A

REPORT ON INDUSTRIAL TRAINING

AT

BHARAT HEAVY ELECTRICALS LIMITED

MAINTENANCE OF BLOCK - 3

(HEEP)

SUBMITTED BY :

VIKRAM SINDHWAL

Roll No. R170205024

B.Sc (Plant Maintenance & Operations)

University of Petroleum & Energy Studies

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PROJECT ON

MAINTENANCE OF BLOCK-3

(HEEP)

SUBMITTED BY
VIKRAM SINDHWAL
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Acknowledgement

Behind every study there stands myriad of people whose help and contribution make it successful.

It has been a remarkable experience of satisfaction and pleasure for me to work out my project under the supervision of the **ER.AMIT TIWARI BLOCK-3(HEEP) PLANT.** I am really thankful to him for his valuable guidance and co-operation during the project work.

I had also benefited from discussions and would also take the opportunity to thank the persons of the company for their valuable support and assistance whenever and wherever needed. A cordial and encouraging environment made it very easier for me to complete the project.

So this acknowledgement is a humble attempt to earnestly thank him and all those who were directly or indirectly involved in preparation of this project.

BHARAT HEAVY ELECTRICALS LIMITED

RANIPUR, HARIDWAR

HUMAN RESOURCE DEVELOPMENT CENTRE

No. : C-07/401

Training Certificate

Mr./Ms. VIKRAM SINDHWAL *S/o/D/o.* Mr. BHARAT SINDHWAL

a Student of (College). UNIVERSITY of PETROLEUM & ENERGY STUDIES D.DUN *branch.* B.SC (P.M.O)

has Undergone Practical Training From 01-08-07 *to* 31-12-07 *in the organization.*

His/Her field of training was:

MAINTENANCE IN BLOCK-III (HEEP)

His/Her performance and conduct during the above training period was found Very Good. *This training imparted is under the curriculum of the Institute of Study.*

31/12/07

(ब्रह्म चैतन्य शर्मा)

Incharge Vocational Trg.

(Sign. & Seal)

Dated 31/12/07

Declaration

This project has been undertaken during the summer break as a summer trainee, after the completion of the Fourth semester of B.Sc. (P.M.O.) under the guidance of **Mr. Amit Tiwari** Further I would like to declare that this project is my original work and has been prepared solely for academic purpose. This project can be presented in any seminar or submitted elsewhere for the award of any degree or diploma.

Countersigned by

( ) **Vikram Sindhwal**

Amit Tiwari

(Project guide)

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About The Organisation

BHARAT HEAVY ELECTRICAL LIMITED-

A CORPORATE GIANT

BHEL was established nearly 40 years ago to become the most important symbol of Heavy Electrical Equipment industry in India and rank amongst the first few in world. It is the largest heavy engineering and manufacturing enterprise of its kind in India with well- recognized track record of performance, making profits continuously since 1971-72.The company achieved a turnover of Rs.105200 Million and Profit before Tax Rs 16060 Million. BHEL caters to core sector of Indian economy viz. Power Generation and Transmission, Industry, Transportation, Telecommunication, Renewal Energy Defence etc. The wide network of BHEL's, 14 manufacturing divisions, 4 Power sector regional centers, over 150 project site and service centers and 15 regional offices enable the company to be closer to its customer and provide them with suitable products, system and services at competitive prices. Having attained ISO 9001, 14001 certification , BHEL is now on its journey towards TQM .The Company inherent potential coupled with its strong performance over the years has resulted in it being chosen as on of the Navratna PSUs which enjoy the support from the government their endeavors to become global players. with its prudent financial management. BHEL occupies an all-important niche as evident by its ranking by CII amongst top eight PSUs based on financial performance. Recently in survey conducted by business India, BHEL has been rated as 7th Best Employer in India.

HEAVY ELECTRICAL EQUIPMENT PLANT, HARDWAR:

Heavy Electrical Equipment Plant, Hard war of this Multi-unit corporation with its 7467 strong highly skilled technicians, engineers, specialists and professional experts is the symbol of Indo Soviet and Indo German Collaboration. It is one of the four major manufacturing units of the BHEL. With turnover of 1400.25 crores and PBT of Rs. crores, HEEP added MW of power to the National grid during 2004-05. HEEP is engaged in the manufacture of Thermal and Nuclear Sets up to 1000MW, Hydro Sets up to HT Runner dia 6300mm, associated Apparatus Control gears, AC& DC Electrical machines and large size Gas Turbine of 60-200 MW. HEEP Hardwar contributes about 44% of India's total installed capacity for power generation with total capacity of Thermal, Nuclear & Hydro Sets of over 45000MW currently working at a Plant Load Factor of 76% and Operational Availability of 86%..

HISTORICAL PROFILE:

The construction of heavy electrical equipment Plant commenced in Oct."1963"after indo-soviet technical co-operation agreement in Sept."1959"The first product to roll out from the plant was an electric motor in January 1967.This was followed by first 100 MW Steam Turbine in Dec.1969and first 100MW Turbo Generator in August 1971.The plant's "break even" was achieved in March 1974.BHEL went in for technical collaboration with M/s Siemens, Germany to undertake design and manufacture to large size thermal sets upto a unit rating of 1000 MW in the year 1976.First 200 MWTG set was commissioned at Obra in 1977.The continum of technological advancement subsequently saw the commissioning of 500 MW TG Set in 1984 .The technical cooperation of Gas Turbine manufacture was also signed with

M/s Siemens Germany. First 150 MW ISO rating gas Turbine was exported to Germany in Feb"1995".Our 250 MW thermal set up at Dahanu Plant of BSES made a history by continuous operation for over 150 days and notching up a record plant load factor greater than 100%.

KEY COMPETITORS:

Power Sector Giant of the World viz. Siemens Germany, ABB, General electric of USA etc. are the major competitors of HEEP. All these are the MNC's and enjoy huge financial and R&D backup.

CORPORATE CITIZEN:

HEEP Hardwars Strategic plans and its policy & strategy are commensurate with BHEL Corporate / strategic Plan . As first PSU to adopt Corporate Planning as a process . Board meetings for long –range development , BHEL has always guided other PSU's in their Corporate planning process .Board meeting , monthly Management Committee meetings, Annual Revenue Budget exercise , Mid term reviews , Apex TQ council reviews, Personnel Heads Meet, Quality Heads Meet , Technology Meets , Product committees meetings, Inter-Unit Quality Circle Meets etc. are the some of crore strengths of BHEL Corporation's vast network.

COMPANY'S BUSINESS MISSION AND OBJECTIVES

BUSINESS MISSION

****

To maintain a leading position as suppliers of quality equipment, systems and services in the field of conversion of energy, for application in the areas of electric power transportation, oil and gas exploration and industries. Utilise company's capabilities and resources to expand business into allied areas and other priority sectors of the economy like defence, telecommunications and electronics.

BUSINESS OBJECTIVES

****

GROWTH:-

To ensure a steady growth by enhancing the compititive edge of BHEL defence, telecommunication and electronics in existing business, new areas and international operations so as to fulfill national expectations from BHEL.

PROFITABILITY:-

To provide a reasonable and adequate return on capital employed, primarily through improvements in operational efficiency, capacity utilisation , productivity and generate adequate internal resources to finance the company's growth.

CUSTOMER FOCUS:-

To build a high degreee of customer confidence by providing increased value for his money through international standards of product quality, performance and superior services.

PEOPLE- ORIENTATION:-

To enable each employee to achieve his potential, improve his capabilities, perceive his role and responsibilities and participate and contribute positively to the growth and success of the company. To invest in human resources continuously and be alive to their needs.

TECHNOLOGY:-

Achieve technological excellence in operations by development of indigenous technologies and efficient absorption and adaptations of imported technologies to suit business need and priorities and provide the competitive advantage to the company.

IMAGE:-

To fulfill the expectations which stakeholders like government as owner, employees, customers and the country at large have from BHEL.

UNITS OF BHEL

- HEAVY ELECTRICAL EQUIPMENT PLANT
  HARDWAR DIVISION.
- CENTRAL FOUNDARY FORGE PLANT
  HARDWAR DIVISION.
- HEAVY POWER EQUIPMENT PLANT
  HYDERABAD DIVISION.
- HIGH PRESSURE BOILER PLANT
  TRICHY DIVISION.
- HEAVY ELECTRICAL PLANT
  BHOPAL DIVISION.
- TRANSFORMER PLANT
  JHANSI DIVISION.
- ELECTRONICS DIVISION,
  BANGLORE.
- INDUSTRIAL VALVES PLANT,
  GOINDWAL.
- BOILER AUXILIARIES PLANT,
  RANIPET.
- ELECTRO PROCELAIN DIVISION,
  BANGALORE.
- INSULATOR PLANT,
  JAGDISHPUR.
- COMPOMENT FABRICATION PLANT,
  RUDRAPUR.
- COMPONENT FABRICATION PLANT ,
  RUDRAPUR
- HEAVY EQUIPMENT REPAIR PLANT , VARANASI .

PRODUCT PROFILE

PRODUCT CAPACITY RATINGS

* Thermal Sets	Upto 1,000 MW
* Hydro Sets	Maximum hydro runner turbine diameter 6,600 manufacturing upto 115 MW
* Gas Turbines	60,200 MW 150 ratings
* Light Aircraft	Two Seater
* AC / DC Machines	5,20,000 KW
* Apparatus and Control Gears	To match with the power equipment
* Steam Turbines for combined cycle power plant	Various combinations
* Heat Exchangers / condensers	Manufacturing upto 800 MW ratings
* Medical Equipment	Linac (for cancer treatment)
* Super Rapid Gun Mount	Naval Guns

KEY CUSTOMERS AND SUPPLIERS

The Power supplier of the country National Thermal Power Corporation, NHPC, NPC, and other IPPs and various State electricity Boards, are the key external customers of HEEP Hardwar. HEEP has a long standing-relationship with its customers. Power Sector-Regions, Power Sector Technical Services and other sister unit of BHEL are the key Internal customers. Manufactures of Casting and Forging, ETS, Steels including alloy steels, component of the product non-ferrous and insulating materials, equipment etc. are its suppliers. Some of the key suppliers are Collaborators M/s Siemens Germany, sister unit CFFP, SAIL, near by Ancillaries developed by BHEL etc.To further strengthen the relations, one to one long term cooperation meetings are being held by BHEL with its 200 major suppliers on regular basis.

MAJOR MILE STONES

1975 Job Redesign concept launched for FIRST time in India.

1978 Well documented Suggestion Scheme launched.

1982 Launched Productivity Movement & Quality Circle. Concept

1993 Accreditation of ISO 9001 quality System.

1995 Adopted EFQM model of TQM for achieving Business Excellence.

1997 BHEL one of the 9 PSE's declared "Navratna" by Govt. of India .

1997 National Productivity Award for HEEP by the President of India .

1998 Certificate of Merit by National Productivity Council for outstanding performance for 2nd consecutive year.

1998 Accreditation of U stamp.

1999 Accreditation of R Stamp from National Board of Boiler and Pressuren Vessel Inspector, USA .

1999 AD-Merkblatt HPO Recertification by RWTUV for Gas Turbine Combustion Chambers

1999 INSAAN Award for Excellence in Suggestion for 9th consecutive year

1999 Launching of 5s concept

1999 PCRI recognized as Environmental Lab by Haryana State Board for Prevention and Control of Pollution

1999 Accreditation of ISO 14001-Enviornment management system

2000 CII Site Visit for CII-EXIM Business Excellence Award-2000

2001 Top Management TQM Workshop at Rishikesh and HRDC

2001 INSAAN Award for excellence in Suggestion for 11th consecutive year

2001 Launching of QTM & RCA at HEEP Hardwar by CMD

2002 Launching of delivery Index , Turnover Index and Manufacturing Index

2002 Accreditation of ISO 9000-2k

2002 JBE Workshop of Apex TQM Group at Tehri to evolve Business policy and CSF

TOTAL QUALITY FOCUS:

To face the increased competition from MNCs(due to liberalization policy of Government) in early 90's and to enter European market we moved towards ISO 9000 Certification.Concept of Business Excellence through EFQM Model was launched in entire BHEL on pilot scale in Oct."1995" In 1997 HEEP launched TQM in the entire Plant and since then Self-Assessment is done every year in September.Based on feedback Report of Assessment, critical success factors are identified.and TQ action plans are drawn. The philosophy of ISO 9001 ,TQM and ISO 14001 has been integrated BHEL Hardwar for ultimately achieving "BUSINESS EXCELLENCE".HEEP Hardwar plant is accredited for ISO 9001 and ISO 14001 and is now on march towards TQM.5-S was launched in March 1999 in a big way and now it has become a way of life in the organisation.In 2000 HEEP applied for CII-EXIM Business excellence award and site visit was conducted bu CII team in Seot."2000.Cii feedback has gone a log way in carrying out further improvement plans and giving a structured thrust to TQM movement

In July 2001, Unit's TQ Council reviewed the TQ Action Plans 2001-02 for its effectiveness and impact on accelerating the pace of improvement and consequent TQ Score.Executive Director laid the challenge of achieving the TQ score of 650.With an objective to bring awareness about he CII-EXIM Business Excellence Model amongst the Sr. Executives, the first 'Top Management TQM Workshop's held at Rishikesh during oct.2001Executive Director who is TQ Assessor also, himself steered the Workshop with assistance from some experienced TQ Assessor of HEEP.It followed by second Top Management TQM Workshop steered again by Ed was held at HRDC on Oct'29,2001.Subsequantly the third Top Management TQM Workshop was held in Nov'2001,where-in Sr.Counsellor,CII deliberate the detail onBest

practices of TATA STEEL-the winner of 'CII-EXIM Business Excellence Award 2000'.Simultaneously ,TQ Assessors training programme for the select group of young managers(to be developed as Think Tanks)was organized in Nov'2001.To give further boost Apex Group was formed.Apex Group developed "Roadmap to Business Excellence" based on Criteria Linkage of CII-EXIM BusinessModel and the initiatives taken at Hardwar was drawn by the group and it was widely circulated amongst the employees through special issue of Hardwar Current in April 2002. To be a responsible corporate citizen and to meet exacting international standards in occupational health, safety and environment, BHEL continued re-certification of all its units/ divisions for OHAS-18001 Occupational Health and Safety Management System as well as ISO-14001 Environmental Management System. BHEL' journey in **Total Quality Management (TQM)** received a boost when all Four major division of BHEL viz Trichy, Hardwar, Bhopal and Hyderabad along with Power Sector Northern Region received the coveted **CII- EXIM commendation certificates.** Other significant achievements included:

- 'IMC Ramakrishna Bajaj National Quality Award 2004' to BHEL's Ranipet plant making it the first PSE to win this award.
- BHEL's Hyderabad plant was adjudged the 'Best Organisation in promoting Quality Circles' for the second consecutive year by QCFI chapter convention.

For contribution to the Renewable Energy sector, the SESI2004: PVSEC Award for Applications', was conferred on BHEL's Electronics Division, by solar Energy Society of India.

BUSINESS POLICY:

"In-line with Company's Vision, Mission and values, we dedicate ourselves to sustained growth with increasing positive Economic Value Addition and Customer focussed business leadership in the **Power and Industry Sector**.

CRITICAL SUCCESS FACTORS:

- Increase Orders of Spares/Services to 230 Cr.
- Decrease Capital employed by Rs. 120 Cr.
- Saving in Material Cost by 16 Cr. i.e. 5%- Rs. 4 Cr.
- Decrease in indirect material +miscellaneous expenses by 5%- Rs. 4 Cr.
- Effective implementation of QTM/RCA/CTQ
- Strengthening Internal customer concept
- Development of an Incentive Scheme
- Reward Scheme including EXCEL Awards
- Effective implementation of PMS
- Effective Contract Management
- Technology Upgradation

'Excellence triangle' for each Critical Success Factor is now being drawn comprising improvement projects. These projects will be Centrally registered under On-line Central Registration system to be developed for it. While CSF Champion will take the total stock of position in the improvement projects undertaken in his respective CSF, progress of individual projects will be reviewed by Area TQ Council (ATQC) and Functional TQ Council (FTQC).

One of the major strengths of HEEP Hardwar is its free, open and consistent work culture for making continuous improvement evident from the participation

of employees in Suggestions and Quality Circles. To recognize their efforts various productivity drives and competition are organized through out the year and Executive director awards the winners in the special Award Distribution Functions. The journey to excellence is unending .It is a continuous search with commitment and belongingness. Sky indeed is not the limit for perfection. The transition has strongly experienced a silent internalization with a blend of commitment of the existing human resource for creating benchmarks for excellence. The emergence of role models and clear-cut driving force at the top provide an anvil to unleash the potential, which remain unexplored in search of "Attitude to perform". The surge has started and is getting communicated down the . BHEL today through TQM is on march towards excellence.

---------- SWOT ANALYSIS ----------

-S-T-R-E-N-G-T-H- (S): -

- Low cost producer of quality equipment due to cheap labour and fully depreciated plants.
- Flexible manufacturing set up.
- Entry barrier due to high replacement cost of its manufacturing facilities.
- Comprehensive turnkey experience from product design to commissioning.

-W-E-A-K-N-E-S-S-E-S- (W) :-

- High working capital requirement due to its exposure to cash starved SEBs (State electricity boards).
- Inability to provide project financing.

