milling centres, vertical machining centres, sophisticated special purpose machines with PLC and CNC controls, and a range of accessories such as CNC rotary tables, index tables and other items. The company was currently working on flexible manufacturing systems and computer-integrated manufacturing.

Technology offers were also made by the following companies:

Auram Engineers - consultancy in manufacture of drilling and tapping machines; *Drillco Hertel* - indexable tooling (ISO specification plus Fix Perfect tools); *ELB Schliff (India)* - Precision surface grinding machines; *Expanding Engineers* - technology for pivot bearings, hydraulic mandrels and chucks, supply of vertical hydraulic honing machines and fixtures; *Himalaya Machinery* - plate bending, guillotine shearing, press brake and sheet/plate levelling machines; *Krishna Engineering Works* - coproduction in manufacturing rail compartment components; *Orbital Systems* - industrial software for automation systems; *Premier Automobiles* - licensing, coproduction and joint ventures in shaping and slotting machines, vertical lathes and CNC vertical turning machines, vertical and horizontal machining centres, planing machines and planomillers, horizontal boring machines, gear hobbing (conventional and CNC); *Raja Bahadur Motilal Poona Mills* - machine tool accessories; *Sandvic Asia* - training and technology for heat treatment, wear parts and cutting tools; *Shiballoy Multiflex* - machinery and know-how for manufacture of tungsten carbide rotary and high-speed burrs/files/cutters; *Telco* - special purpose machines (including CNC machines), transfer lines, material handling systems, general purpose machines, CNC machining centres, CNC inline production centres, flexible manufacturing systems; *Verson International* - metalforming technology, expertise and consulting services in design, process engineering and manufacturing of metalforming equipment (mechanical and hydraulic presses), cut-to-length and slitting lines, galvanizing lines, roll-forming lines, welding machines and coil joining machines.

VII. RESULTS OF BILATERAL DISCUSSIONS ON CO-OPERATION PROJECTS

A total of 39 working agreements were reached. They included technology transfer, representation of manufacturers abroad, potential joint ventures, training, expert assistance, R and D cooperation, evaluation and rehabilitation assistance, upgrading of conventional machine tools and establishment of an R and D centre.

UNIDO together with the Indian Machine Tool Manufacturers' Association would undertake follow-up activities to promote practical realization of the working agreements as their resources permit.

The result of the bilateral discussions are summarized in annex 2.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The meeting recognized that although India was a developing country, it had adequate industrial experience, capability and experience of machine tool building to share with developing countries, more advantageously and efficiently in the mutual interest of the developing world. Simultaneously with importing machine tools designs and technology it has been building up and developing its own designs. Thus India has emerged as one the important machine tool producing countries among the developing countries of the world who are looking for joint ventures or licenses to establish and enlarge the range of their own machine tool building activities.

The group also acknowledged the success of IMTEX 92, which underlined the importance of machine tools trade fairs as a vehicle for promoting international

cooperation; a number of delegations referred to their own national and international fairs as further opportunities for South-South cooperation.

Referring to the focus of the meeting on production and application of advanced machine tools, many countries had introduced their advanced technologies from abroad. However, special attention had to be given to the way in which it was imported, digested and assimilated. While most technology originated in the industrialized countries, there had been a breakthrough in export of technology from one developing country to another. Examples were especially in metalcutting machines, measuring, and cutting tools.

Developing countries, the meeting agreed, could not ignore the world trend to increase the use of NC machines and other automation equipment. They should also enter the field, starting preferably with conventional machines and subsequently upgrading to NC and CNC machine tools.

In particular, CNC technology is powerful and potent: if it is appropriately applied and appropriately managed can it bring high profits. If it is mismanaged it can cause extensive damage. Successfully introduced, it brings an entirely new work ethos in the whole organization. From the design stage through process planning, programming of tool paths, random sample inspection of critical dimensions, to use of stored data to produce management reports it makes it easy to plan execute, control and manage manufacturing schedules to meet schedules and raise customer satisfaction.

