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HEAVY MANUFACTURING FACILITIES OF PAKISTAN ATOMIC ENERGY COMMISSION

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The Pakistan Atomic Energy Commission started operation of the first nuclear power plant of the country at Karachi in 1971. The Indian nuclear explosion in 1974 forced the PAEC authorities to strengthen its efforts for indigenous manufacture of spare parts, components and equipment. Scientific and Engineering Services Directorate (SES) was established at Islamabad in 1984 with a mandate to establish infrastructure facilities in design and engineering, fabrication and welding, machining, testing, quality assurance and control, and non-destructive testing to gear up the indigenous manufacturing of mechanical equipment and parts. The SES conceived and constructed two major infra-structure projects, namely, Seamless Tube Plant (STP) at Kundian and Nuclear Equipment Workshop (NEW) Project. The NEW Project comprises The Pakistan Welding Institute (PWI), Islamabad; National Centre for Non-Destructive Testing (NCNDT), Islamabad; Design and Development Division, Islamabad; NEW-II, Karachi, and NEW-III Project, Taxila. The NEW-III Project was primarily planned to produce unique heavy equipment, sophisticated components and complex parts for nuclear set-ups of the PAEC. It was named as Heavy Mechanical Complex-3 (HMC-3) after entering into a Joint Venture Agreement with the State Engineering Corporation, Islamabad. HMC-3 is one of the largest projects in the heavy engineering sector of Pakistan. It can produce a single-piece job weighing up to 320 tons with the existing facilities. Only HMC-3 caters to the national requirements for producing most of the precision and hi-tech components, and heavy and large equipment.

Keywords : Nuclear energy, Embargoes, Indigenization, Expansion, Joint venture, Import-substitution.

Engineering industry plays a pivotal role in the development of national economy, as it provides many of the necessary tools, equipment, machinery, etc., and increases the value of almost every segment of the economy. The engineering industry is also known as the mother of all industries and is considered as a pre-requisite for the economic growth and self-reliance of a country.

Pakistan, at the time of independence in 1947, inherited a small base of light engineering industry. There were small manufacturers, producing engineering goods such as machine tools, diesel engines, surgical instruments, oil expellers, fans, cinema projectors, spare parts, etc. Pakistan, therefore, had to develop its engineering capabilities almost from scratch. The government realized the fact that developing nations like ours are threatened by the advanced countries in their growth and even respectable survival in the absence of a strong domestic industry, and took various steps to develop industrial projects in the public and private sectors.

The Pakistan Atomic Energy Commission (PAEC) was established in 1955, and was given a mandate to promote peaceful uses of nuclear energy in the fields of basic research, power production, agriculture, medicine, etc., as well as to develop and achieve self-reliance in the essential and strategic nuclear technologies. PAEC, therefore, took a step forward and produced and trained manpower in the engineering disciplines as well as developed requisite infra-structure over a period of time for design and development, manufacturing and construction, and operation and maintenance of its nuclear programmes.

1. Background

The first nuclear power plant of the country, i.e. Karachi Nuclear Power Plant (KANUPP), became operational at Karachi in 1971. Realizing the importance of indigenous design and manufacture of spare parts for KANUPP, market surveys of the engineering industries in Pakistan were conducted in 1974. The PAEC established a Directorate of Industrial Liaison (DIL), Islamabad, in 1975 and a

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Design and Development (D & D) Division at KANUPP, Karachi, in 1976. In 1980, a directory of manufacturing facilities in Pakistan was compiled by DIL.

The PAEC was pursuing the policy of peaceful applications of nuclear energy and had worked out a plan to add more nuclear power plants in the country. However, the Indian nuclear explosion in 1974 jeopardized that plan. Moreover, foreign suppliers imposed embargoes on the supply of spare parts to KANUPP. This step forced the PAEC authorities to strengthen its efforts for indigenous manufacture of spare parts through DIL, Islamabad, and D & D Division, KANUPP, Karachi.