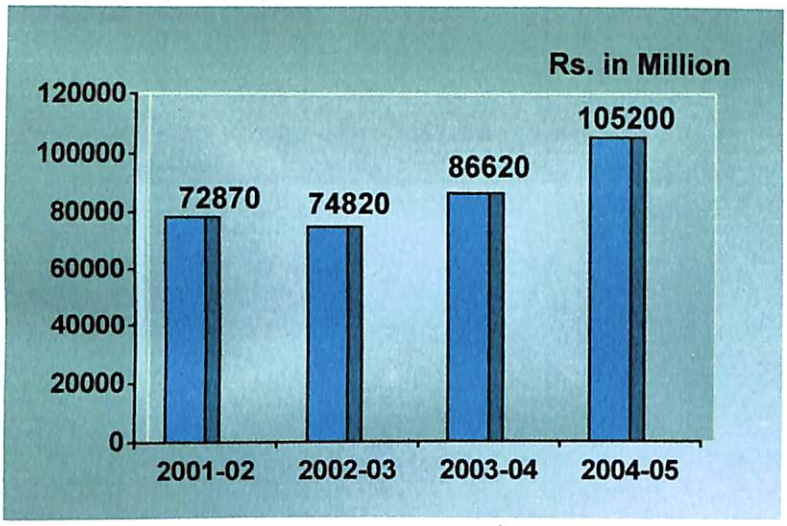
-O-P-P-O-R-T-U-N-I-T-I-E-S- (O) :-

- High expected growth in power sector (7000 MW/p.a.needs to be added).
- High growth forecast in India's index of industrial production would increase demand for industrial equipment such as motors and compressors.

-T-H-R-E-A-T-S- (T):-

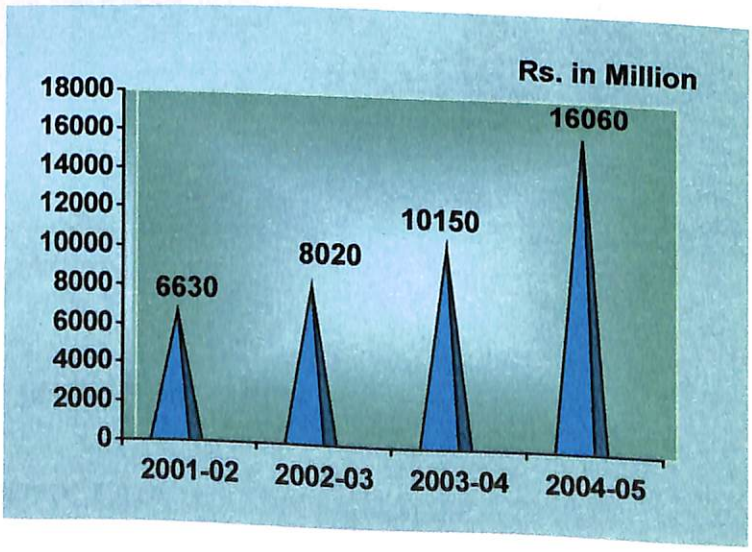
BHEL's Performance Highlights 2004-05

TURN OVER



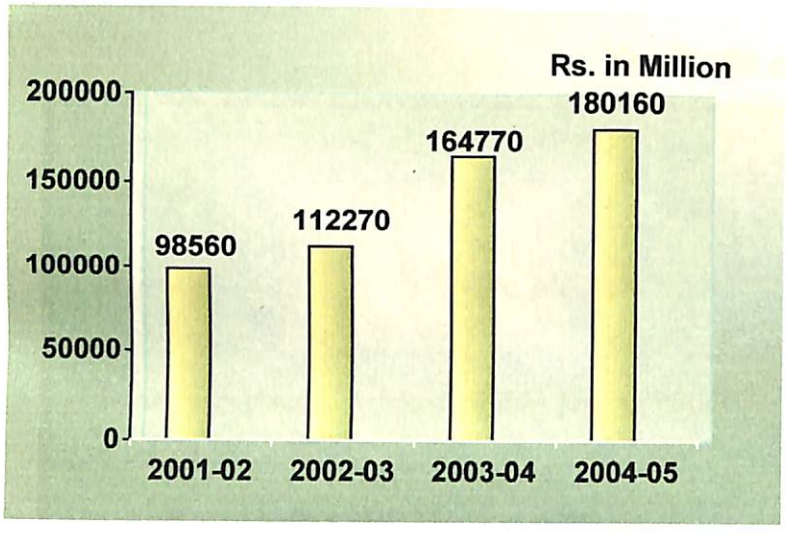
- Over 21% growth on top of 16% of 2003-04, the highest in last two decades.
- Turnover zooms past Rs. 100,000 Million mark

PROFIT BEFORE TAX



- Better benchmark established in execution of power projects.
- Strong fundamentals will drive capacity enhancement

ORDER BOOK

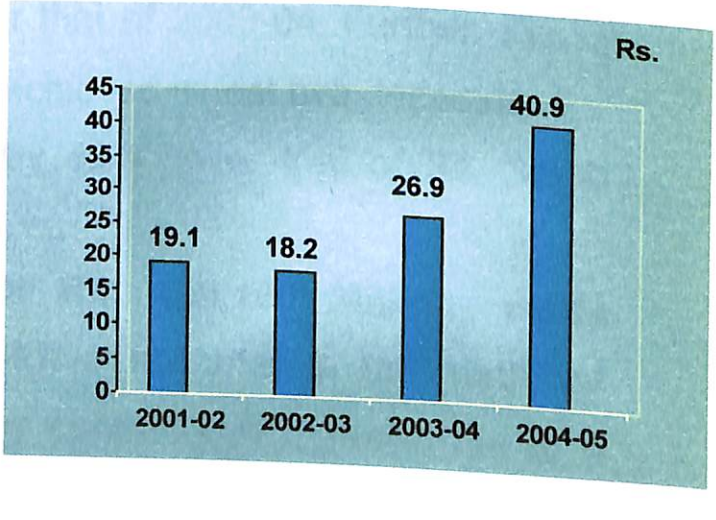


- Highest ever order received in a single year.

- Centres of Excellence established in computational Fluid Dynamics & Permanent Magnet Machines

- BHEl employee wins 'Padma Shri'

EARNING PER



Note Figure for 2004-05 are unaudited and on provisional basis.

Sterling Performance with new landmarks
Company scoresa double

- **Turnover above Rs.100,000 Million**
- **Net Profit over Rs. 10,000 million.**

	Units	2003-04	2004-05	% Change
Turnover	Rs.Million	86620	105200	↑ 21
Economic Value Added (EVA)	Rs. Million	3660	5180	↑ 42
Profit Before Tax (PBT)	Rs. Million	10150	16060	↑ 58
Net Profit (PAT)	Rs. Million	6580	10020	↑ 52
Order Inflow	Rs. Million	104770	180160	↑

- **Turn over at Rs 10,5200 Million** was **growth of 21%**on top of 16% achieved in 2003-04 **Net profits at Rs. 10,020 Million** witnessed a **jump of 52%** over that of 2003-04. Further, this is the highest turnover growth rate achieved in last two decades.
- **EVA at Rs. 5,180 Million up by 42%** over that of Rs. 3,660 million achieved in 2003-04
- **Highest ever order inflow of Rs. 180,160 Million- while operating in intensely competitive national & international markets.** Maximum EPC/Turnkey contracts in a year-6 out of 8 orders for thermal power projects.
- **New benchmark created in execution of power projects.** Ramagundam (500MW) STPS (unit7) was synchronized in a record time of 36 months & 10 days.
- **Installed equipment performance improves further** BHEL supplied thermal sets record a new high in PLF at 75.7% - 1.4%

more than the national average and operating Avilibility of BHEL supplied thermal sets reaches 84.3%. Furhter, of the 27 power station awarded Govt. of India's Shield for excellent performance 23were equiped with BHEL's power generating equipment.

- **B Furhter success in overseas business achieved** with first ever export order for 63 MW (ISO) Combined Cycle Power Plant (CCPP) in Australia. A maiden order for mainline Locomotives from Sudan marked BHEL's entry into a new market with new product.
- **BHEl is gearing up to enhance its annual manufacturing capacity** from the present 6,000 MW to 10,000 MW by March 2007 to cater to country's ambitious power capacity addition programme.
- **To maintain R&D edge** World class centres of Excellence for Computational Fluid Dynamics and Permanent Magnet Machines established - ceating environment in crucial technology areas. Furhter, India's first indigenously developed Thyistor Controlled Series Capacitors for improving power flow and system stability in 400 KV system, successfully test-commissioned at Ballabhgarh.

BHEL has maintained the momentum gained in the last fiscal and once again recorded an excellent performance, notching up sizeable gains in all areas of its activity and reaffirming its commitment to ' Brightening Lives & Powering Progress'.

ORDERS INFLOW

- During the Year ,BHEL secured orders worth **Rs. 180,160 Million** from domestic & overseas markets. At the end of the year, outstanding orders in hand for execution in future, stands at over **Rs. 318,000 Million- the highest ever** both in physical as well as financial terms.

INTERNATIONAL BUSINESS

- Bhel achieved a physical export order inflow of **Rs.4,480 Million** during the year
- Several prestigious orders were secured, each one of which signifies a major step forward towards for western consolidation in international business:
  - First ever export order for 63 MW(iso) Combined Cycle Poer Plant from Clough Australia fro western Energy Pvt. Ltd. Australia.
  - Largest oveseas orders for compressors- onerfor Lekhwair and three for Yibal projects of Petrolium Development Oman.
  - First- ever export order from sudan for six 2200 HP & two 1700 HP Diesel Electric Locomotives for sudan Railways. This is the first ever export order form Sudan as well as the maiden export order for mainline Locomotivereceived by BHEL.
  - First ever export order for supply and suppervision of 15.3 MW STG package from thiland placed on BHEL Thai Carbon Black Co. Ltd., Thailand.

- ✦ Largest overseas orders for supply of solar cells and PV Modules to Italy & Germany. The orders were secured from SE Projects, Italy and IRROn, Germany, further expanding BHEL's presence in the export market for photovoltaics.

- ❖ Continued focus on After-sales Services led to orders for spares & services from Bangladesh South Korea, Kazakhstan, Cyprus, Oman, Sri Lanka, Malta, Malaysia Greece and China.

CAPITAL INVESTMENT & ASSET MODERNISATION

- ❖ BHEL is implementing a phased investment programme of Rs.8000-10,000 Million aimed at enhancing its installed manufacturing capacity of power plant equipment to 10,000 MW per annum. This should enable the company to pay a major role in poer plant capacity addition programme of country in future .

- ❖ An Investment of **Rs. 1,550 Million** was made under capital programme, during the year, to enhance the competitiveness of key products/areas through completion of ongoing modernization schemes, capacity augmentation and replacement of ageing faclities. In addition, Rs. 390Million was spent on refurbishment and modernization of existing machines tools for realizing better accuracies and reliability leading to enhance productivity.

FINANCIAL PERFORMANCE

- Bhel notched up itshighest turnover of **Rs 105,200 Million,** crossing the Rs.100,000 **Million** figure mark for the first time compared to Rs. 86,620 Million of the previous year. The turnover growth of over 21% has been achieved on top of 16% achieved in 2003-04. Further, this is the highest growth rate received in last two decades.

- The Company's Net profit (PAT) surged by 52% at Rs.10,020 Million against Rs 6,580 Million in the previous fiscal, profit Before Tax (PBT) also rose by 58% at **Rs. 16,060 Million,** during the Year. An all- time high interim equity dividend of 35% was paid for fiscal 2004-05, maintaining the track record of paying dividends uninterruptedly for the last 29 years.
- Earning per Share (EPS) , during the year has gone up to **Rs. 40.9** - an increase of 52% over that achieved in 2003-04.

- EVA surged to Rs. 5180 Million registering an increase of 42% over that of Rs. 3,660 Million in 2003-04.

- Value Added per Employee went up to **Rs.9.92 lakh** from Rs.8.37 Lakh in 2003-04 and Net Asset Value (NAV) per share increased to **Rs.248**, from Rs.216 in the previous year, indicating the instrinsic strength of the company.

- Total export turnover (Physical+Deemed) stood at **Rs.23,310 Million** during the year, accounting for over 22% of the company's turnover during the year.

Sustained performance by the company became possible as a result of strategic management with a blend of appropriate measure including improvements in operational efficiencies, benchmarking against international standards, prudent financial management, upgrading manufacturing facilities and dynamic HRM policies.

Major credit rating agencies like ICRA and CRISIL have reaffirmed their faith in BHEL's strong fundamentals and commendable performance during the year, by retaining the highest rating for the company's debt and deposit programmes. This also reflects the company's dominant position in the domestic power generation and electrical equipment market.

CHALLENGES BEFORE THE MAINTENANCE MANAGEMENT:

- **Maintenance of old machines & equipment**
- **Matching the demand of increased Production targets & reduced delivery**
- **Depleting Manpower**
- **Complex maintenance of Modern machines**
- **Enhanced requirement of availability of machines and equipment**
- **Spare parts management**
- **Development of Service providers**

MAINTENANCE:

"Maximise availability and enhance capability of m/c tools, equipment, plants & services through technology up-gradation employing latest maintenance techniques"

There is an old saying among maintenance personnel: "Engineering has it for a year, but maintenance has to live with it for 20 years." this goes with engineering saying: "get it out the door; we can always fix it on someone else's order historically, the maintenance function was seen as a non-core service organization that did not contribute to competitiveness.

Actually maintenance is an age –old function, which developed and progressed, knowingly or unknowingly, along with the operation of the equipments/machines. in early ages, maintenance was not a separate identity but the job of maintenance was considered as part and parcel of operator's job.

Objective of maintenance

(a) Timely & Quality repair

(b) Increased **Machine Availability** through **more** stress on preventive maintenance

(c) Root cause analysis of failures & take appropriate preventive measures.

(d) Improve machine accuracy & life through rebuilding

(e) Modernization & retrofitting to enhance the machine capability

(f) Development of skills and competencies

Purpose of maintenance

The main purpose of maintenance in an industrial perspective is to reduce the business risks. In general, operation and maintenance is synonymous with high level of availability, reliability and assets operability linking directly with production capacity, productivity and business profit.

MAINTENANCE FUNCTIONS

To get a smooth reliable and cost effective maintenance in a company, different functions in the company has to be coordinated and not only the maintenance department alone. Primarily it affects questions of economical technical and organizational nature at a system level. Maintenance Function is the more dominant amongst those. Earlier the objective of maintenance function was considered to optimize plant availability at minimum cost.

Maintenance functions can be grouped in two categories – basic functions and composite function

1. Basic function

(a) **Replace**: To remove an unserviceable item and install a serviceable counter part in its place.

(b) **Repair**: The application of maintenance services, including fault location/troubleshooting removal installation, and disassembly/assembly procedures, and maintenance actions to identify troubles and restores serviceability to an item by correcting specific damage

(c) **Overhaul**: That maintenance effort prescribed to restore an item to a completely serviceable/operational as required by maintenance standards in appropriate technical publication. Overhaul is normally the highest degree of maintenance performed by the industry

(d) **Rebuild**: It consists of those services necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to any equipment.

(e) **Service**: Operations required periodically keeping an item in proper operating condition. lubrication is introduction of any various
substances between sliding surfaces to reduce wear and friction.

(f) **Inspect:** To determine the serviceability of an item by comparing its physical, mechanical, electrical characteristics with established standards through examinations.

(g) **Test:** To verify serviceability by measuring the mechanical or electrical characteristics of an item and compare those characteristics with prescribed standards.

(h) **Adjust** : To maintain, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to specified parameters

(i) **Align:** To adjust specified variable elements of an item to bring about optimum or desired performance.

(j) Install: The act of emplacing seating or fixing into position an item, part, or module in a manner to allow the proper functioning of an equipment or system.

2.COMPOSITE FUNCTIONS :

(a) Protecting the buildings, structures and plants.

(b) Reducing downtime and increasing equipment availability

(c) Controlling and directing labour forces,

(d) Economy in maintenance department

(e) Maximizing utilization of available resources,

(f) Ensuring safety of utilization and reducing environmental pollution,

(g) Cost reduction and cost control; Also helping in costing of individual jobs and departments,

(h) Preparing maintenance budgets,

(i) Waste reduction and waste recovery

(j) Improving technical communication,

MAINTENANCE OBJECTIVES :

Maintenance purposes, functions and objectives are inter-realted and are overlapping to some extent. Maintenance objectives for a big industry **BHEL** follow these maintenance:

1. To maintain plants and equipments at its maximum operating efficincy, reducing downtimes and ensuring operational safety.

2. To safeguard investments by minimizing rate of deterioration and achieving this at optimum cost through budgeting and controls,

3. To help management in taking decision on replacements or new investments and actively participate in specification equipment selection.

4. Help in implementation of suitable procedures for procurement, storage and consumption of spares, tools and consumables etc.

5. Standardization of spares and consumable in conformity with plant, national and international standards and help in adoption of these standards by all users in the plant.

6. Running of centralized services like steam generation & distribution, water supply air supply and fuel supply.

FAILURE MODE:

Failure mode generally means the category, type style, way or status of a failure event. The term "Failure mode" is often in all failure analysis etc. It fosters good communications since every one knows what is important and it also provides a basis for a common understanding of what the facility's needs are.