Nevertheless, before entering the higher technology end of the industry a comprehensive evaluation of constraints and opportunities should be made. Factors to take into account included the size of the domestic market, availability of skilled personnel, the need to develop a strong R and D base, the need for an efficient network of subcontractors, the correct product mix, and the correct balance of government policies that protected the new industry in the initial stages of growth while stimulating international competitiveness.

In general, joint production and joint ventures played an active part in raising the technology and management level of the industry and improving intrinsic quality and the appearance of products. The Government played and important role with the formulation policies supportive of direct foreign investment.

Given the similar industrial environment and technical competence, developing countries needed to strengthen their interchange and cooperation in order to make up each other's deficiencies, satisfy each other's needs and support each other. Collectively, developing countries' machine tool industries could supply most of each other's demand for mechanical machining equipment featuring technical flexibility, reasonable price, easy operation, simple maintenance and well-adapted to developing countries' industrial operating conditions. Interregional transfer of technology and engineering know-how is also significant.

Transfer of technology among developing countries could be at affordable prices notwithstanding the fact that these technologies were often imported from the industrialized countries at exorbitant prices. Such transfers should be supported by drawings, comprehensive after sales services, maintenance programmes and training programmes. On-the-job training programmes should be arranged to enable those who buy machines grown each other to operate them with easy. Measures should be taken to extend the big time of those machines through courses scheduled for better application and maintenance.

Recommendations

(1) Building on formal and informal contacts established during the meeting and at IMTEX 92, the participants should follow up their preliminary agreements with further negotiations with a view to reaching legally binding cooperation arrangements. Such cooperation may be supported, on request of the cooperating partners by trust fund arrangements with UNIDO to provide for pre-feasibility and feasibility studies, study tours,

exchange of experts and training arrangements.

(2) Cooperation should be promoted through the existing associations of machine tool manufacturers who themselves should assist creation of new associations where none existed. Such cooperation would be reinforced by arrangements to link the manufacturers associations in an interregional network. In the Asia region, the machine tool associations were already loosely associated but they should strengthen their cooperation and coordination arrangements.

(3) A key activity of machine tool associations was to build national data bases enabling them to become focal points for the exchange of data with other associations and individual machine tool manufactures. Subject to availability of funds, UNIDO is recommended to assist in this endeavor.

(5) Cooperation should be promoted in R and D for machine tools and UNIDO was recommended to arrange a follow up meeting among R and D institutions along similar lines to the present meeting, to compare programmes and proposed joint R and D activities.

(6) Complementarity and interregional co-operation among selected developing countries should be vigorously pursued. UNIDO should continue to promote regional and interregional cooperation in this field, and, subject to funds, organize another meeting like the present one. UNIDO should also continue to provide technical assistance in the field of machine tools.

Notes

1. Chapter III presents in summary form the plenary paper Assessment of Developing Country Criteria for Economic Manufacture and Use of Advanced Machine Tools, by H.C. Gandhi.

2. Chapter IV presents in summary form the plenary paper *South-South Cooperation - India's Experience in Transferring Machine Tool Technology*, by S.M. Patil.

3. Held in Shanghai, China, 1989, see report PPD.131 (SPEC.).

4. Chapter V presents in summary form the plenary paper *Choice between CNC and Conventional Machine Tools: Issues and Guidelines based on Indian Experience*, by K.K. Taneja.

5. The plenary paper included two techno-economic studies. According to one, production in batches of 10 involving turning facing, profile, facing and turning, drilling and boring on a NC lathe showed savings in manufacture of alloy steel compressor shafts of 90 per cent on cycle time and 11.8 per cent on cost, compared to production on centre, turret and copy lathes. Machine rates were Rs. 250/- and Rs. 40/-/hour respectively. The NC machine reduced the number of setups from 16 to 4. In the second study, production of cams for folding cylinders in batches of 15 on a NC showed savings of 80 per cent on cycle time and 44 per cent on overall cost compared to a conventional milling machine. Machine rates were Rs. 120/- and Rs. 30/- per hour.