2. Scientific and Engineering Services Directorate (SES), Islamabad

The PAEC conducted further studies of the engineering and manufacturing capabilities of Pakistan, and it was found that the local industry was not able to meet all the requirements of the PAEC to design and manufacture equipment and parts owing to insufficient design know-how, lack of precision engineering and adequate manufacturing facilities, flimsy quality assurance and control programmes and testing facilities, etc. Consequently, in 1984 a Scientific and Engineering Services Directorate (SES) was established at Islamabad by merging the afore-mentioned DIL and D& D Division. Besides, the PAEC authorities gave the go-ahead signal to establish workshops in other important projects such as Karachi Nuclear Power Plant, Kundian Chemical Plant-I, Kundian Chemical Plant-II, New Lab Project, Directorate of Technical Development, Optics Lab., etc.

The PAEC gave the mandate to the SES to establish infrastructure facilities in design and engineering, fabrication and welding, machining and testing, quality assurance and control, and non-destructive testing to gear up the indigenous manufacturing of mechanical equipment and parts. In line with this policy the SES carried out specific studies, both in the country and abroad, so as to set up production capabilities and to develop sophisticated manufacturing technologies required to produce the requisite mechanical equipment, complex parts and sophisticated components for the PAEC. As a result, the following two projects were conceived of and approved by the Government of Pakistan:

2.1. Seamless Tube Plant (STP), Kundian

After necessary construction and commissioning by the SES, the STP (Seamless Tube Plant) Project was handed over to the Kundian Nuclear Fuel Complex. It is successfully working today to provide seamless tubes required in nuclear reactors and meets other needs of the national engineering sector.

2.2. Nuclear Equipment Workshop (NEW) project

This Project comprises the following components:

2.2.1. NEW-I, Islamabad

NEW-I started partial operation in 1986 and was completed in 1992. It is a well known organization in the country, and is equipped with unique manufacturing facilities to produce small to medium sized pressure vessels, storage tanks, heat exchangers and other equipment.

NEW-I has provided vital and important services in design, development and manufacturing of mechanical and process equipment, fabrication of steel structures up to 20 tons, development and promotion of welding technology, NDT training and certification, etc.

There are three major technical organs of NEW-I :

2.2.1.1. Design and development division

It is equipped with the latest versions of computers and other hardware and software, such as Computer Aided Design and Computer Aided Manufacturing. It is also equipped with light-to-medium size fabrication and machining facilities, such as cutting, rolling, conventional as well as CNC (Computerized Numerical Control) machining and accurate measuring and assembling facilities.

2.2.1.2. The Pakistan Welding Institute (PWI)

The PWI, Islamabad, is equipped with very specialized welding facilities to undertake Submerged Arc Welding, Gas Tungsten Arc Welding / Tungsten Inert Gas Welding, Shielded Metal Arc Welding, Flux Core Arc Welding, Gas Metal Arc Welding, etc. It is engaged in research and development, and training in welding technology, so as to enhance the existing level of knowledge, skill and capability of welding personnel in the country. The PWI is working to develop and apply standard procedures for qualification and approval of welding technology, equipment, materials and workshops, and undertakes qualification and certification programmes for welding procedures and welders / operators. It is also engaged in undertaking specialized welding jobs, besides trouble-shooting, repair/maintenance and calibration of welding equipment.

2.2.1.3. National Centre for Non-Destructive Testing (NCNDT)

A wide range of destructive and non-destructive testing facilities are available at NCNDT, Islamabad.

The Centre has ultrasonic, radiographic, eddy-current, magnetic-particle, dye-penetrant, acoustic emission and failure analysis, hydrostatic and pneumatic testing equipment as well as hardness, impact and universal testing machines.

The Centre is fully equipped and well staffed for carrying out training programmes and certification of NDT personnel for levels 1, 2 and 3 as defined by PAEC/SES/NDT-001 and ISO-9712.

It provides requisite NDT services to the PAEC, government organizations and the industrial sector of Pakistan at client's site or at NCNDT premises during manufacture, pre-service inspection (PSI) and in-service inspection (ISI), mechanical testing of materials, third party inspection, etc.

2.2.2. NEW-II, Karachi

This Project was made partially operational in 1981, and was completed in 1992. It consists of high-precision machining workshops and a specialized foundry for small and medium sized jobs. It has provided specialized components to various projects of national importance and to local industries.

NEW-II can perform all types of machining operations, such as turning, milling, and drilling with a precision of ±5 microns per metre. The advanced concept of machining DNC (Direct Numerical Control) is also practised through a dedicated hardware for the purpose.