FAILURE ANALYSIS:

Defect Analysis or fault Analysis is generally similar approach in industrial maintenance scenario. through one may argue that Defect Analysis covers wider areas than Failure Analysis, but henceforth, we would use the term " Failure Analysis" to include all defects, faults and failures etc in industries. It involves investigation of reason as mentioned in the basics above. We may use different types of visual inspection, electrical testing, on destructive evaluation, destructive

Evaluation and other examinations .

1) proper Failure Mode deter mention
2) fatigue analysis
3) overloads
4) stress corrosion cracking

FAULT TREE ANALYSIS: (FTA) is logical structured process that can help identify potential causes of system failure before the failure actually occur. The most serious fault/failure, such as explosion, toxic releases breakdown, damage malfunction etc is selected as the top level Event/fault. A fault tree is then constructed downward by relating the sequences of events.

EVENT TREE ANALYSIS: (ETA) It is a visual representation of all the events, which can occur in a system. As the number of events increases, the picture fans out like the branches of a tree. The event tree displays the sequences of events involving success and failure of equipments.

ROUTE CAUSE ANALYSIS: (RCA) Route Cause Analysis is normally done in those unwanted situations which consume resources and causes problems and dealing with it rather than simply continuing to deal with the symptoms. It consider mainly following four points –

1) How does one determine which situations items are for root cause analysis?

2) How does one figure out what the root cause is?

3) Does the removal of the cause entail less resources expenditure than it takes to continue to deal with the symptom?

4) Removal of route cause.

ROUTE CAUSE FAILURE ANALYSIS: Is another name for similar technique, specifically for maintenance. RCFA focuses on eliminating the risk of recurrence of the failures by identifying the physical, human and latent systems roots that lead to the failure. RCFA is a simple, yet disciplined process used to investigate, rectify and eliminate equipment failure, and it's most effective when directed at chronic breakdowns. RCFA combined with RCM (Reliability Centered maintenance) gives a successful formula for maintenance.

TYPES OF MAINTENANCE

BASIS OF SELECTING MAINTENANCE SYSTEM:
Maintenance types are methodologies and software programmers which balance maintenance costs against the impact of plant failure. By optimizing equipment maintenance strategies against both target availability and the penalty of failure, you can optimize your assets life-cycle costs.

There are various reasons for evaluating maintenance systems such as-

(a) Set of tasks that should be performed and their frequency,

(b) With aging of the plant a different mix of tasks is need to maintain reliability.

(c) The plant operators may want to reduce maintenance expenditures without elevating risks or reducing reliability.

BREAKDOWN OR EMERGENCY MAINTENANCE
In such maintenance, repair is done after failure has already occurred. The equipment is allowed to run undisturbed till it fails. Only when the equipment fails to perform designated functions or comes to a grinding halt, any maintenance or repair job is taken.

(a) Number of equipments are few,
(b) Equipments are simple and repair does not call for specialists or special tools.
(c) When sudden stoppage of the equipment will not cause severe financial loss in terms of delivery commitment or further damage to other equipments.
(d) When sudden failure will not cause any severe safety or environmental hazards.

CORRECTIVE MAINTENANCE:

Corrective maintenance means maintenance actions for correcting or restoring a failed. Its scope is very vast and may include different types of actions from small actions like typical adjustments and minor redesign of equipment.

Corrective maintenance is generally one time task; once taken up, completed fully. Each corrective job may differ from other. Some bigger corrective maintenance jobs may have the following stages-

Collection of data/information and analysis,

(a) Identify likely causes,

(b) Find out the best possible solution to eliminate those likely causes

(c) Implement those solutions etc

OPPORTUNISTIC MAINTENANCE: In multi component system, with several failing equipments, often it is advantageous to follow opportunistic maintenance also. Normally cost of changing several parts together is much less than the sum of the costs of several separate replacements.

Opportunistic maintenance is very useful for non-monitored components. For non-monitored components, which are inaccessible and can not be inspected without changing, such replacement policy may be considered.

ROUTINE MAINTENANCE: Routine maintenance is the simplest but very essential form of maintenance system. Earlier the routine maintenance was considered about preventing failures. Today routine maintenance is being considered about avoiding, reducing or eliminating the consequences of failures. The small and critical defects, observed during such inspection, are rectified immediately and bigger jobs are planned for rectification during next available shutdown.

Routine maintenance is not necessarily need based. in a equipment some motor be running for 4 hours a day and some others may be running 20

Hours a day but, in routine maintenance, all may be inspected at the same frequency.

PREVENTIVE MAINTENANCE: Preventive maintenance has a vast scope. As the name applies, it may include any action to prevent equipment failure. An enhanced preventive maintenance may include predictive maintenance , CBM,CMMS, Proactive maintenance etc Analysis ,assessing new reliability and other requirements and planning of new PM programmers, integrating programmers of new or other equipments with existing system if any , establishing system support requirements and configuration .

Preventive maintenance is the planned maintenance of plants and equipments (including and resulting from routine maintenance inspections, others and condition monitoring etc.) in order to prevent or minimize breakdown and deterioration rates. It covers a vast area and occasionally people get misled by its coverage.
In general, the various components of Preventive Maintenance are as follows-

1) Check drawing, design and installation of equipments including subsequent redesign and minor modifications, depending on specific nature of problems.

2) Proper identification of all items, proper documentation and codification; check –

(a) Spares catalogues, equipment catalogues and inventory lists,
(b) Records,
(c) Job manuals and standard maintenance practices
(d) Maintenance work orders and other pending work orders.

3) Periodic inspection of plant and equipments
(a) Use of checklists by inspectors and its frequency; shift wise, daily , weakly and monthly
(b) Well qualified and experienced inspectors.
(c) Preparing total defect list and its categorization,

4) Adequate lubrication, cleaning and painting of equipments; Changing of oils and lubricates of system as per inspection reports,
5) Typical failure analysis and plan for their elimination

6) Organization for preventive maintenance
7) Budget provision and control for repairs and preventive maintenance.

PREDECTIVE MAINTENANCE (Pd M) :

A predictive maintenance approach strives to detect the onset of equipment degradation and to address the problems as they are identified. This allows casual stressors to be eliminated or controlled, prior to any significant deterioration in the physical state of the component or equipment. In Pd M, maintenance needs are based on the actual condition of the equipment rather than on some predetermined schedule it involve predating the failure before it occurs, identifying the root causes for those failure symptoms and eliminating those result in extensive damage to equipments. Thus there are three distinct stages of Pd M –

(a) Detection

(b) Analysis

(c) Correction

SAMPLE PREVENTIVE MAINTENANCE CHECK LIST OF HORIZONTAL BORER, BLOCK-3/ 1-012

DEL	DMAIN	DSUB	ACTIVITY	STANDARD CHECKS
7T	BED	**********	OIL LEAKAGE FROM JOINTS ETC	LEAKAGE CHECKING
			CLEAN FILTERS , OIL POCKETS.	ENSURE CLEANING
			660 LTRS CLEAN OIL (HEAVY)	ENSURE CLEANING
		LUBRICATION	INTACK STRAINER	ENSURE CLEANING
			FREE MOTION NO LEAKAGE	ENSURE FOR PROPER
			AFTER SHUTTING OFF THE LUBR,RACK OILING	CHECK PROPER
			PRESSURE SHOULD BE THROTTLES FILL.	CHECK PROPER PRESSURE
			ADJUST THROTTLE FILL AND PRESS DROPS	CHECK & ADJUST
			ADJUST SO THAT SIRON & 16 KG/CM2 WITH THE	CHECK & ADJUST
			AFTER SWITCHING ON.	CHECK & ADJUST
	SADDLE	CLAMPING	CHANGE COUPLING	CHECK FOR PROPER
			REPLACE OIL SEAL	LEAKAGE CHECKING
			PRESSURE SLIDE VALVE WITH NON-RETURN	ENSURE CLEANING
			CLEARANCE 10mm B/N PSTN FACE &STOP CYL	CHECK & ADJUST
			.06mm CLEARANCE BETWEEN GUIDE WAYS AND	LIMIT SWITCH CHECKING
	******	GUIDE WAYS	NO FOREIGN MATERIAL INSIDE THE WAYS	ENSURE CLEANING
	FEED BOX	SAFETY	CLUTCH SHOULD SLIP.6000 Kg.FORCE	CHECK FOR PROPER
		BEARING	UNDAMAGED TEETH & INTACT BOLTS & RACES	ENSURE IT IS UNDAMAGED
		**********	UNSCRATCHED TEETH WORM & REDUCTION	CHECK & ADJUST
	SPINDLE FEED	GEAR BOX	INTACT COUPLING,NO LEAKAGE,UNSCRATCHED	CHECK & ADJUST
	HEAD	**********	SAFETY CLUTCH	CHECK & ADJUST
			BEARING & REDUCTION GEAR	ENSURE PROPER
			SLEAVE COUPLING CONN.LONG.SHAFT FIRM	ENSURE FOR PROPER
			SLEAVE COUPLING CONNECTING LEAD SCREW	ENSURE FOR PROPER
			UPPER SUPPORT LEAD SCREW	CHECK PROPER

OPERATORS CHECK POINTS

Plan No. : Type of m/c : Month :

No	Assembly	Activity	Frequency	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Op Plateform	Clean	Daily																					
2	Telescopic Cover	Clean.	Daily																					
3	Chip Conveyor	Check for material other than chips specially tools, clamps etc.	Daily																					
4	Face plate and lead screw & nut of jaws	Clean lubricate with light oil	before / after every loading / unloading.																					
5	X & Z lubrication.	Oil level in lubrication tank SW68.	Daily																					
6	Auto tool changer	Check oil level in its hyd. Tank SS 46 and visual check for oil leakage.	Daily																					
7	Head stock lubrication	Check oil level in head stock SS 46 and its recirculating tank as well as visual check for oil leakage.	Daily																					
8	Tool cassatte holder	Check oil level in its hyd. tank (SS 32)	Daily																					
9	Sliding cover of machine.	Clean its guideway & lubricate.	Daily																					
0	Telescopic Cover	Clean & lubricate.	Weekly																					
1	Coolant system.	Clean tank and replace coolant.	Every Month.																					
	OPERATOR'S SIGNATURE																							

IMPORTANT INSTRUCTION
Do not walk on telescopic covers when its motion
Do not clean machine with compressed air.
Move all the axis to extermes at least once in each shift.
Do not clean m/c guideways, lead screws etc. with cotton waste . Unsilent free cloth for cleaning.

INTRODUCTION

MAINTENANCE

Maintenance is a Department provides Maintenance for manufacturing facilities; safety regulations are observed and are maintained within desired level of accuracy to enable the respective manufacturing department to produce quality products as assigned by the management within the scope of HEEP BHEL Haridwar. Department has responsibility for Field Maintenance and Shop Maintenance.

OBJECTIVES

Commensurate with HEEP's Quality Policy and Works Engineering & Services Manual, Mechanical Maintenance Department has identified its objectives as under.

1. Commissioning and ensuring availability of all Machines for manufacturing of products with in BHEL, HEEP's scope of supply by way of suitable Maintenance.
2. Timely arrangements of Spares required for mechanical Maintenance.
3. To Develop Skilled Manpower.
4. Shop Maintenance Sections Shall ensure suitable corrective/Preventive actions to be taken for Class A Category Critical machines based on Pareto Analysis report received form Maintenance Planning every month.
5. Shop Maintenance sections monitor regularly quality through Measurement (QTM) index and is utilized thereof for continual improvement of quality index.

6. Feed Back from shop is analyzed for taking corrective & preventive action.

PRINCIPLES & POLICES

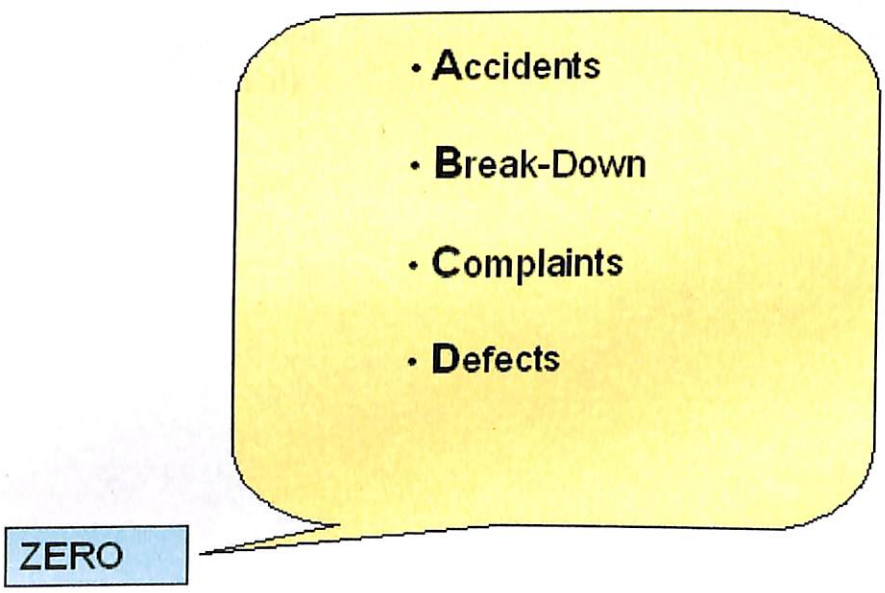
QUALITY POLICY: In its quest to be World-class, BHEL pursues continual improvement in the Quality of its Products, Services and Performance leading to Total Customer Satisfaction and Business Growth, through dedication, commitment and teamwork of all employees.

POLE STAR STATEMENT

"Maximise availability and enhance capability of machine tools, equipment, plants & services through technology up-gradation and latest maintenance techniques"

GUIDING PRINCIPLE

ABCD to Z



SMARTER ACTION PLANS

S – Specific
M – Measurable
A – Achievable
R – Result Oriented
T – Time Bound
E – Evaluated periodically
R – Review Periodically

MAINTENANCE ETHICS

- Building a strong maintenance culture
- Truth telling
- Proactive action
- Seeing the invisible
- Practicing RCA & 5S
- Being fast learning
- Managing Risk
- Walk the Talk

5'S & OEE

ELEMENTS OF 5'S

1. SEIRI
2. SEITON
3. SEISO
4. SEIKETSU
5. SHITSUKE

ADVANTAGES OF 5S

- Nice to work in a Clean, Beautiful, Organized Workplace
- Time taken to reach things minimized
- Lesser time wasted in material handling
- Problems detected fast
- Machine / Production down time reduced
- Lower cost of production
- More usable space
- Better preventive maintenance
- Higher employee involvement
- Reduction in errors / defects due to standardized procedures
- Consistent and better quality product
- Higher productivity
- Lesser accidents
- Higher Employee morale
- More time for improvement activities/

OVERALL EQUIPMENT EFFECTIVENESS (OEE)

OEE- indicates the latent capacity of any manufacturing Plant & helps to focus on improving the performance of Plant & Machinery.

OEE- is an essential Tool to improve equipment effectiveness by creating- Operator as well as Organizational awareness to the current accepted losses.