Annex 1
Technology sought under collaboration arrangements by selected Indian companies

Metal cutting machines

- High-precision lathes with or without CNC
- CNC vertical lathes with automatic tool/chuckchanging features and live tools
- CNC-controlled EDM machine for die making
- High-precision boring machine
- CNC ram-type plano-miller with automatic tools and attachment changer
- Grinding centre with automatic wheel and job handling
- High-speed cylindrical grinder, wheel speed approx. 100 m/sec
- CNC internal grinder, turret type with nad without automatic wheel changing and job handling
- High-precision creep-feed surface grinder with or without CNC
- CNC crankshaft grinder
- CNC cam shaft grinder
- Gear grinder with or without CNC
- Thread grinder with or without CNC
- CNC jig grinder with whell-changing facility
- CNC EDM with automatic electrode changer, high metal-cutting rate (at least 1000 cu mm/min on steel)
- Five-axis machining centres
- CNC toolroom milling machine with automatic head changing from vertical to horizontal spindle for 5-face machining
- CNC honing machine with auto gauging
- CNC machining modules with or without tool changer
- 6-axis articulated robots with sensor-based control and artificial intelligence
- Vision system for robots
- Robotic welding cells
- Robotic PCB assembly cell
- AGVs, tool management software, FMS integration software, FMS controller
- Precision CNC rotary table, precision CNC rotary and tilting table
- Development of various probes for applications, software for general and special purpose measurements; high precision CMM (accuracy over 0.002 mm over 500 mm, resolution 0.0001 mm).

Metal forming machines

- High-speed presses (accuracy to be improved for carbide dies and with allied line automation equipment, i.e. feeder, leveller, decoiler, etc.)
- Presses up to 500 ton and with speeds up to 400 spm with flexible automation (AC/DC servo feeder, moving bolsters, QDC, stacker for finished blanks, automatic strapping unit for stackers and others)
- AC/DC servo feeder up to 250 m/min coil handling equipment and decoiler for 32 ton x 1830 wide coils; stack strapping, reversing handling devices; swing shear tools for trapezoidal blanks
- Link drive D.A. and S.A. presses (up to 2,000 tons capacity and 1,200 mm stroke) with flexible and robotized automation for handling systems for toolings, blanks interpress transfer and finished parts
- Transfer presses with multiple slides for S.A. and D.A. operation, 2- and 3-axes flexible (freely programmable) transfer feed for handling large family of SM parts
- Hydraulic, CNC, plasma/laser turret punch presses
- 400 ton and 630 ton high-speed press lines for large-sized canisters
- Hihg-speed coining press line with speeds up to 600 spm
- CNC shearing centres, heavy-duty shears and press brakes
- Presses with 630 ton and higher capacity, automated production setups for watch cases, automobile parts and other applications.

Annex II

Results of Bilateral Discussions of Co-operation Projects

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
INDALG01	Manufacture of press brakes and guillotine shears	Verson International Ltd., India	Entreprise Nationale de Production de Machine-Outils (PMO), Algeria	Verson will send technical and commercial presentations to PMO in advance of a visit to PMO in April; PMO will send a draft contract to Verson. UNIDO support for training and supply of experts may be requested.
INDALG02	Representation and joint venture to manufacture carbide inserts	Drillco Hertel Ltd., India	Entreprise Nationale de Production de Machine-Outils, Algeria	Representation of the Indian manufacturer in Algeria for sale of carbide inserts, leading to a joint arrangement to transfer technical know-how and supply plant and machinery. Drillco-Hertel to submit offer and terms within 1 month.
INDALG03	Representation and joint venture to manufacture turning and milling inserts	Widia (India) Ltd.	Entreprise Nationale de Production des Machines-Outils, Algeria	Representation of the Indian supplier in Algeria leading to a joint venture to manufacture and sales of turning and milling inserts in Algeria.
INDALG04	Representation and joint venture to manufacture automatic machinery	PMT-Machine Tool Automatics Ltd., Pune, India	Entreprise Nationale de Production des Machines-Outils, Algeria	Representation of the Indian manufacturer in Algeria leading to a joint venture to manufacture and sell cam automats in Algeria. A preliminary protocol will be drafted covering both phases and presented at a further meeting in Algeria, to be arranged.