NEW-II has good measuring facilities, such as computerized coordinate measuring machines, which can measure complex geometries of sizes up to1500 x 1400 x 1000 mm, having a maximum weight of 2 tons.

2.2.3. NEW-III, Taxila

The above-mentioned NEW-I and NEW-II Projects are very important and vital for the development and production of nuclear equipment in the country, but are not equipped with heavy manufacturing facilities. NEW-III was, therefore, established and is described below in detail.

3. NEW-III Project

NEW-III Project was primarily planned to design and manufacture heavy equipment, sophisticated components and complex parts for nuclear set-ups of the PAEC. However, its scope was extended to design, manufacturing and testing of jobs for energy, chemical and petro-chemical, and other industrial sectors.

On February 1, 1989, the Chairman, PAEC granted approval for preparing a master plan / scheme design for the NEW-III Project. Various sources were explored and finally a contract was signed with Shanghai Boiler Works, China, on November 9, 1991, to prepare the master plan and scheme design of the Project.

4. Heavy Mechanical Complex-3 (HMC-3), Taxila

The Pakistan Atomic Energy Commission and the State Engineering Corporation joined hands and entered into a Joint Venture Agreement on 17 May 1992 to construct the Project for mutual benefit of both the prestigious organizations of the country. The NEW-III Project was named as Heavy Mechanical Complex- 3 (HMC-3).

This Joint Venture Agreement has enhanced the design, engineering and manufacturing as well as management experience of both the national organizations, which are successfully serving all the essential sectors of economy of Pakistan.

4.1. Construction of HMC-3

On 28 June 1992, a contract was signed with the Seventh Institute of Nuclear Industries (SINI), China, for designing the civil works of the large buildings and heavy steel structure of the Project. HMC-3 engineers participated in all the design activities at SINI, China. All the smaller buildings and utilities were designed by the engineers of the PAEC, Works and Services Organization (WASO) and HMC-3.

The construction activities were started in November 1992 by building the boundary wall all around the Project, and fabrication of steel columns of a Warehouse, which served as a construction base for the Project. The steel structures of all the smaller and medium sized Workshops as well as electrical overhead cranes up to 10 ton capacity were designed, fabricated and installed by the HMC-3 engineers and technicians. However, fabrication and installation of large and heavy steel structures and heavy electrical overhead cranes were contracted out to Heavy Mechanical Complex.

Owing to heavy expenditure involved and limited allocation of funds, the construction activities were divided into phases:

4.1.1. Phase-A (1993-97)

The construction of basic facilities, utilities and 60 % of the Pressure Vessel Shop, procurement and installation of machinery and equipment, and joint design and manufacture of some of the equipment were completed. It may be added here that the foundation stone of the Project was laid by the President of Pakistan on May 6, 1996. In order to expedite the completion of the Project, the provision of utilities and installation and commissioning of machinery were carried out in those Workshops that were then just in a position to move in. Installation and commissioning of all the machines were carried out by the HMC-3 engineers and technicians.

4.1.2. Phase-B (1997-99)

Procurement and installation of heavy and large machines, joint design and joint manufacture of 30 m long Annealing Furnace, and High Pressure High Temperature Test Loop were carried out.

4.1.3. Phase-C

Construction of the remaining 40% of the Pressure Vessel Shop, the Heavy Vessel Shop and purchase of heavy presses and some dedicated machines of this phase were deferred to the future.

HMC-3 Project, Taxila, has been constructed on a piece of land measuring 404,682 m^2. So far an area of 40,670 m^2 has been constructed out of the total planned covered area of 59,344 m^2. It has a network of strong load-bearing roads of 3.5 km long. The installed electric load is 1.5 MW and an application for another 1 MW is in process against a planned total load of 4 MW. Water storage capacity for overhead and underground tanks is 150,000 gallons.

4.2. Joint design and joint manufacturing at HMC-3

The Scientific and Engineering Services Directorate had been focusing on the indigenization and transfer of technical know-how for a large variety of equipment and facilities. It entered into many agreements with foreign sources and ensured that SES / NEW engineers could participate in the design and construction activities. Partial production activities were initiated in the afore-mentioned semi-completed Workshops of HMC-3 in 1996. In addition to steel structure and civil works of the buildings and workshops, the following were designed and produced under the Joint Design and Joint Manufacturing programme in HMC-3:

- High Pressure and High Temperature Test Loop: and the testing loop.
- 30 m long Annealing Furnace.