FEATURES OF OEE

OEE PROCESS INVOLVES 06 BASIC ACTIVITIES;

A) AUTONOMOUS MAINTENANCE,

B) QUALITY MAINTENANCE,

C) PLANNED MAINTENANCE,

D) FOCUSSED IMPROVEMENT,

E) OPERATION AND MAINTENANCE SKILL TRAINING,

F) SAFETY & ENVIRONMENT (5S ACTIVITIES

DETAIL ACTION PLAN OF OEE IMPLEMENTATION

Activity	Date of Completion	Responsibili
dentification of core activity machines		Production
Education (By GKW on machines)		OEE Cell
nstallation of measuring system		Prod. / OEE C
xternal Audit		OEE Cell
nternal Audit (As per format- 1)		OEE Cell & P
reparation of Audit report & Data for losses and corrective ction with time schedule.		OEE Cell & P
eview of Status by Block lead.		Block Head.
eview by Concerned Product Manager.		Product Mana

OPERATOR'S CHECK POINTS (SAMPLE)

Plan No. : Type of m/c : Month : Year :

Sl. No	Assembly	Activity	Frequency	1	2	3	4	.	.	.	.	.	30	31
1	Op.Plateform	Clean	Daily											
2	Telescopic Cover	Clean.	Daily											
3	Chip Conveyor .	Check for material other than chips specially tools clampes etc.	Daily											
4	Face plate and lead screw & nut of jaws.	Clean lubricate with light oil.	before / after every loading / unloading.											
5	X & Z lubrication.	Oil level in lubrication tank SW68.	Daily											
6	Auto tool changer	Check oil level in its hyd. Tank SS 46 and visual check for oil leakage.	Daily											
7	Head stock lubrication	Check oil level in head stock SS 46 and its recirculating tank as well as visual check for oil leakage.	Daily											
8	Tool cassatte holder	Check oil level in its hyd. tank (SS 32)	Daily											
9	Sliding cover of machine.	Clean its guideway & lubricate.	Daily											
10	Telescopic Cover	Clean & lubricate.	Weekly											
11	Coolant system.	Clean tank and replace coolant .	Every Month.											
OPERATOR'S SIGNATURE														

IMPORTANT INSTRUCTION
Do not walk on telescopic covers when its motion
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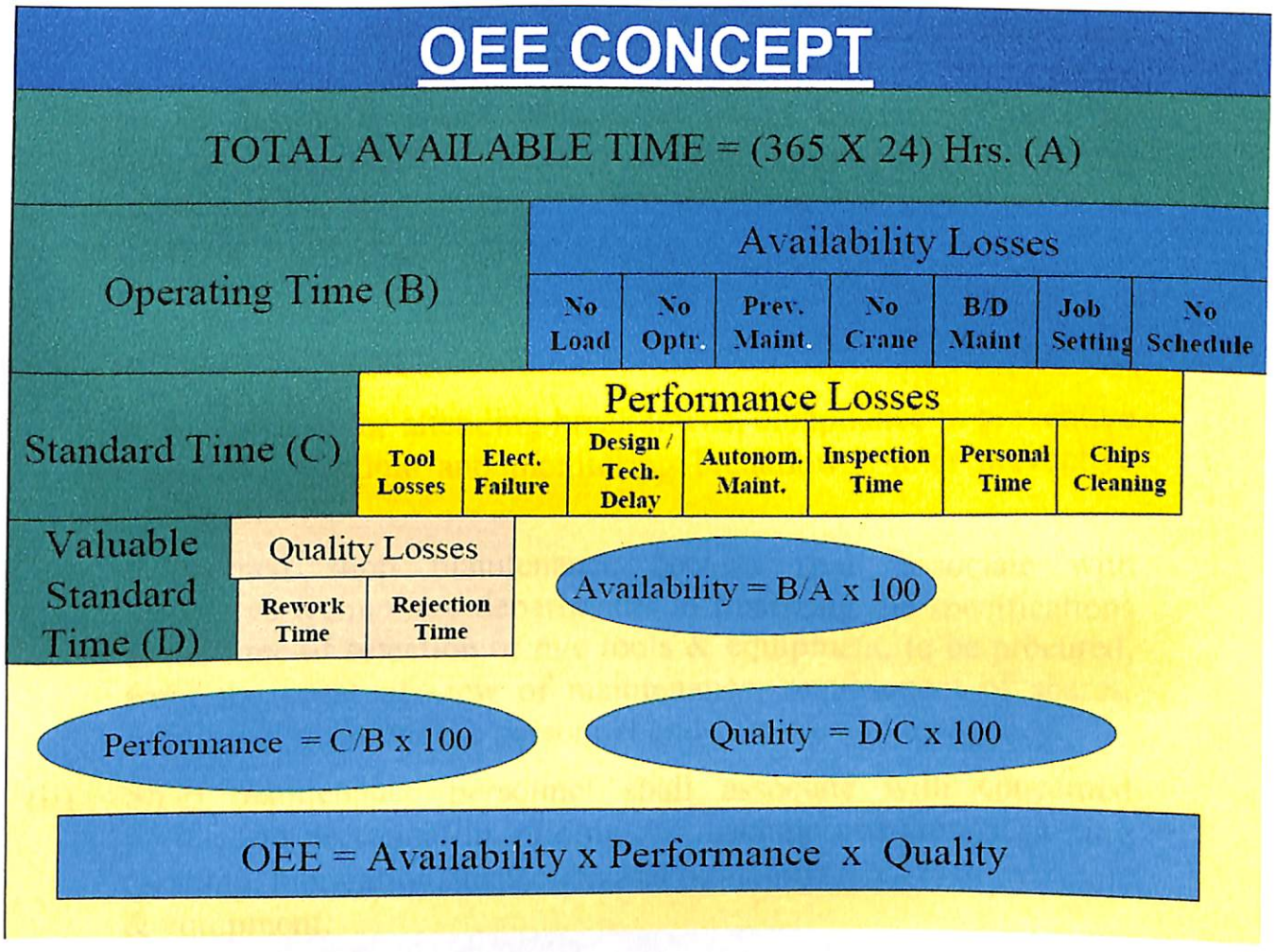
Move all the axis to extermes at least once in each shift.
Do not clean m/c guideways , lead screws etc. with cotton waste . Unsilent free cloth for cleaning.

OEE CONCEPT

To calculate OEE we use the following formula. We take all the required data for this calculation from shop and calculate OEE to improve the productivity.



Target of OEE for 2005-06 : **48%**

Average OEE achieved during 2005-06 : **52%**

Target of OEE for 2006-07 : **60%**

FIELD MAINTENANCE

FIELD MAINTENANCE GROUP

In-charge Field Maintenance group has the needed authority and responsibility for ensuring following services through in-charges of sections shown in organization chart under his charge have the authority & responsibility to carry out their allocated tasks and may delegate performance of any of their duties to those who report to them in the spirit of Quality Policy.

(A) SHOP MAINTENANCE

Speedy response for attending breakdowns, compliance to preventive maintenance schedule and monitoring breakdowns after preventive maintenance

(i) Concerned shop maintenance section shall associate with respective technology departments in finalizing the specifications at the time of selection of m/c tools & equipment, to be procured, from the point of view of maintenance, requirement of spares, training of maintenance personnel and commissioning agency.

(ii) Shop maintenance personnel shall associate with concerned production personnel in guiding the machine operators regarding cleaning, lubrication, inspection and tightening (CLIT) of m/c tools & equipment.

(iii) Shop maintenance in association with concerned production department shall finalize list of other important machines for carrying out preventive maintenance for every financial year.

(iii) Critical machines list shall be updated every year by incorporating alteration/addition made, if any, on the basis of information received from central planning.

(v) Depending upon the nature of failure of m/c tools & equipment and corrective measures required to be taken, the maintenance shall be categorized as under:-

1) Break-down maintenance.

2) Preventive maintenance.

1. BREAK-DOWN MAINTENANCE

(i) Break-down reports of machine tools & equipment due to problems in Systems/machine component/assemblies/control or due to m/c inaccuracies received from shop (refer SMI-236) shall be registered by concerned shop maintenance. Supervisor/in-charge of maintenance section shall take prompt necessary steps/action to rectify the fault and hand over back the machine/equipment to user on the same report.

(ii) A copy of duly filled in shift log book, along with record of accuracy tests or any other special report generated, if any, shall be fed on-line on computer. Duly fed on-line log-book reports shall be sent to maintenance planning section monthly.

(iii) Suitable corrective/ preventive action/ maintenance based on Root Cause Analysis (RCA) shall be carried out for class 'A' category Critical machines based on Pareto analysis report received from maintenance planning every month. The work plan/ completion of such machines shall be sent to maintenance planning every month on prescribed format along with RCA/Why analysis as defined in respective Work Instructions.

(iv) Appropriate corrective action shall be taken in case of general machines (other than Critical and Important machines) based on monthly break-down reports available on-line.

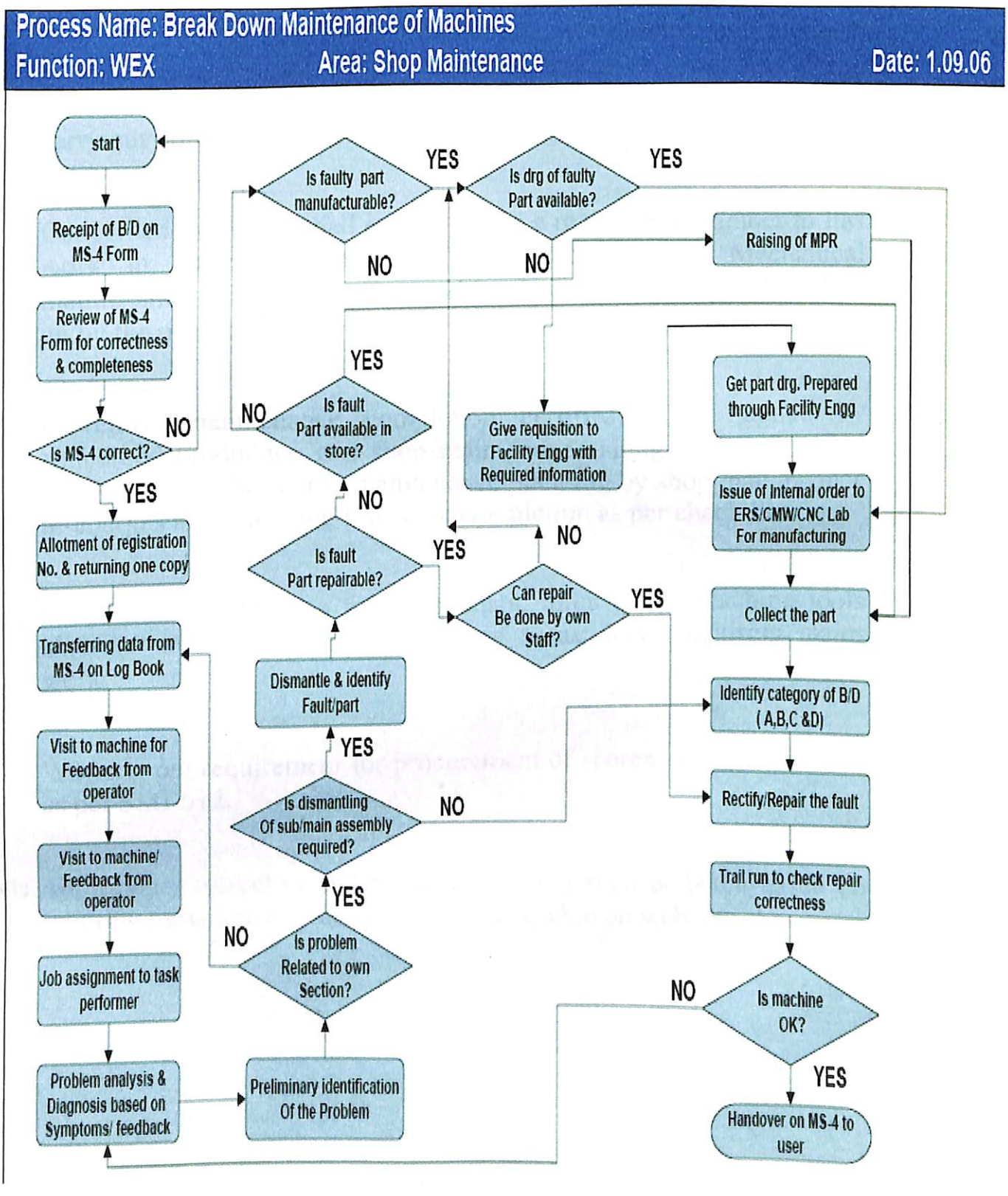
(v) Erection & maintenance of Pipe & ventilation systems installed in HEEP shall be done.

(vi) Maintenance of pneumatic & electrically operated hand tools, welding & cutting torches, regulators and allied equipment.

(vii) It shall be ensured by concerned shop maintenance executive in-charges to offer mechanical measuring instruments periodically, wherever required, to CML for calibration as per SMI-309.

(viii) Concerned shop maintenance shall assist production shop in qualification of process equipment as per SMI-237 and Plant Standard.

BREAKDOWN MAINTENANCE PROCESS FLOW CHART



2. PREVENTIVE MAINTENANCE

(i) Based on Annual & Quarterly preventive maintenance plan received from maintenance planning section along with check lists for Critical and Other important machines, respective shop maintenance shall carry out preventive maintenance accordingly.

(ii) Concerned executive shall ensure, giving a registration number to PM work in daily log-book of CNC, Electrical and Mechanical maintenance. All points mentioned in check lists are factually filled up by the person carrying out the PM work order at the location.

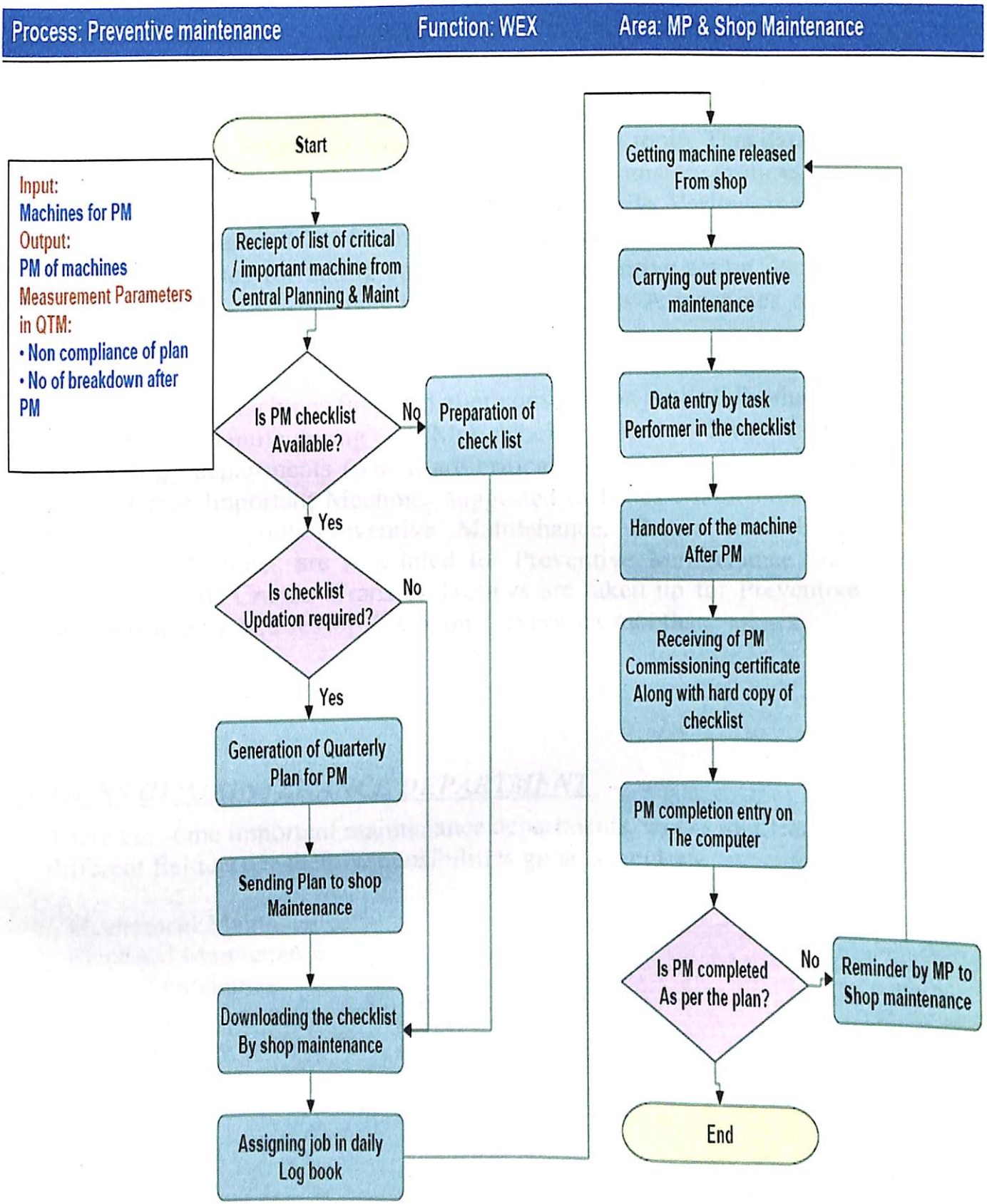
(iii) Preventive maintenance completion certificate duly signed by concerned production and shop maintenance along with duly filled checklists shall be sent to maintenance planning by shop maintenance in-charges after ensuring PM work completion as per check lists.

(iv) Preventive maintenance for problematic units in the machine tools shall be undertaken on occurrence of break down requiring major work.

(v) Working out requirement for procurement of spares/ material shall be as per SMI-612.

(vi) Appropriate corrective and preventive action shall be taken based on monthly measurement indices (QTM) available on web site.

PREVENTIVE MAINTENANCE PROCESS FLOW CHART



MAINTENANCE SYSTEM

1. Logbook database contains information regarding break-down registration number, reporting date & time, handing over date & time, fault location in Main/Sub Assemblies of Machine tools. This database is updated for all Machine tools, Cranes & Transfer Trolleys and utilized for maintaining history of break-down details. Various analyses reports are generated PC-Room of Maintenance planning and sent to shop maintenance for taking corrective and preventive action. Pareto's analysis of Critical Machines being done & Class-A machines report generated to focus attention.

2. List of Critical Machines finalized after consultation with all Production Control & Manufacturing (PCMs) blocks, Product Finance and Technology departments (which are critical from Production point of view). Other Important Machines suggested to Block Maintenance by PCMs to carry out Preventive Maintenance. Critical and Other Important Machines are scheduled for Preventive Maintenance once every year. All Cranes/ Transfer Trolleys are taken up for Preventive Maintenance by M/s Jessop & Co. once every six months.

SECTIONS OF MAINTENANCE DEPARTMENT

There are some important maintenance departments, works in different–different field as per their responsibilities given as under:-

1. Mechanical Maintenance
2. Electrical Maintenance
3. CNC Maintenance
4. A/C maintenance etc.

MECHANICAL MAINTENANCE

Mechanical Maintenance department is a basic need of any organization. In BHEL this department plays a very important role to achieve the target fixed by the management. Different types of activities are carried out by this department to maintain the machine tools. This department follows all the works instructions for maintaining & repairing the machine. Break down maintenance & Preventive maintenance carried out as per methods & instructions given by the management.