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
INDALG05	Representation and joint venture to manufacture machine tool accessories	HMT (International) LTD., Bangalore	Entreprise Nationale de Production de Machines-Outils, Algeria	Representation of the Indian manufacturer in Algeria leading to a joint venture and sales of drills and taps, establishment of a foundry and setting up a unit for reconditioning machine tools. HMT(I) to submit a preliminary proposal.
INDIRA06	Training and expert assistance to Iran	HMT (International) Ltd., Bangalore	Tabriz Machine Sazi (MST), Islamic Rep. of Iran	Upgrading of manpower through technical on-the-job training in HMT or sending HMT engineers to MST. Specific areas will be identified by MST and communicated to HMT(I).
CPRIRA07	Co-operation in upgradation of Iranian machine tool products	Beijing MT Research Inst. & Inst. of Project Planning & Research	Tabriz Machine Sazi (MST), Islamic Republic of Iran	Iranian identification of engineering specifications of new products in MST. The process of design should be carried out jointly by China and Iran in their respective countries. Renovation may be assisted with studies and proposals prepared by the Institute of Project Planning and Research.
INDIRA08	R & D co-operation	CMTI Bangalore	IDRO Tabriz Metal Working Institute, Islamic Republic of Iran	A team of CMTI executives to study the status of MWRI and suggest a suitable programme for assisting MWRI with training, equipment and other functions.

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
INDKEN09	Evaluation of a foundry and metalworking factory	Central Machine Tool Institute, Bangalore, India	Ministry of Industry, Kenya	Setting up an R & D cell within the East African Foundry Works to identify areas where more training is needed, where quality needs improvement, help increase capacity, and to recommend areas where production needs strengthening.
CPRINS10	Upgrading of conventional lathe CNC system	Beijing Machine Tools Research Institute	ASIMPI, Indonesia	(1) Modifying conventional lathe from Indonesia with incorporation of CNC systems; (2) technology transfer; (3) in assembly training for CNC machine tools.
INDTHA11	Technical co-operation agreement	Verson International Ltd., India	Taksin Steel and Equipment Co., Ltd., Thailand	Taksin Steel and Equipment Co. to either license or purchase technical know-how from Verson International to upgrade the existing manufacturing technology level of press machines. Verson International to visit Taksin in early April.
INDPHI12	Dealership agreement for machine tools/ metalforming machines	Orbital Systems (Bombay) PVT LTd., Electronica Group of Companies	Board of Investments and Asia Industries, Philippines	Establishing a dealership in equipment supply, followed by assembly of product in the Philippines. Provision of 2 weeks training within 6 months.
INDPHI13	Joint venture to manufacture machine tools in the Philippines	Tata Engineering & Locomotives	Board of Investments Philippines	New investment and transfer of technology to manufacture CNC machine tools.

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
INDNEP14	Distributorship	PAL Automobiles Ltd., Batliboi, India	National Trading Ltd. (NTL), Nepal	An exclusive distributorship for machine tools from Indian counterparts supplied to Nepal, followed by franchise agreement of both machine tools and automobile products.
INDBGD15	Rehabilitation agreement	HMT(I), Telco, India	Bangladesh Machine Tools Factory	HMTI to send experts to BMTF to draw up a restructuring plan to rehabilitate existing factory and later diversify products. Project to be carried out under joint venture, technical agreement or other arrangements.
INDURT16	Rehabilitation of Kilimanjaro Machine Tools Co.	HMT(I), PAL, India	Kilimanjaro Machine Tools Co. Ltd., UR of Tanzania	Provision of a new co-operation partner in lathe assembly, milling machines, wood-working machines, following a market and rehabilitation study. UNIDO to approach UNDP Dar-es-Salaam to arrange possible funding.
INDUGA17	Sale and transfer of technology for manufacture of tungsten carbide ancillaries.	Shiballoy Multiflex Ltd., Bombay	MC Industries Ltd., Kampala, Uganda	(1) Sale of machinery for manufacture of tungsten carbide components and ancillaries. (2) Technology transfer.
INDUGA18	Purchase of boring and honing machines	Daljeet Engineering Works, India	MC Industries Ltd., Uganda	Supply of vertical fine boring machines and hydraulic vertical honing machines from India to Uganda.