  (The Test Loop and Annealing Furnace were inaugurated by the Chairman, PAEC / Board of Governors HMC-3 on 23 August 2000)
- 12 m long Plate Heating Furnace.
- 63; 100; and 200 ton Transport Bogies.
- 5 and 25 ton Welding Positioners.
- 5, 30 and 50 ton Roller Supporters.
- 5 – 50 ton Electrical Overhead Cranes.
- Hydrostatic Test Bench.
- Motorized steel Curtain Doors and heavy Sliding Doors.
- Waste Water Treatment Facility.

4.3. Capabilities of HMC-3

HMC-3 is one of the largest design, engineering and manufacturing projects in the heavy engineering sector of Pakistan. It has been set up to provide complementarities to the existing heavy engineering units of national importance. Therefore, small and medium facilities already available in the country were not included in the HMC-3 works. HMC-3 can produce a single-piece job weighing up to 320 tons with the existing facilities, under an electrical overhead crane having a hook height of 13 m in a bay of 30 m width. It is planned that an electrical overhead crane of lifting capacity 400 tons will be added in future.

Table 1. Indigenous manufacture of a typical 300 MW thermal power plant.

Section	Component of plant equipment	Indigenous manufacturing of plant equipment (cost - wise)	
		All other engineering units of Pakistan	contribution of HMC-3
Power Boilers	30 %	15 %	21 %
Turbo-Generators	18 %	2 %	3 %
Balance of Plant	32 %	13 %	17 %
Electricals and Controls	20 %	7 %	9 %
TOTAL	100 %	37 %	50 %

Only the HMC-3 caters to the national requirements for producing and supplying most of the precision and hi-tech components and equipment and, hence, is achieving the objectives of self-reliance in terms of increased import substitution and enhanced saving of foreign exchange. Table 1 highlights the capability of HMC-3 for improving the programme for a typical 300 MW thermal power plant.

The above table indicates that HMC-3, alone, will be able to increase indigenization component in a typical 300 MW thermal power plant by 13 % cost-wise. Another study was conducted in 1997 with respect to indigenization of a nuclear power plant of 900 MWe capacity. It suggested that HMC-3 would be able to produce about 10 % of electro-mechanical equipment for conventional and nuclear islands worth US$ 72 million.

HMC-3 is ISO-9001 certified for design and manufacture of engineering products for medium and heavy industries. HMC-3 was awarded an ISO-9001:1994 Certificate by Moody International Certification Ltd for UKAS (England), TGA/DAR (Germany), ANSI-RAB (USA) and COFRAC (France). In this regard a ceremony was held at the Project site on July 24, 2000, and the Chairman, State Engineering Corporation / Executive Committee, HMC-3, was the chief guest. On that occasion a four-page special press supplement was published in three national dailies, i.e., The News, Dawn, and Business Recorder. Now, HMC-3 has obtained the latest version of ISO-9001:2000 Certificate for UKAS, England, and Pakistan National Accredition Council (PNAC), Pakistan.

The Chairman of the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers (ASME) has authorized HMC-3, Taxila, to use its five symbols. A, S, PP, U and U2 in accordance with the provisions of ASME Boiler and Pressure Vessel Code. The coded vessels stamped with these symbols ensure that these vessels have been constructed strictly in accordance with the provisions of the relevant ASME code on boiler and pressure vessels. HMC-3 is also registered with the Federal Boiler and Pressure Vessel Safety Board of Pakistan to design and manufacture boilers, pressure vessels, heat exchangers, etc.

HMC-3 is working to obtain six API Specifications of drilling and oil-well structure 4F; shop-welded tanks for storage of production liquid 12F; field-welded tanks for storage of production liquid 12D; vertical and horizontal emulsion treater 12L; oil and gas separator 12J; and glycol-type gas dehydration unit 12 GDU. It has also obtained Pakistan Nuclear Regulatory Authority (PNRA) license for the manufacture of nuclear grade pressure-retaining equipment of nuclear safety class-2 and below.

HMC-3 has more than 1,100 professional employees comprising graduate, post-graduate and PhD engineers and scientists, qualified and skilled technicians, and well trained workers.