Works Engineering & Services assists Technology, Production and Quality department in finalization of equipment/ facilities, verification/ validation of processes. calibration of temperature, pressure and flow measuring instruments. Works Engineering & Services ensures proper maintenance of machine tools and carries out preventive maintenance of Critical, Other Important Machine and Cranes in a planned manner. Proper preservation of spare parts/ other material stored in sub-stores shall be ensured by sectional in-charges. Sectional heads raise Indents/ give requirement to Maintenance Planning section for requirement of spare parts/ equipment needed in their areas.

Work Instructions for Mechanical Maintenance

This Work Instructions lays down guidelines for "Mechanical Maintenance" to enable them to perform their functions in a Planned, controllable & orderly Manner in line with the "WORK ENGINEERING & SERVICES MANUAL", HEEP BHEL HARDWAR.
The implementation of this WI would ensure that the services are made available, safety regulations are observed and manufacturing facilities are maintained within desired level of accuracy to enable the respective manufacturing department to produce quality products as assigned by the management within the scope of HEEP BHEL Haridwar.

RESPONSIBILITY & AUTHORITY OF SHOP MAINTENANCE

In charge Shop Maintenance Group has the needed authority and responsibility for ensuring following functions.

All executives/Supervisors under his charge have the authority and responsibility to carry out their tasks and may delegate performance of

any of their tasks and may delegate performance of any of their duties to those who report them in the spirit of quality policy.

1. Break down report of all machine tools/ equipments of conventional machines shall be received in respective maintenance sections from concerned production department.
2. On receiving the break down report from concerned production department the report shall be registered in the daily Log Book format MS-69 and a unique Registration No. shall be allotted to each break down report.
3. After necessary repair the machine shall be handed over to production department on the same break down report and necessary entries shall be made on daily maintenance log book on format MS-69.
4. Data Entry form MS-69 is fed on line daily.
5. Preventive Maintenance of all machines shall be carried out as per the schedule issued by Maintenance Planning Section preferably during the Mechanical preventive Maintenance.
6. While analyzing the break down of machine tools and equipments and deciding the corrective/Preventive action if any is required to be taken by the operating staff, the same shall be communicated to the concerned shop In charge by maintenance In charge.

6.1 After Preventive Maintenance, Mechanical Maintenance group issues a Preventive

Maintenance Commissioning Certificate on format MS-27A to Planning Section.

7. Association in Commissioning of all machines shall be ensured as per SMI-205.
8. Identification of Critical Machine tools with obsolete control and drives and initiation of their retrofitting as per SMI-239.
9. Identification of training needs shall be carried out as per SMI-712 & sent to Maintenance Planning Section.
10. Shop Maintenance Sections take Corrective and Preventive actions with respect to the following.

- For respective & major break down after RCA.

- Detailed Analysis of QTM data.
- Shop Feed Back
- Updation in preventive checklist & operator Check Points based on RCA & Break down Analysis.

11. Necessary data for Measurement of quality indices in respect of Preventive & Break down Maintenance will be fed periodically as per QTM for ensuring effectiveness & continual improvement of Maintenance System. Accordingly Corrective & Preventive action shall be taken.

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MS-4A

BREAK DOWN REPORT

(Mech./Elect./CNC/A.C./Inst..... Section)

Deptt./Shop ..... Plan No..... M/C Descrip..... Date..... Time.....

Nature of Fault Experienced .....

.....

Sign. of Exec./Supervisor

Reported on Date ..... Time ..... B/D Reqd. No. .....

Sign. of Maintenance Exec./Supervisor

Reported by (Maint.)	Reported to (Maint.)	Handed over to Production
Date		Date .....
Time		Time .....
Maint. Exec./Sup.	Maint. Exec./Sup. (Mech./Elect./CNC/A.C./Inst.)	Maint. Exec./Sup. Sign of Exec./Sup.

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MS-4A

BREAK DOWN REPORT

(Mech./Elect./CNC/A.C./Inst..... Section)

Deptt./Shop ..... Plan No..... M/C Descrip..... Date..... Time.....

Nature of Fault Experienced .....

.....

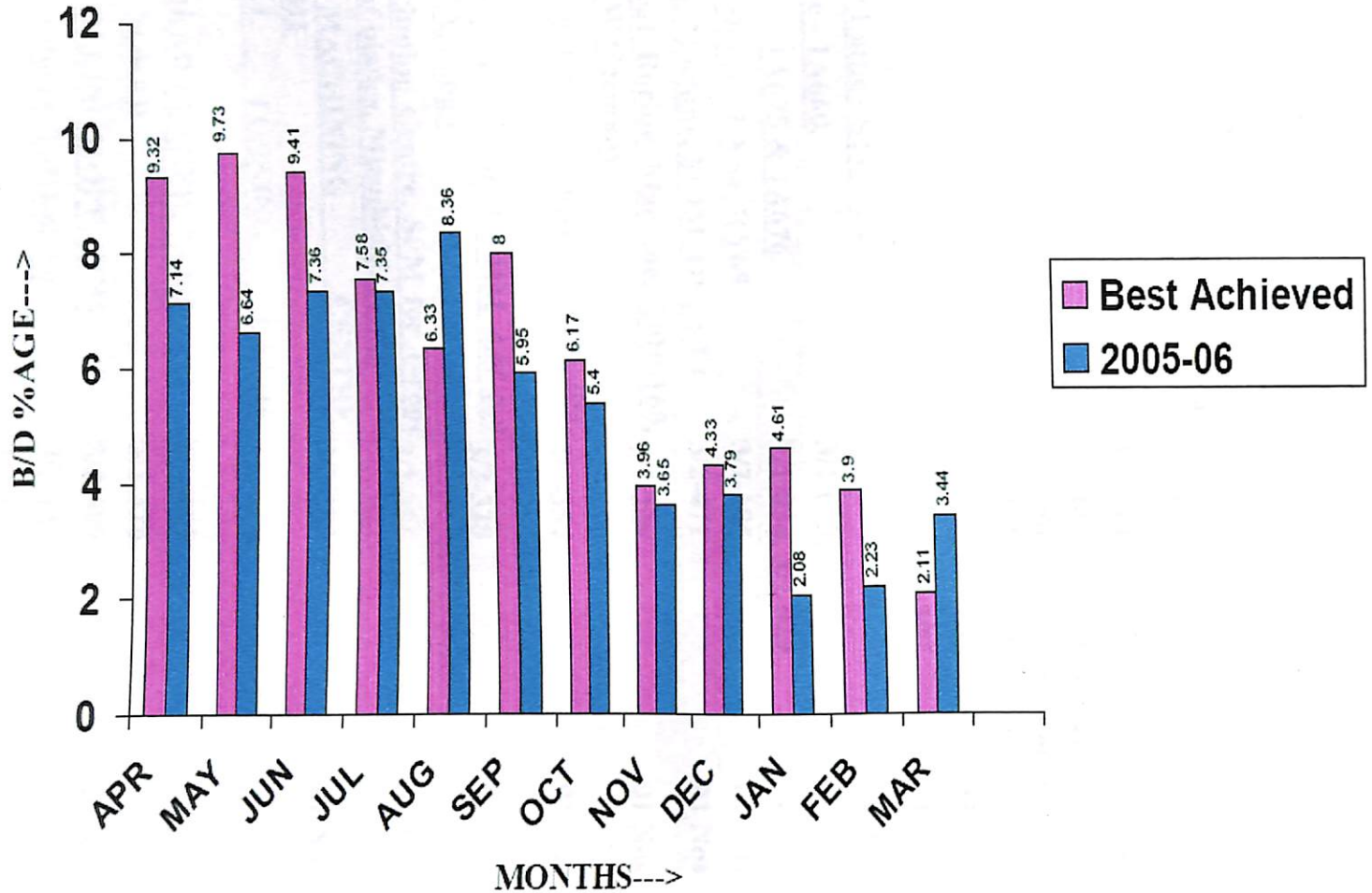
Sign. of Exec./Supervisor

Reported on Date ..... Time ..... B/D Reqd. No. .....

Sign. of Maintenance Exec./Supervisor

Reported by (Maint.)	Reported to (Maint.)	Handed over to Production
Date		Date .....
Time		Time .....
Maint. Exec./Sup.	Maint. Exec./Sup. (Mech./Elect./CNC/A.C./Inst.)	Maint. Exec./Sup. Sign of Exec./Sup.

BEST IN LAST 60 MONTHS
BREAK DOWN %AGE OF CRITICAL M/CS



BREAKDOWN TREND OF CRITICAL MACHINE

MACHINE TOOLS IN BLOCK-3

S.No.	M/c Description, Model & Type	Location(Blk/Plan)	Nos
1.	Horizontal Boring & Milling(SKODA) Types W160 G, W200 G, W250 G.	3/1-112, 3/1-118, 3/1-119, 3/2-317, 3/2-387, 3/2-473	08 Nos.
2.	CNC Centre Lathe MFD - Type D2300 N-YFS-1. PDF Document(2-360)	3/2-360	01 Nos
3.	Double Column Vertical Turning - Type 40 DZ 23.	3/2-472	02 Nos
4.	CNC Horizontal Borer - Wotan Rapid-5.	3/1-114	01 Nos
5.	CNC Horizontal Milling Machine - BFH-15, BFK-15, BATLIBOI.	3/2-449, 3/2-453, 3/2-454, 3/2-456, 3/2-459, 3/2-460, 3/2-463, 3/2-466	08 Nos
6.	CNC Machining Centre - HTC 600.	3/2-434, 3/2-435	03 Nos
7.	Horizontal Boring Machine - HC29T.	3/1-003, 3/2-197	04 Nos
8.	CNC Centre Lathe - STC - 25	3/2-437	02 Nos
9.	Centre Lathe - 1A660.	3/1-023, 3/2-186	03 Nos
10.	Centre Lathe - 1A675 & 1A676.	1/1-034, 3/1-029	02 Nos
11.	DC Vertical Borer - KY64, KY65.	3/2-195	01 Nos
12.	CNC Milling Machine, FP4M, DECKEL	3/2-471	01 Nos
13.	CNC Vertical Boring Machine, 20DS160, (SCHIESS) W.Germany	1/1-239	01 Nos
14.	CNC Machining Centre, NTH-200, Switzerland	3/2-354	01 Nos
15.	CNC Vertical Borer, Model HM 4.0/ 5.0 GT, HOMMA, Japan	3/2-328	01 Nos
16.	T Root Machining Centre, SPM for T-root machining of blades, Mitsubishi, Japan	3/2-356	01 Nos
17.	CNC MACHINING CENTRE, MITSUBISHI	3/2-380	01 Nos
18.	UNIVERSAL TURNING LATHE, NHCNC	3/2-393	01 Nos
19.	DOUBLE HEAD PLANER, 7A288	3/2-189	01 Nos
20.	CNC STUB BORER	3/2-420	01 Nos
21.	SPECIAL MILLING KOPP, KF56	3/2-389	01 Nos
22.	CNC Vertical Borer, TMD-40/50	3/2-422	01 Nos
23.	Centre Lathe, LB-17/20/25 Machine & Operators Manual HMT	3/2-142, 3/6-045, 3/6-044, 3/1-116 3/1-070, 3/1-069, 3/1-057, 3/1-054, 3/1-053, 3/2-055, 3/6-016, 3/6-015, 3/8-014,	*01 Nos*

		3/2-133, 3/2-134, 3/2-135, 3/2-136, 3/8-006, 3/6-079, 3/2-137, 3/2-138, 3/2-139, 3/2-065, 3/2-056, 3/6-082, 3/6-080, 3/6-078, 3/2-057, 3/2-058, 3/6-077, 3/2-059, 3/2-061, 3/2-062, 3/2-063, 3/2-064, 3/6-076, 3/6-040, 3/2-095, 3/8-013, 3/6-038, 3/2-094, 3/2-093, 3/6-039, 3/6-041, 3/6-042, 3/6-075, 3/6-086, 3/1-051,	
23.	Centre Lathe, LB-17/20/25 Machine & Operators Manual HMT	3/2-142, 3/6-045, 3/6-044, 3/1-116 3/1-070, 3/1-069, 3/1-057, 3/1-054, 3/1-053, 3/2-055, 3/6-016, 3/6-015, 3/8-014, 3/2-133, 3/2-134, 3/2-135, 3/2-136, 3/8-006, 3/6-079, 3/2-137, 3/2-138, 3/2-139, 3/2-065, 3/2-056, 3/6-082, 3/6-080, 3/6-078, 3/2-057, 3/2-058, 3/6-077, 3/2-059, 3/2-061, 3/2-062, 3/2-063, 3/2-064, 3/6-076, 3/6-040, 3/2-095, 3/8-013, 3/6-038, 3/2-094, 3/2-093, 3/6-039, 3/6-041, 3/6-042, 3/6-075, 3/6-086, 3/1-051,	*01 Nos*
24.	CNC Center Lathe, PNE-710L	3/2-392	01 Nos
25.	CNC Milling M/c, Model - FSQ-80	3/2-484	01 Nos
26.	CNC Horz. Broaching, Model- Champion	3/2-485	01 Nos
27.	CNC Facing Lathe, Model - KH-100	3/2-474	01 Nos
28.	CNC Lathe, Model - L-18N	3/2-436	01 Nos
29.	CNC Vertical Borer, Model - 32DS250	3/2-483	01 Nos
30.	CNC Lathe (Turning Center), INNSE-BERARD	3/2-512	01 Nos
31.	Creep Feed Grinding, ELTAC-SFR-200	3/2-491	01 Nos
32.	CNC EDM Wire Cutting M/c, ROBOFIL 290	3/6-230	01 Nos
33.	CNC Bed Type Milling M/c, BSK-CNC	3/2-467	01 Nos
34.	Vertical 3D Copying Milling, ITALY, FB2 /TCA-20	3/2-468	01 Nos

35.	Universal Cylindrical Grinder, G-17, HMT	3/6-104	01 Nos
36.	CNC Machining Center, CINCINATI, T-30/ CX	3/2-481	01 Nos
37.	Rotor Slot Milling Machine	3/2-390	01 Nos
38.	Vertical Copying Milling	3/2-335	01 Nos
39.	Horizontal Borer	3/1-001	01 Nos
40.	CNC Stub Borer	3/2-420	01 Nos
41.	Horizontal Boring M/c, 2b660, Russian	3/1-001, 3/1-002	02 Nos
42.	D.C. Vertical Borer, Model 1580	3/1-008	01 Nos
43.	Heavy Duty Lathe, Model IA665	3/2-181	01 Nos
44.	Precision Heavy Duty Lathe, KS-I6I4	3/2-182	01 Nos
45.	Radial Drilling Machine, NOVISA	3/2-316	01 Nos

MAJOR FAULTS & THEIR RECTIFICATION

PLAN NO. 1-114 (WOTAN)

PROBLEMS:

1. Aerostatic problem
2. Boring head
3. Over loading of table
4. Hydraulic problem.

ACTION:

1. (a) Nozzle to be replaced, which needs expertise of OEM

   (b) Refrigeration type air drier to be made fully functional.

2. Needs replacement.
3. Look for alternative tech.
4. Resolved.

PLAN NO. 1-119 (SKODA HB)
PROBLEMS:

1. Oil leakage from table and tool clamping.
2. Coolant getting mixed with lubrication and hydrostatic oil.
3. Over loading of m/c tools (a) Spindle taper sleeve damaged (b) Spindle feed sleeve damaged.

ACTION:

1. Seals procured, to be replaced.
2. (a) Cleaning and monitoring of oil return path and coolant path is must.

   (b) Coolant with de/emulsification properties must be used.

   (c) Daily draining of coolant from lubrication tank.

3. (a) New sleeve procured. (b) Under repair.
4. Under replacement.

PLAN NO. 1-118 (SKODA HB)

PROBLEM:
Telescopic covers damaged
ACTION: Problem rectified.

PLAN NO. 1-112 (SKODA HB)
PROBLEMS:

1. Lead screw of spindle damaged due to over travel.
2. Z-axis feed motor tripping and getting burnt.
3. Leakage of oil from table.
4. Hydraulic valves and pipe lines defective.

ACTION:

1. Corrective action has been taken.
2. (a) Incorporation of fast acting fuse to protect the motor from over current.

(b) Aligned and adjusted the three clutches for feed.

3. Seals procured, to be replaced.
4. Hydraulic system needs retrofitting. Action being taken.

PLAN NO. 2-317 (SKODA HB)
PROBLEMS:

1. Spindle lead screw defective.
2. Spindle play.
3. X – Y feed problem.
4. Table oil leakage and hydraulic system problem.

ACTION:

1. Under procurement.
2. Support bearings need replacement.
3. Due to uneven wear and tear of guide ways needs scrapping/grinding. Vertical lead screws nut replacement.

4. Hydraulic system needs retrofitting. Action being taken.

PLAN NO. 2-485 (BROACHING M/C).
PROBLEMS:

1. Axis clamping.
2. Water cooling pump shaft seal defective.

ACTION:

1. Pumps and valves are to be replaced. Pump under procurement. Valves to be procured.
2. Alternative pumps are being replaced.

PLAN NO. 2-360 (MFD LATHE)
PROBLEMS:

1. Tail stock movement problem.
2. Steady movement gear box broken.
3. Frequent clogging of filters.

ACTION:

1. Repair of worn end support under progress.
2. Under procurement
3. Oil returns passage to kept clean.

PLAN NO. 2-389 (KOPP MILLING HEAD)
PROBLEMS:

1. Jerk in maching heads axis and spindle.
2. Steady lubrication and clamping.
3. Head lifting for movement of base not working.