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
INDMAL19	SIRIM/TATA co-operation to upgrade their know-ledge of advanced manufacturing technology	Tata Engineering & Locomotive Co. Ltd.,	AMTC, SIRIM, Malaysia	Subject to top management approval, TATA to offer training in the following fields: CNC technology, CAD/CAM, machine tool design computer simulation, precision machining, jigs and fixtures design, machine tool retrofitting, robotic technology, automation, mechatronics, control engineering, plastics injection mould design. AMTC (SIRIM) will cover cost of travel, board, lodging, training fees etc.
INDMAL20	AMTC and CMTI (India) advanced manufacturing technology co-operation programme	Central Machine Tool Institute, Bangalore, India	AMTC, SIRIM, Malaysia	CMTI to accept an AMTC officer for on-the-job training at CMTI in the areas of CAD/CAM robotics and machine tool technologies. CMTI also is willing to send experts to AMT to help in upgrade the various technologies related to machine tool development. CMTI will provide training and expertise, with fees to be paid by AMTC.
INDCPR21	Mutual co-operation at association level	IMTMA India	CMTBA China	Coordinated action between the two asso-ciations in regional machine tool bodies to strengthen bilateral and multilateral co-operation at non-governmental level among the Asian developing countries' machine tool associations by (1) exchange of information through the associations of machine tool manufacturers, (2) strengthened coordinating body for Asia's

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
				national machine tool associations, (3) co-operation arrangements to support and assist the creation of new national associations of machine tool manufacturers in countries not yet having them, and (4) creation of national databases on machine tool technology and interchange of their data through the national associations.
INDINS22	Training for manufacturing CN special purpose machine	TELCO India	ASIMPI Indonesia	(1) A training programme for 6 fellows for 6 months each, (2) training of 2 engineers for 6 months each, (3) experts sent to Indonesia for a short period, (4) factory visits to Telco, in order to increase technical knowledge for manufacturing CN special purpose machines.
IDONIG23	Establishment of a R & D centre	UNIDO	Federal Ministry of Industries, Nigeria	Transfer of technology through provision of expertise and training.
INDPAK24	Transfer of technology to manufacture various machines	HMTI, TELCO, BFW, Batliboi, PMT and Parishudh, India	Pakistan Machine Tool Factory	Transfer of technology and design know-how for manufacture of CNC machine tools, conventional gear hobbing machines, cylindrical internal grinding machines, special purpose machines based on modular units, transfer lines.
INDCPR25	Representation for Chinese machine tools in the Indian market	CMTBA, India	Greves, Cotton & Co., China	CMTBA to advise which of China's machine tools would be suitable for Indian markets and assist with their selection.

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
INDCPR26	Adaptation of Chinese machine tools for Indian market	Technofour Electronics, India	CMTBA and Beijing Machine Tool Research Institute, China	Upgrading of conventional machine tools made in China by incorporation of Indian NC systems to be sold in India by Technofour.
INDCPR27	Transfer of EDM technology	MMT, India	CMBTA China	Transfer of EDM high technology from BMTRI to MMT.
INDCPR28	Upgrading ot tool and drill heads	CMBTA, China	WIDIA, India	Enhancement of the tooling range from Indian sources with the introduction by WIDIA (India) of tools for machine tools and drill heads using synthetic diamond (single and polycrystal) supplied by China.
INDCPR29	Joint research and development in machine tools	CMTI, India	BMRTI, China	Visit by Chinese delegation to CMTMI immediately following the meeting in New Delhi to compare R & D programmes between the two institutions and outline co-operation possibilities.
INDBGD30	Training of Bangladeshi engineers	IMTMA, India	Bangladesh Machine Tools Factory	Training offered to engineers from Bangladesh for machine tool development activities subject to UNIDO or UNDP assistance. Training should be designed to raise basic engineering knowledge and skills of Bangladeshi.