4.4. Production programme

The design, development, manufacturing and testing capability of the HMC-3 Project cover a wide range of thick-walled high-pressure vessels, sophisticated process equipment, complex machine components and heavy steel structure products for power, chemical, petro-chemical, processing and industrial projects.

Some of the items included in the production programme of HMC-3 are high pressure vessels, boiler drums, chemical vessels, water and steam drums, storage flasks, cylinders and tanks, heat exchangers, high pressure heaters, air pre-heaters, columns, distillation towers, chemical reactors, CO_2 absorbers, hydro-cracking reactors, condensers, high pressure piping, penstocks and hydel turbine components, heating furnaces, roller supporters, welding positioners, shot blasting equipment, electrical overhead cranes, heavy steel structures, dish ends and numerous other mechanical components, equipment and spare parts.

The HMC-3 Project has the manufacturing capacity to produce mechanical equipment of various types totalling 13,000 tons per year on a single-shift basis.

4.5. Technical disciplines of HMC-3

The major technical areas of HMC-3 are Design, Engineering and Development Division, Manufacturing Division, Quality Assurance and Control Division. In addition to these, a Sales and Marketing Division has been established to market the HMC-3 capabilities in the local industry. These are discussed as under:

4.5.1. Design, engineering and development capabilities of HMC-3

Design and engineering capabilities have been acquired by the HMC-3 engineers through "hands-on" experience. The highly qualified engineers, scientists and technicians work in mechanical, metallurgical, welding, electrical and electronic areas, a majority of whom have also obtained specialized training abroad. The areas of their expertise are as under:

a) Design of Process Equipment

b) Design of Mechanical Equipment, Components and Parts

c) Design of Special Products.

Standards and codes in use at HMC-3 are American Society of Mehanical Engineers (ASME), Tubular Exchanger Manufacturers Association (TEMA), American Institute of Steel Construction (AISC), Federation Europeene e La Manutention (FEM), Deutche Industrial Norman (DIN), Chinese Standards (GB), American Welding Society (AWS), etc.

The design set-up is equipped with the latest computer network which employs modem software and information technologies. A comprehensive library comprising books, technical journals, international standards, catalogues, etc., supports the design, production and testing engineers.

Besides meeting the customers' technical requirements prescribed in the relevant governing codes, HMC-3 design engineers, subsequently, improve the design, too. A constant contact with the local and international developments of the engineering sector paves the way for research and development in the existing manufacturing procedures and products.

4.5.2. Manufacturing

HMC-3 Works are equipped with heavy cutting and forming facilities, large and high precision computerized numerical control machining equipment, state-of-the-art welding equipment, a large heat-treatment furnace, wide range of non-destructive and destructive testing equipment, and heavy electrical overhead cranes. These facilities cover a wide range of light, medium, large-sized and heavy-weight jobs.

Salient features of some special and large size machinery and equipment, mostly CNC, available in the HMC-3 Works are as under:-

Cutting:

- Semi auto-gas cutting up to 350 mm thick carbon steel plates
- Plasma cutting up to 75 mm thick stainless steel plates
- Automatic saddle type gas cutting of 50-150 mm thick and 250-700 mm diameter
- Shearing of carbon steel / mild steel plates up to 16 mm thickness and 4.2 m width
- Plate-edge planing up to 250 mm thickness and 12 m length with a rotation angle of $\pm 35^o$.

Forming:

- Plate bending and rolling up to 120 mm (cold) / 250 mm (hot) thick carbon steel plates having width of up to 4,000 mm

- Dish-end making up to head dia 4,000 mm of 20 mm thick carbon steel plates and 16 mm stainless steel plates.
  (A large-diameter Dish-end making facility will be made operational shortly).

Welding:

- Column and boom type submerged arc welding of shells up to dia 6,000 mm
- CNC narrow gas submerged arc welding up to plate thickness 350 mm for shells up to dia 8,000 mm. It can rotate by ± 180^o
- Automatic saddle-type nozzle to shell welding of nozzles diameter 200 - 1,100 mm
- Submerged arc strip cladding on inner surfaces of dia 106 mm (min) and length up to 24 m
- Mechanized TIG welding system for stainless steel, carbon steel, mild steel and aluminium based metals
- Flux core arc and gas metal arc welding with and without CO_2
- Shielded metal arc welding
- Automatic tube to tube sheet welding for tubes of dia ranging from 10 to 62 mm
- Welding positioners and roller supporters
- Arc monitoring system for welding equipment calibration.