ACTION:

1. (a) Guide ways and linear bearings damaged. Guide ways needs rebuilding and linear bearings needs replacement.

(b) Spindle taper worn out, needs repair/regrinding.

2. (a) Power packs for clamping under procurement.

(b) Special high quality seals procured. Already replaced in one steady.

3. Under operation. Special high quality seals procured.

PLAN NO. 1-114 (CNC V.BORER – WOTAN)

PROBLEMS:

1. Jamming of table longitudinal movement.
2. Excessive loading of drive motor.
3. Air pneumatic system for aerostatic is not dry enough.

ACTION:

1. Aerostatic nozzle were cleaned. Problem solved partially.
2. Nozzles of all the axis with aerostatic system need replacement which may need expertise of OEM. OEM was contacted earlier for the same job two years back. Estimated cost was 22 lakhs.
3. Refrigeration type air drier is not functioning properly.
4. Provision of inter cooler to improve efficiency of refrigeration type drier is being explored.

PLAN NO. 2-389 (ROTOR SLOT MILLING M/C)
PROBLEMS:

1. 1 No. DC drive r/h, 1 No. Retro L/h & 1 No. Hydraulic R/h not functioning.
2. Hydraulic systems of steady # 1&2 are not functioning properly.
3. 1 No. hydraulic r/h planned for MCR.
4. 1 No. DC r/h and 1 No. DC l/h under operation but at reduced cutting rate.

ACTION:

1. 1 No. Retro l/h has been checked thoroughly and trial was done on a job. Result is not satisfactory. More on the job trials are required to identify the faults. Extra set of steadies and indexing head is being brought from BHEL Bhopal to facilitate on the job trials.
2. Modification of hydraulic system has been planned. New power packs under procurement.
3. Technical bids of M/s HEC Ranchi & HMT have been cleared.
4. Guide ways and roller strips worn out. New set of roller strip is under procurement, but recently OEM has refused to supply. Alternative sources are to be explored.

PLAN NO. 2-387 (RAM BORER)

PROBLEMS:

1. Oil leakage in table hydraulic system.
2. Vibration type chip conveyor malfunctioning.

ACTION:

1. Oil seals of table clamping system replaced with high quality polymer seals.
2. Pressure pipe replacement required.
3. Malfunctioning of NW4 size valves which have become obsolete and need replacement with NW6 valves.

Conveyor repaired several times but operation is noisy and inefficient. Possibility of providing chain type chip conveyor is being explored

PLAN NO. 1-118, 1-119 & 2-473 (CNC RAM BORER)
PROBLEMS:

1. Coolant mixing with table hydrostatic system oil through the gaps between wiper boxes of telescopic covers.
2. Vibrator type chip conveyor malfunctioning, although the systems are thoroughly repaired and aligned.

ACTION:

1. Telescopic covers have been repaired but problem still persists. Possibility of providing extra tank unit with pump for on one centrifuging is being explored.
2. Conveyor repaired several times but operation is noisy and inefficient. Possibility of providing chain type chip conveyor is being explored.

PLAN NO. 2-384 (TOSS MILLING)
PROBLEM:

Temperature rise of spindle at high rpm.

ACTION:
OEM contacted, action has been taken as per their guideline.

PLAN NO. 2-328 (HOMMA)
PROBLEM:

Excessive oil leakage from hydraulic system.

ACTION:
All defective hoses replaced, joints tightened, drastic improvement found. Under constant watch for further improvement. Action to be initiated for spare hoses of better design.

PLAN NO. 1-001, 1-002, 2-198, 2-197 & 1-11 (RUSSIAN HORIZONTAL BORER)
PROBLEMS:

Upper and lower saddle clamping problem. Hydraulic system elements such as pumps and valves are not easily available.

ACTION:

1. A Russian make pump supplier has been located and pumps are under procurement.
2. Modification of hydraulic system has been planned.

PLAN NO. 2-420 (STUB BORER)
PROBLEMS:

1. Excessive oil leakage, to check all pipe lines.

2. Alignment of machine and rotary table.
3. Replacement of obsolete oil flow valves in lubrication circuits.

ACTION:

Planned for next year, may be early March/April, 2001.

RUSSIAN VERTICAL BORING MACHINES (BAY 1&2)
PROBLEMS:

1. Oil leakage, pump motor tank to be modified, if helps the in system.
2. Plan for entire modification

ACTION:
To be examined.

PLAN NO. 1-11 (HORIZONTAL BORER)
PROBLEMS:

Oil getting drained out.

ACTION:
To check and controlled.

SKODA RAM BORER
PROBLEMS:

Critical spare parts are imported. They are to paid in US $ and expensive. Also procurement cycle is very high.

ACTION:
Indian suppliers are being developed for supply of Techno generators, gear box lubrication pumps and clutches.

PLAN NO. 2-114 (VERTICAL BIRING)
PROBLEMS:

1. Job table having play.

ACTION:

1. Thrust bearing of the table is replaced.

MACHINES OF BAY III

- **CNC VERTICAL BORING MACHINE**

PLAN NO. 2-472

MODEL : SCHIESS

SPECIFICATION

Maximum swing &turning diameter : 3200mm

Maximum working height (turning height) above top of the table : 2200mm

Table diameter : 2500mm

Cross rail head – Vertical travel : 1400mm

Cross rail head – Horizontal travel

From centre of rotation to the right :1170mm

From centre of rotation to the left : 1300mm

Cross rail travel range : 1500mm

Faults encountered :-

Tapper setting of the Ram, Chocking of the coolant circuit.

Remadial action :-

Tapper is set mechanically

Coolant circuit is checked & filter is cleaned.

CNC HORIZONTAL BORING MACHINE

PLAN NO. 2-434

MODEL : HTC-600

SPECIFICATION

TABLE

Pallet table surface : 600mmX600mm

Maximum adjustable weight on pallet table : 1000Kg

TRAVERSES

Saddle longitudinal (X-axis) : 800mm

Spindle head vertical (Y-axis) : 700mm

Column cross (Z-axis) : 800mm

FEED

Rapid traverse (All axes) : 12000mm/min

Contouring feed rate 1-4000mm/min

SPINDLE

Speed : 20-4000 R.P.M.

AUTOMATIC TOOL CHANGER

Tool capacity : 32 Nos.

Average tool changing time : 6 sec.

AUTOMATIC PALLET CHANGER

No. of pallets : 2

Pallet change time : 40Sec.

Faults encountered

Spindle is not clamping the tool.

Hydraulic clamping is there, with the help of disc springs

Generally springs are replaced to get proper tension.

Faults encountered :-

Tool is not properly clamped & ATC is not working.

Remadial action :-

Generally disc spring which is used for

Coolant circuit is checked & filter is cleaned.

- **CNC CENTRE LATHE MACHINE**

PLAN NO. 2-436

MODEL : L-18N (KARATSU)

SPECIFICATION

MAXIMUM WORK PIECE DIMENSION

Diameter of work piece : 1000mm

Length of work piece :1500mm

Distance between centres : 4500mm

Weight of work piece between centres : 15000Kg

HEAD STOCK

Centre height : 900mm

Face plate diameter : 1200mm

Spindle speed : 1.5-320rpm

BED

Length : 8200mm

Width : 1700mm

CARRIAGE & CROSS SLIDE

Longitudinal feed (Z-axis) : 0.01-500mm/rev.

Cross feed (X-axis) : 0.01-500mm/rev.

Swing over carriage : 1100mm

TAIL STOCK

Quill diameter : 400mm

Length of quill traverse : 300mm

- **CNC TURNING MACHINE**

PLAN NO. 2-512

MODEL: INNSE BERARDI

SPECIFICATION

Centers height: 1300mm

Maximum turning diameter admitted on carriage: 1500mm

Center to center distance: 7000mm

Maximum turning length between centers: 6500mm

BED

Width: 2400mm

HEADSTOCK

Maximum no. of revolution at max power : 32

CARRIAGE

Longitudinal feeding speed (Z-axis) : 0-20000mm/min

Cross feeding speed (X-axis): 0-8000mm/min

Carriage longitudinal stroke: 8400mm

Carriage cross stroke: 1200mm

TAIL STROKE

Quill diameter: 180mm

Quill stroke: 150mm

Quill travel speed: 35mm/min

COOLANT UNIT

Total tank capacity: 4000L

Except above mentioned CNC machines, there are also some other CNC machines & conventional machines viz:

- **Double column Vertical Boring Machine**

  Model: 1M553/1M557

  Centre lathe

  Model: LB 17/20

- **Russian Lathe**

  Model : 163/165

- **Horizontal/Vertical milling**

  Model : M2H/M2V

- **Radial drilling Machine**

  Model : RM65

- **Cylindrical grinder**

  Model : G17

- **Horizontal Boring Machine**

  Model : 2A635

TURBINE

A turbine is a type of engine that can extracts energy from a fluid, such as water, steam, air, or combustion gases. It can be contrasted with a piston engine, which uses a piston instead of a turbine to extract energy.

The physical makeup of a turbine is a series of blades, typically made of steel but sometimes ceramic, which can withstand higher temperatures. The fluid goes in one end, pushing the blades and causing them to spin, then gets ejected out the other end. The fluid leaves the turbine with less energy than it had going in - a portion of the difference is captured by the turbine.

Turbines are the core of our civilization. Practically every form of electric power is generated by a turbine. When we say coal power, nuclear power, hydrothermal power, etc., we mean using some energy source to agitate a gas which then drives a turbine and generates power. A turbine is one of the most common types of engines, where an engine is defined simply as something that takes an input and generates an output. Along with heat engines and motors, turbines make up the vast majority of dynamic machinery.

Gas turbines are one of the most flexible type of turbine, and are used to power a variety of mobile machines above a certain size, jets being the most famous application. Even the Space Shuttle uses a gas turbine to combine fuel at tremendous rates. Because they can spin at extreme rates, gas turbines allow a huge amount of power to be packed in a relatively tiny space. A typical gas turbine engine operates between 3,000 and 10,000 rpm, and smaller variants can climb above 100,000 rpm. A recently constructed matchbox-sized gas turbine spins at 500,000 rpm and generates 100 watts. Scientists want to push these turbines to operate at a million rpm or above, but making this possible without melting the assembly can be tricky.

TWO TYPES OF TURBINE MADE BY BHEL HARIDWAR

1) STEAM TURBINE

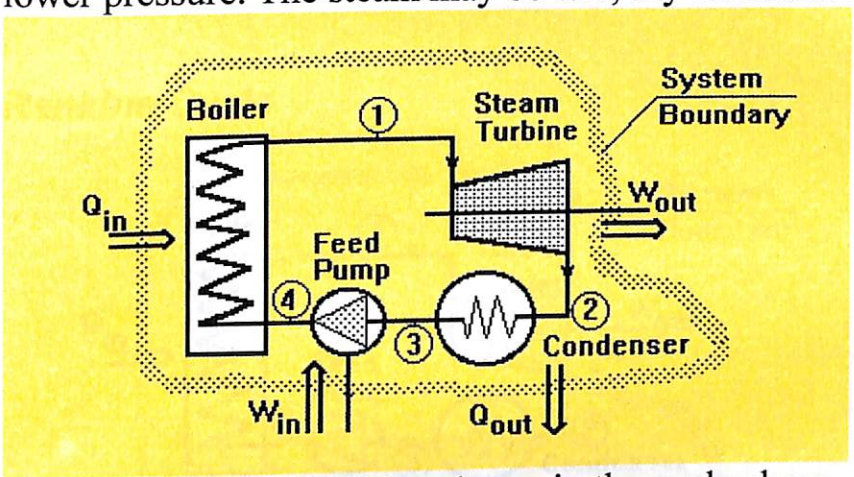
2) GAS TURBINE

Steam Turbine

Steam turbines are devices which convert the energy stored in steam into rotational mechanical energy. These machines are widely used for the generation of electricity in a number of different cycles, such as:

- **Rankine cycle**
- **Reheat cycle**
- **Regenerative cycle**
- **Combined cycle**

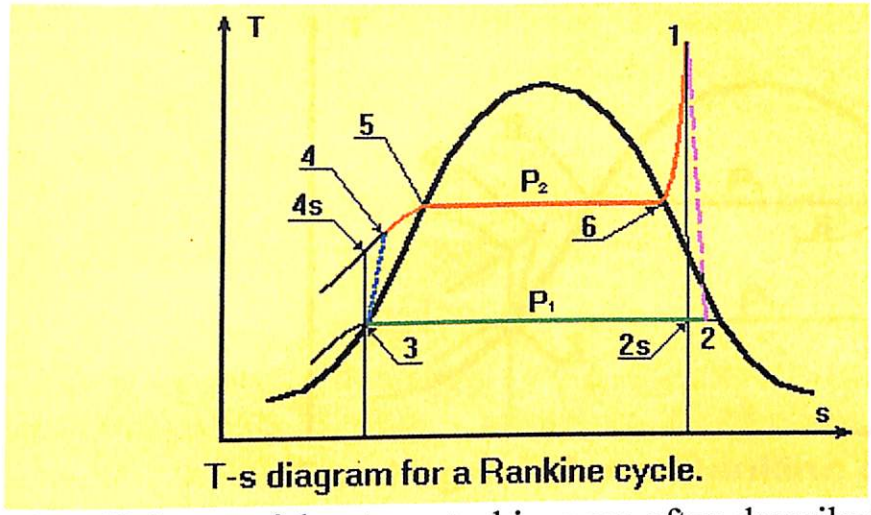
The steam turbine may consists of several stages. Each stage can be described by analyzing the expansion of steam from a higher pressure to a lower pressure. The steam may be wet, dry saturated or superheated.



Consider the steam turbine shown in the cycle above. The output power of the turbine at steady flow condition is:

$$P = m\ (h1-h2)$$

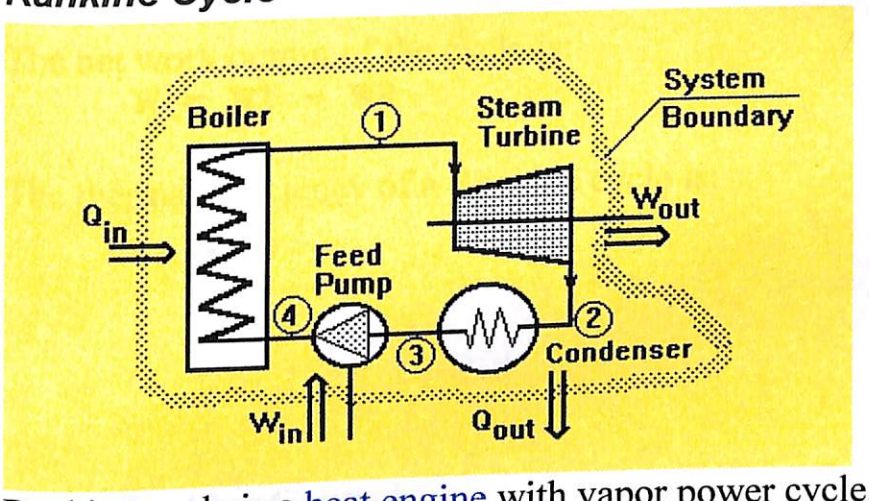
where **m** is the mass flow of the steam through the turbine and **h1** and **h2** are specific enthalpy of the steam at inlet respective outlet of the turbine.



T-s diagram for a Rankine cycle.

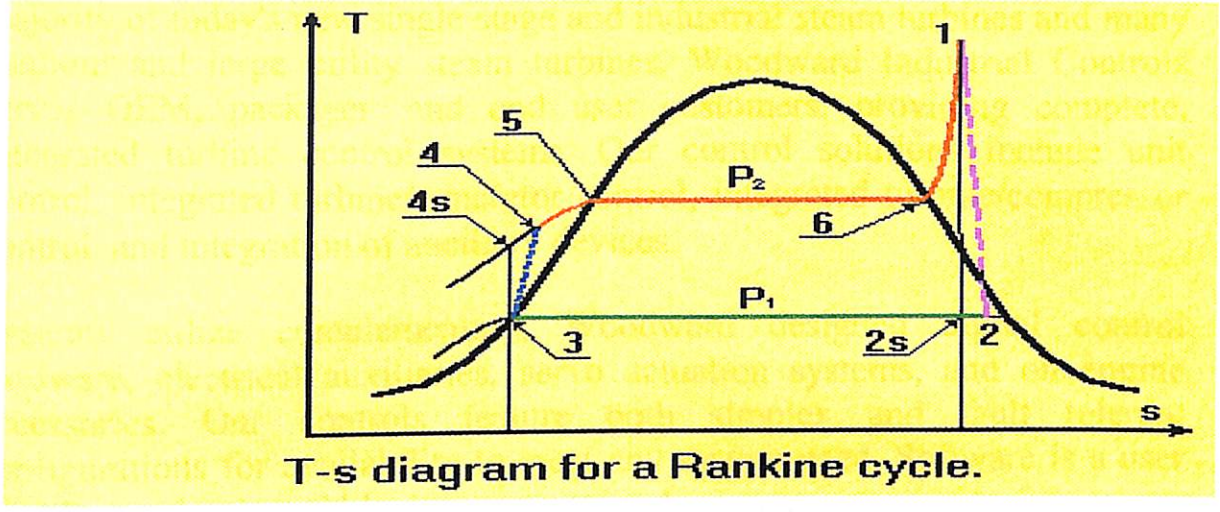
The efficiency of the steam turbines are often described by the isentropic efficiency for expansion process. The presence of water droplets in the steam will reduce the efficiency of the turbine and cause physical erosion of the blades. Therefore the dryness fraction of the steam at the outlet of the turbine should not be less than 0.9.