Project No.	Project Title	Project Sponsor	Project Contributor	Project Description
CPRBGD31	Training of Bangladeshi engineers	CMTBA, China	Bangladesh Machine Tools Factory	Training offered to engineers from Bangladesh for machine tool development activities, subject to UNIDO or UNDP assistance, designed to upgrade basic engineering skills and knowledge in Bangladeshi factories.
INDPHI32	Strengthening of design engineering centre in the Philippines	Tata Engineering & Locomotive	Board of Investments, Philippines	Supply of long-term experts to upgrade the knowledge and provide technical know-how to Philippino machine builders.
INDPHI33	Joint venture in machine tool manufacturing and metalforming	WIDIA, India	Board of Investments, Philippines	Manfuacture inthe Philippines of metal-forming and rivetting machine.
PAKBGD34	Provision of expertise	Pakistan Machine Tools Factory (PMTF)	Bangladesh Machine Tools Factory (BMTF)	PMTF to send a team of experts to exchange ideas and assess technology requirements to upgrade BMTF.
INDBGD35	Manufacture of milling and drilling machines	Batliboi, India	Bangladesh Machine Tools Factory (BMTF)	Batliboi to undertake studies in support of technology transfer to BMTF for manufacture of selected milling and drilling machines.
INDINS41	Representation in Indonesia	AMETELP Machine Tools, India	ASIMPI, Indonesia	Technical co-operation and/or representation in Indonesia for 63-ton press.

Annex 3
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Annex 4
Work Programme

Monday, 9 March 1992

Opening ceremony
Election of officers
Presentation and discussions of UNIDO technical assistance programme in the field of machine tools
Presentation and discussion of assessment of developing countries criteria for economic manufacture and use of advanced machine tools
Presentation and discussion of guidelines based on Indian experience to assist developing country users and manufacturers in choosing between conventional and automated machine tools
Presentation and discussion of identification of South-South co-operation possibilities with special consideration of the experience of India in transferring machine tools technology
Presentation and discussion of Indian national papers by Indian machine tool manufacturers

Tuesday 10 March 1992

Presentation of UNIDO programmes of ECDC and TCDC in support of enterprise and institution co-operation in the field of machine tools
Presentation of country papers on national development in machine tools and possibilities for co-operation with other developing countries

Wednesday 11 March 1992

Organized visit to the Indian Machine Tool Exhibition (IMTEX '92) in small groups
Bilateral negotiations guided by UNIDO staff and IMTMA

Thursday 12 March 1992

Continuation of bilateral negotiations

Friday 13 March 1992

Organized factory visits to Escorts and Parishud Yantra Nigam, Ghaziabad

Saturday 14 March 1992

Discussion of recommendations
Meeting conclusions and closing ceremony

Annex 5
Formal papers presented or made available for the meeting

UNIDO technical assistance in the field of machine tools (UNIDO Secretariat)

ECDC and TCDC: UNIDO programmes in support of enterprise and institution co-operation in the field of machine tools (UNIDO Secretariat)

Assessment of developing country criteria for economic manufacture and use of advanced machine tools (UNIDO consultant)

South-South co-operation - India's experience in transferring machine tool technology (UNIDO consultant)

Choice between CNC and conventional machine tools: Issues and guidelines based on Indian experience

National papers

Bangladesh - A report on Bangladesh machine tools industry

Algeria - The machine tool industry in Algeria - present state and prospects

China - Machine tool and tool industry in China

Iran - Development of machine tool industries in Islamic Republic of Iran

Indonesia - Indonesian machine tool industry 1992

Kenya - Machine tool industry in Kenya

Malaysia - Strengthening of advanced manufacturing technology centre

Nigeria - Towards achieving self-reliance

Nepal - Machine tool industry in Nepal

Pakistan - Machine tool industry in Islamic Republic of Pakistan

Philippines - The machine tool industry in the Philippines

Thailand - Machine tool industry in Thailand

Tanzania - Development of the machine tools industry in Tanzania

Background papers

Metalworking and machine tools industries - programme of the unit (UNIDO Secretariat)

The world machine tool industry (UNIDO Secretariat)

Regional study on the machine tools industry in Asia: the case of India (UNIDO Secretariat)

Conditions of entry and measures to promote competitive local production and effective utilization of machine tools (UNIDO Secretariat)