Computerized Numerical Control(CNC) Machining:

- CNC facing and horizontal turning of jobs up to dia 4.5 m, length 12 m and weight 110 tons with facing accuracy ± 0.01 mm/m, positional deviation ± 0.015 mm/m. It is equipped with grinding and milling attachments
- CNC vertical boring and turning of jobs up to dia 16 m, height 6.5 m and weight 320 tons with positioning accuracy of X and Y axis ± 0.012 mm/m, repeatability ± 0.08 mm, positioning and repeatability of C–axis ± 10 seconds and ± 5 seconds, respectively. It has milling and grinding attachments.
- CNC milling and boring with X, Y, Z and W strokes up to 12 x 6 x 1.6 x 1.6 m, respectively, quill dia 250 mm. It can have weight of jobs up to 150 tons with linear axis accuracy ± 0.015 mm/m, repeatability ± 0.01 mm, milling and boring accuracy ± 0.015 mm/m, positioning and repeatability of rotary table ± 7 seconds and ± 3 seconds, respectively
- CNC horizontal machining centre of X, Y and Z travel of 1.0, 0.8 and 1.1 m, respectively, equipped with rotary axis B and C having maximum speed of 15 rpm, linear axis accuracy ± 0.005 mm/m, repeatability ± 0.003 mm
- CNC electrical discharge machine with X, Y and Z strokes 450 x 350 x 350 mm, respectively, table size 500 x 700 mm, surface finish Ra 0.25 µm
- A number of small CNC lathes, vertical machining canters, milling centers, etc., to undertake machining of small internal accurate fittings
- Centre lathes for machining jobs up to dia 2 m, length 8 m and weight 18 tons
- Sliding radial drilling machine of drilling dia 110 mm with spindle horizontal travel 3.5 m.

Heating and Heat Treatment:

- In-situ heating for pre-weld and post-weld treatment of welded joints on pipes and vessels
- Oil-fired annealing at a temperature of 1,050 ^{o}C for a job of length 28.5 m and dia 6 m with loading capacity of 600 tons. It is fully computerized
- Gas-fired plate-heating furnace for heating plates of width 4 m and length 12 m at a temperature of 1,200^o C.

High-pressure high-temperature testing:

The high-pressure and high-temperature test loop has a temperature up to 300^o C, pressure 15.2 MPa and maximum flow rate of 350 m^3/hr.

Material handling equipment:

HMC-3 has electrical overhead cranes in accordance with the capacity and need of each and every shop. Fabrication and welding bay of the Pressure Vessel Shop is equipped with 100 tons; machining and welding bay of the Pressure Vessel Shop is equipped with 150 tons; the open bay has 50 tons; and other workshops have 5 ton electrical overhead cranes.

HMC-3 also has mobile-truck mounted cranes and fork lifters up to a capacity of 8 tons.

These manufacturing facilities are operated by foreign-trained mechanical, metallurgical, electrical and electronics engineers and computer experts and highly skilled technicians.

4.5.3. Quality assurance and quality control

The quality assurance has a wide spectrum of activities, commencing from pre-production planning. It aims to exclude chances of errors during actual planning. Thereafter, quality assurance and control checks come at essential successive stages up to the finishing of products to ensure quality. The quality assurance and quality control (QA/QC) spectrum concludes on the preparation of quality documentation.

HMC-3 has an effective system of quality control, i.e. ISO-9001, to meet the high standards required by regulatory prescriptions and codes. The guiding principle of the system is to mobilize and organize the working hands so as to bring all the manufacturing activities into the orbit of quality assurance.

A well-equipped Division of qualified and foreign-trained engineers and scientists assures that all the manufacturing processes, right from the material purchase to the product delivery, are in conformity with the quality assurance programmes and the quality plans. Advanced tools and instruments are being used for the execution of inspection and testing, and thus assure the safe, reliable, economical and normal operation of the products within their design life.

The various types of inspection and testing activities implied at different stages of production are given below:

Quality control activities:

The quality control activities are carried out to check the material compatibility and dimensional conformance. The time-tested quality document-tation system provides information regarding:

a) Material verification, identification and traceability

b) Dimensional analysis

c) Results of different types of tests performed on the products

d) Personnel performing those tests.