Rankine Cycle



Rankine cycle is a heat engine with vapor power cycle. The common working fluid is water. The cycle consists of four processes:

- **1 to 2: Isentropic expansion (Steam turbine)**
- **2 to 3: Isobaric heat rejection (Condenser)**
- **3 to 4: Isentropic compression (Pump)**
- **4 to 1: Isobaric heat supply (Boiler)**



T-s diagram for a Rankine cycle.

Work output of the cycle (Steam turbine), **W1** and work input to the cycle (Pump), **W2** are:

$$W1 = m\ (h1-h2)$$

$$W2 = m\ (h4-h3)$$

where m is the mass flow of the cycle. Heat supplied to the cycle (boiler), **Q1** and heat rejected from the cycle (condenser), **Q2** are:

$$Q1 = m\ (h1-h4)$$

$$Q2 = m\ (h2-h3)$$

The net work output of the cycle is:

$$W = W1 - W2$$

The thermal efficiency of a Rankine cycle is:

$$\eta = W/Q1$$

Steam Turbine Control

Steam turbines are the most common and versatile prime movers used today. The capabilities and flexibility of operation, as well as the range of power provided is unparalleled in today's power generation and process markets.

Woodward has served the steam turbine market for over 60 years. As the world's largest independent manufacturer of prime mover controls, Woodward is both a market and technology leader. Today, Woodward provides a complete line of standard digital control systems, as well as robust, reliable mechanical controls. These controls are found on the

majority of today's new single stage and industrial steam turbines and many medium and large utility steam turbines. Woodward Industrial Controls serves OEM, packager, and end user customers, providing complete, integrated turbine control systems. Our control solutions include unit control, integrated turbine/generator control, integrated turbine/compressor control, and integration of ancillary devices.

Systems utilize complementary, Woodward designed digital control hardware, electrical auxiliaries, servo actuation systems, and on engine accessories. Our controls feature both simplex and fault tolerant configurations for availability to meet any system need. Software is a user friendly, sophisticated block programming language.

Quality and performance is assured through the use of advanced control algorithms, system analysis, and system modeling to verify application before installation.

Basic principles of steam turbine

1) Conversion of heat energy into kinetic energy

2) Depends upon the dynamic action of the steam

3) Drop in pressure of steam through some passage resulting to

a) Increase in velocity

b) Change in direction of motion gives rise to a change of momentum or force

c) This is driving force of the prime over

Improvement in steam turbine performance

1) Improved blade profile

2) Optimized flow path

3) Improvement in shaft sealing system

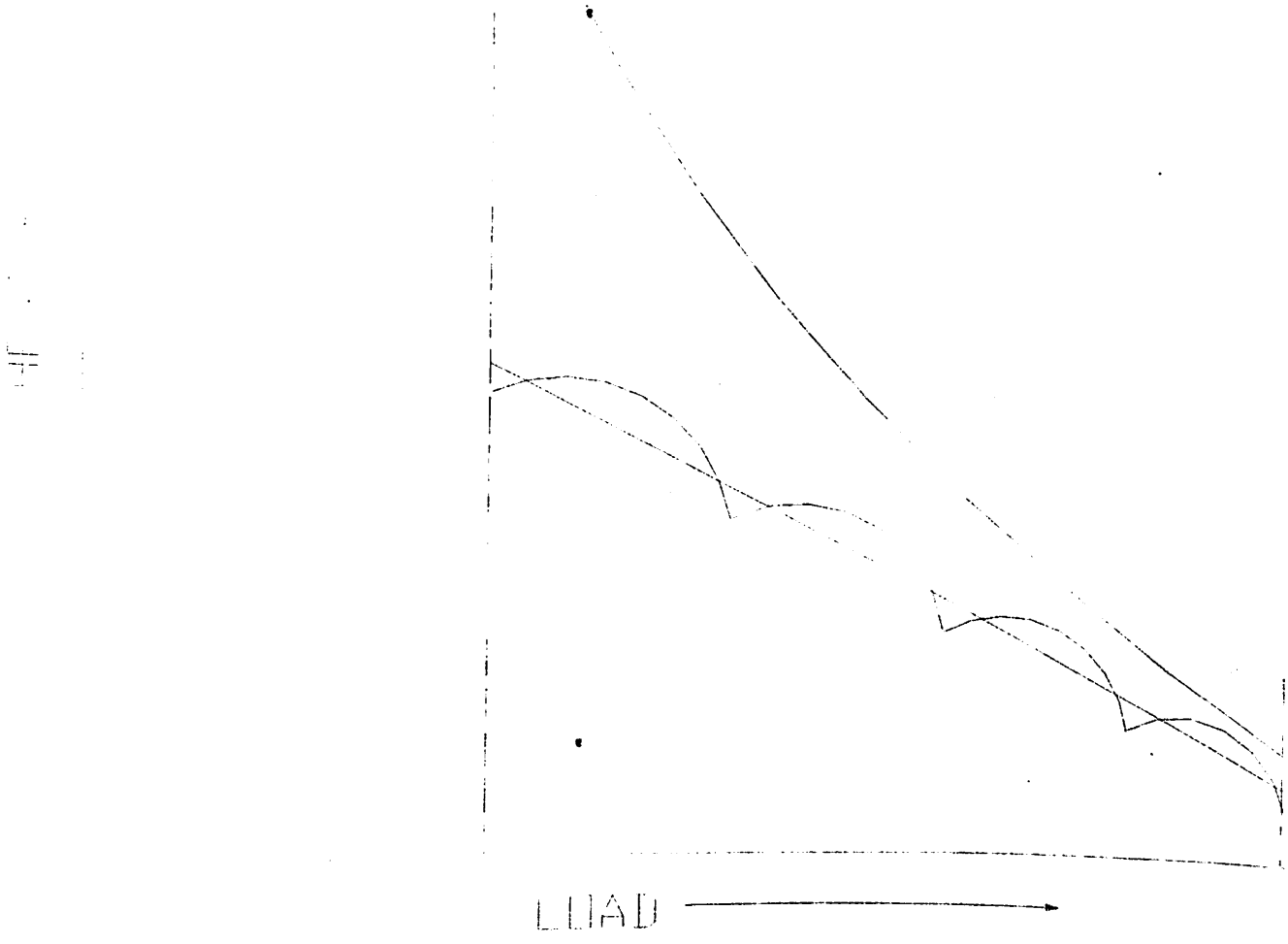
4) Reduction in pressure drops

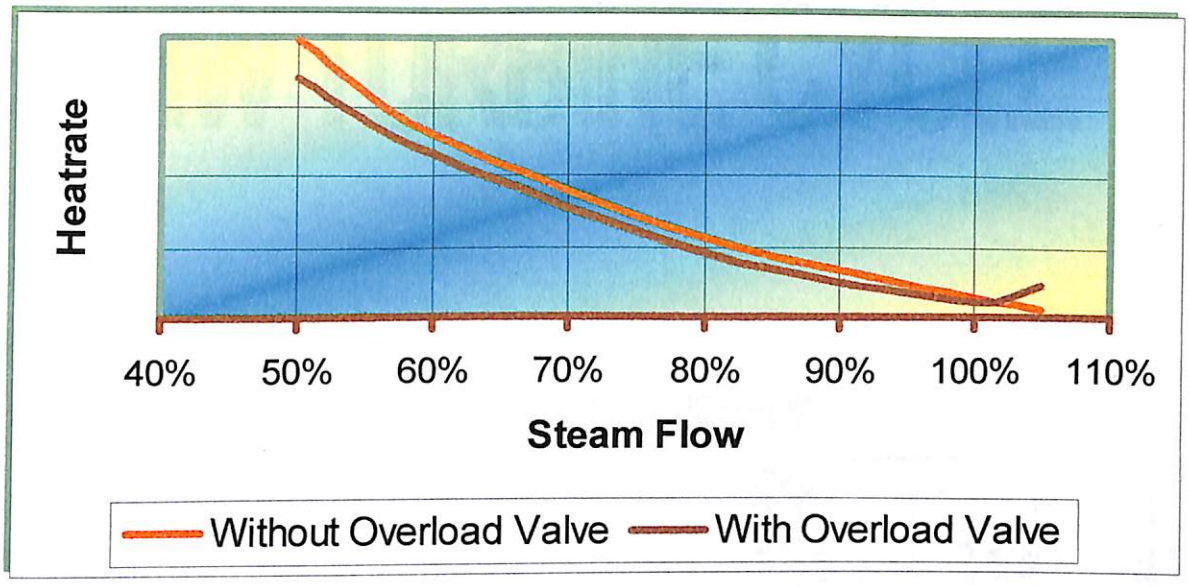
5) Reduced friction losses

5) Optimization of inlet & exhaust section

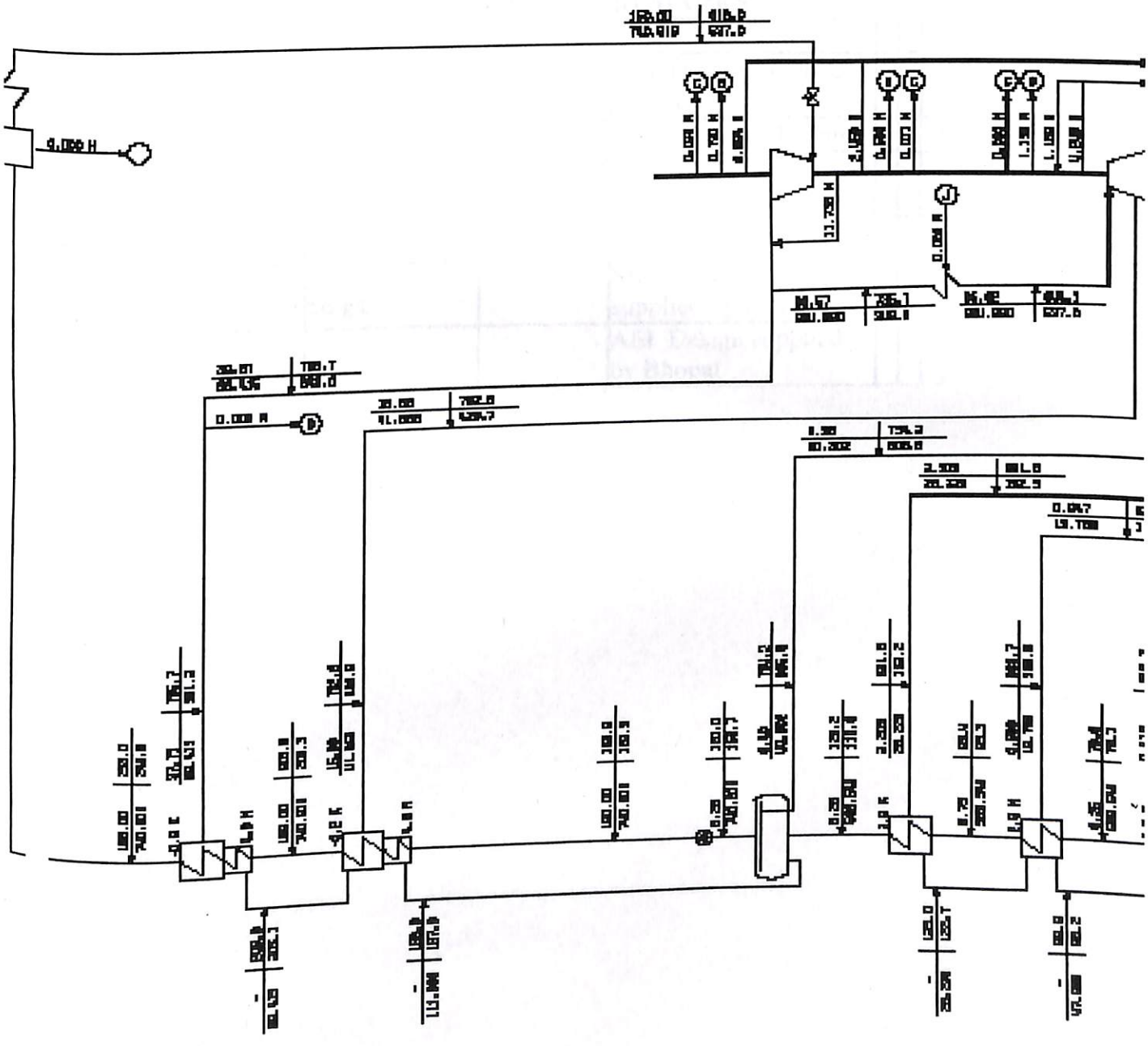
7) Optimized exhaust loss

Steam turbine characteristics curve




Heatrate
40%
50%
60%
70%
80%
90%
100%
110%
Steam Flow
Without Overload Valve
With Overload Valve

250 MW TURBINE CYCLE



GRADUAL IMPROVEMENT IN HEAT RATES OF STEAM TURBINE SUPPLIED BY BHEL				
OLD SETS				
	TG CYCLE	TG CYCLE		
	HEAT RATE	EFFICIENCY	PROJECT	REMARKS
	(Kcal/KWh)	%		
30 MW	2491	34.52		AEI Design supplied by Bhopal
50 MW	2371	36.27		LMW Design Turbine
60MW	2378	36.16		SKODA Design supplied by Hyderabad
100MW	2270	37.88		LMW Design Turbine
110 MW	2159	39.83		SKODA Design supplied by Hyderabad
120 MW	2080	41.34		AEI Design supplied by Bhopal