Welder qualification testing:

To maintain high quality of welds, all the welders are qualified according to the applicable codes before putting them to work.

Calibration:

Each and every tool and instrument is calibrated at regular intervals. HMC-3 has in-house facility for calibration of welding plants and some of the inspection tools; however, the remaining tools are calibrated by reputed institutions in the country.

Chemical analysis:

HMC-3 has access to the most advanced equipment for chemical analysis of materials covering the range of elements from Be to U.

Non-destructive testing:

Non–destructive testing, including radiographic testing (RT), ultrasonic testing (UT), magnetic particle testing (MT), penetrant testing (PT), and visual testing (VT), are carried out for surface and sub-surface flaws in raw materials, welds, castings, forgings, etc. Services of NCNDT are availed as and when needed in testing and training areas.

Mechanical testing:

Universal testing machines for tensile, compression testing, bend and shear testing, impact testing, hardness, etc., are available.

Leak testing:

High-pressure hydraulic, pneumatic and helium leak-testing facilities determine the strength of joints and evidence on leakage.

Metallurgical testing:

Facilities for studying corrosion properties as well as macro- and micro-structure of materials are available.

To summarize, HMC-3 has very comprehensive inspection and testing arrangements, which are comparable to those in use in the engineering and manufacturing industries of the advanced countries.

4.5.3. Sales and marketing and commercial activities

The Sales and Marketing Division was established to introduce HMC-3 in the local market and to get commercial orders. It has developed, with the support of the senior officials, a positive image and reputation of the HMC-3 Project as a qualified designer and manufacturer of high-tech mechanical equipment and sophisticated components through press advertisements, articles and news in newsletters, leaflets and brochures, calendars and greeting cards, exhibitions and seminars, presentations, documentary, etc. The quality-conscious clients of fabrication-based mechanical and process equipment were also approached at all levels.

HMC-3 has been pre-qualified and registered with the major industrial organizations in the country such as Oil and Gas Development Corporation, Pakistan Steel, Water and Power Development Authority, Sarhad Hydel Development Organization, Pakistan Railways, refineries, fertilizer plants, cement mills, oil and gas companies, thermal power plants, engineering and manufacturing set ups, defence organizations, etc.

HMC-3 is supplying a large variety of fabrication-based mechanical equipment, components and parts to the above-mentioned commercial clients, besides meeting the needs of the PAEC and its establishments. It is manufacturing and delivering equipment worth millions of rupees annually.

Further, HMC-3 is working with the research institutes, local universities, etc., since industrial set-ups and research organizations work together in collaboration with each other in a flexible way in theoretical and applied research. HMC-3 has worked in collaboration with National University of Science and Technology, Pakistan, and European Organization of Nuclear Research (CERN), Switzerland. It has exported to CERN equipment worth millions of dollars, and has signed another memorandum of understanding to supply equipment worth US$ 10 million. The scope of co-operation has been spread to other national scientific organizations in their research areas, too.

5. After-Sale Service

Last but not the least, the successful performance of the HMC-3 products, at the client's premises, is guaranteed by the after-sale service. This represents a set of important advantages, such as back-up technical services at the client's site as and when required, lifetime commitment to supply spare parts, training for operational and maintenance purpose, etc.

6. Conclusions

To sum up, the PAEC has established most advanced engineering and manufacturing facilities in Pakistan. Its engineering set-ups, coupled with its technological developments, have achieved, progressively, a higher indigenization level and import substitution, and saved the much-needed foreign exchange. The higher level of indigenization has helped in bringing down the local production costs significantly as compared to prevalent international prices.

Scientific and Engineering Services Directorate and HMC-3 are supplementing the manufacturing facilities of the public and private sectors of the country. These are playing an important role in the production of heavy and high value-added industrial machinery and equipment.

HMC-3 has substantially expanded the capability of the national engineering industry, and enhanced self-reliance levels as well as foreign exchange savings by increasing the indigenous production of high-tech, large and heavy mechanical equipment, components, and spare parts. With the highly progressive outlook, and establishing a team of result-oriented professionals, HMC-3 is committed to making an invaluable contribution to projects of national importance. It looks forward to marching fast and playing a significant role in the development of Pakistan through maximum import-substitution in the engineering sector.