Steam turbine module selection

Fix following parameter

(a) Unit rating

(b) Main steam pressure

(c) Main steam temperature

(d) final feed water temp

(e) hot reheat temp

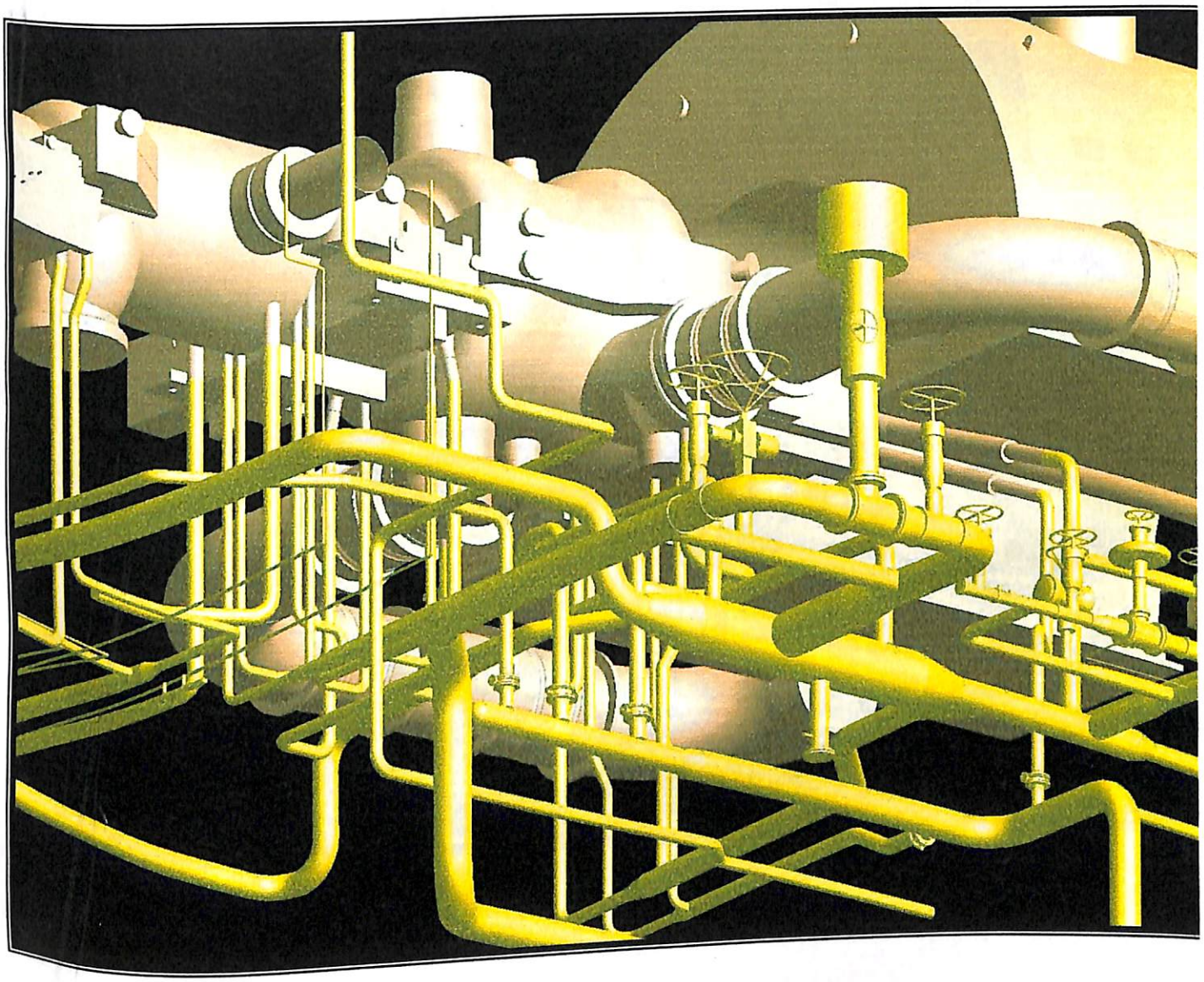
(f) IP inlet pressure

(g) condenser vacuum

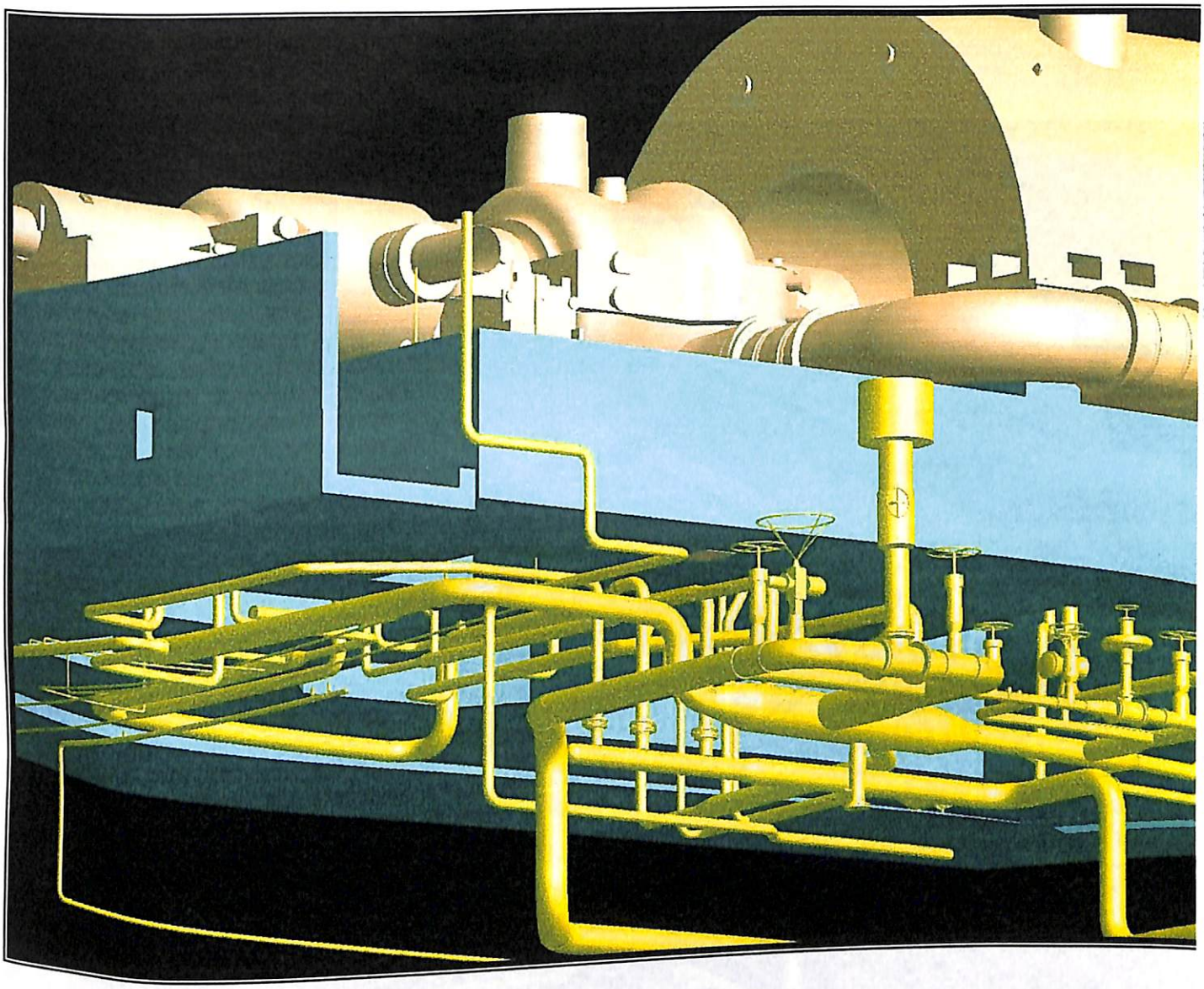
TURBINE MODULES FROM SIEMENS THREE CYLINDER TURBINE

	MODULE	MODULE VARIANT RECEIVED FREE
HP MODULE	H30-25-2	H30-25-2M (MODIFIED SERIES), HR30-25-2
	H30-63-2	HR30-63-2
	H30-100-2	H30-100-2M, H30-100-M2
	HR30-40-2	-
IP MODULE	M30-20	M30-25 (SINGLE FLOW), M30-25 (CCPP)
	M30-50	M30-63 (SIDE EXHAUST), M30-63 (TOP EXH.)
	M30-100	-
LP MODULE	N30-2x3.2	-
	N30-2x5	N30-2x5 (ADV. BLADING, TOP ADMISSION)
	N30-2x8	N30-2x5-6 (CCPP)
	N30-2x10	-
	N30-2x12.5	N30-2x10(ADV. BLADING, TOP ADMISSION)
	BLADING OF 2x6.3	N30-2x10-6 (CCPP)
		-
		ADVANCE BLADING OF 2x6.3

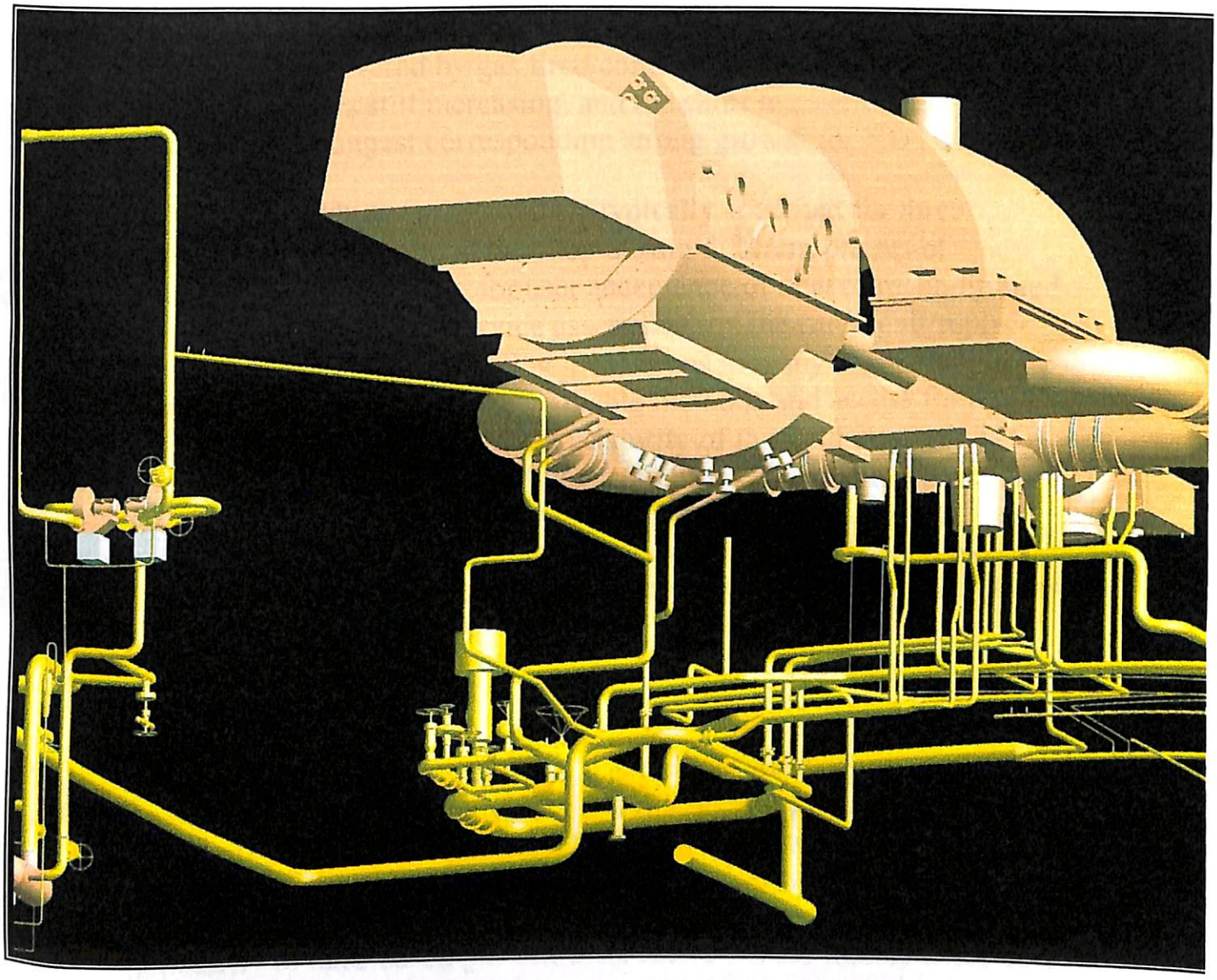
Seal Steam Piping: Without deck

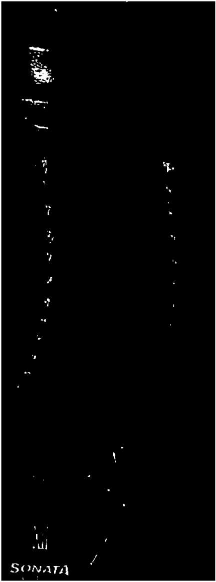


Seal Steam Piping: Below deck



Seal Steam Piping: GSC Exhauster

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Gas turbine

Gas turbines and particularly their hot path components exhibit relatively high maintenance cost and short in-service inspection cycles, in comparison with most main components of thermal power plants. The overall share of production capacity covered by gas fired combined cycle and CHP plants utilising gas turbines is still increasing, and the short inspection and maintenance cycles suggest corresponding strong growth for NDT services.

NDT of gas turbine components is typically specified for three different purposes: within the shop during different phases of manufacturing or repairs, for user acceptance of new or reconditioned components, and for in-service assessment on the run/repair/replace decisions. The most demanding inspections in many ways are those performed in the field, as the available methods and access for the inspections can be fairly limited. Majority of the field inspections apply visual and surface techniques, but also ET and UT appear to find increasing use as they provide the potential advantage of indicating flaw depth. Examples are shown on in-service and ex-service inspections of hot end components, particularly turbine blades and vanes.

Introduction

Importance of power plants using gas turbines has been increasing worldwide in regions with access to suitable fuels, mainly natural gas. Good efficiency in combined cycle and CHP service, lower emissions than from most other fossil plant, relatively modest investment cost and fast technical development are features behind the increased popularity of land-based gas turbines. However, the maintenance cost of gas turbines remains high because of high operating temperatures, short overhaul cycles and expensive materials required. Frequent overhauls also imply frequent inspections to ensure correct timing and extent of maintenance. Extensive use of NDT is therefore needed for inspecting gas turbine components. NDT is generally used for three different purposes:

- for quality control in the shop during different phases of manufacturing or repair,
- for user acceptance of new or reconditioned components, and

- to support in-service assessment for run/repair/replace decisions or forensic assessment after failures.

Typical faults and defects targeted in NDT of gas turbine components include original defects and deviations from manufacturing or repairs, and defects of coatings and base materials emerging and growing during service. Apart from cracks or other discontinuities, the deviations can also appear for example as wear, corrosion, excessive strain, or blocking or inappropriate positioning of cooling channels.

Much of the maintenance cost as well as risk related to unplanned gas turbine downtime is due to the hot end components of the gas turbines. Here, examples are shown on NDT methods applied for in-service and ex-service inspections of gas turbine blades and vanes.

NDT of land based gas turbines - surface inspections

The in-service inspections on-site are the most demanding ones, because of limited access to many components and limitations in the available (useful and accepted) NDT methods. The majority of the on-site work make use of visual inspections (Figs 1 and 2) and surface techniques. The dominance of surface inspections appears to remains although ET and UT find increasing use where depth indication of the defects is needed.

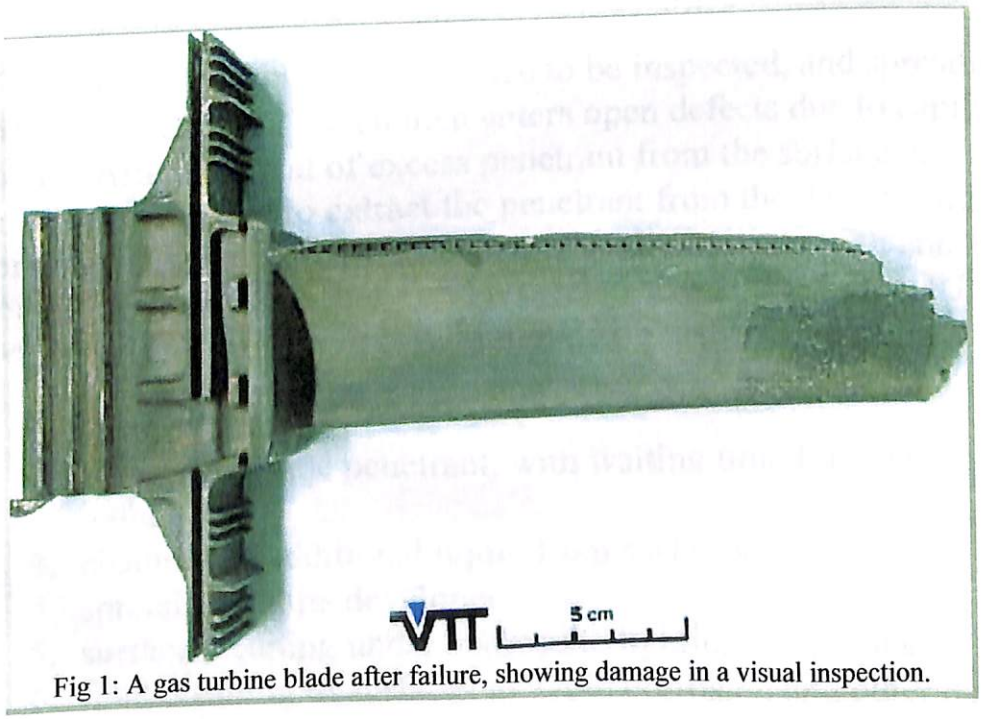


Fig 1: A gas turbine blade after failure, showing damage in a visual inspection.

Penetrant testing (PT) is efficient and well suited for revealing discontinuities such as cracks, pores and other defects opening to the outer accessible surface. On this surface, PT also indicates the length, shape and density of the defects. However, PT provides no direct indication of the depth of the defect, and this is the most important drawback of all PT methods.

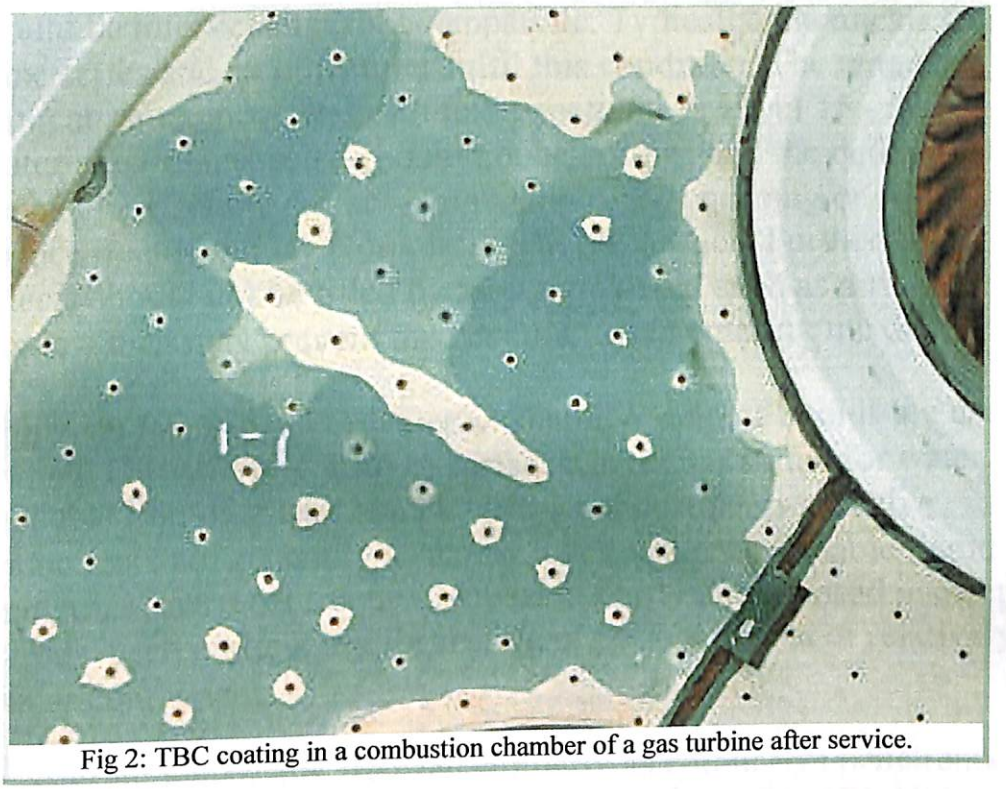
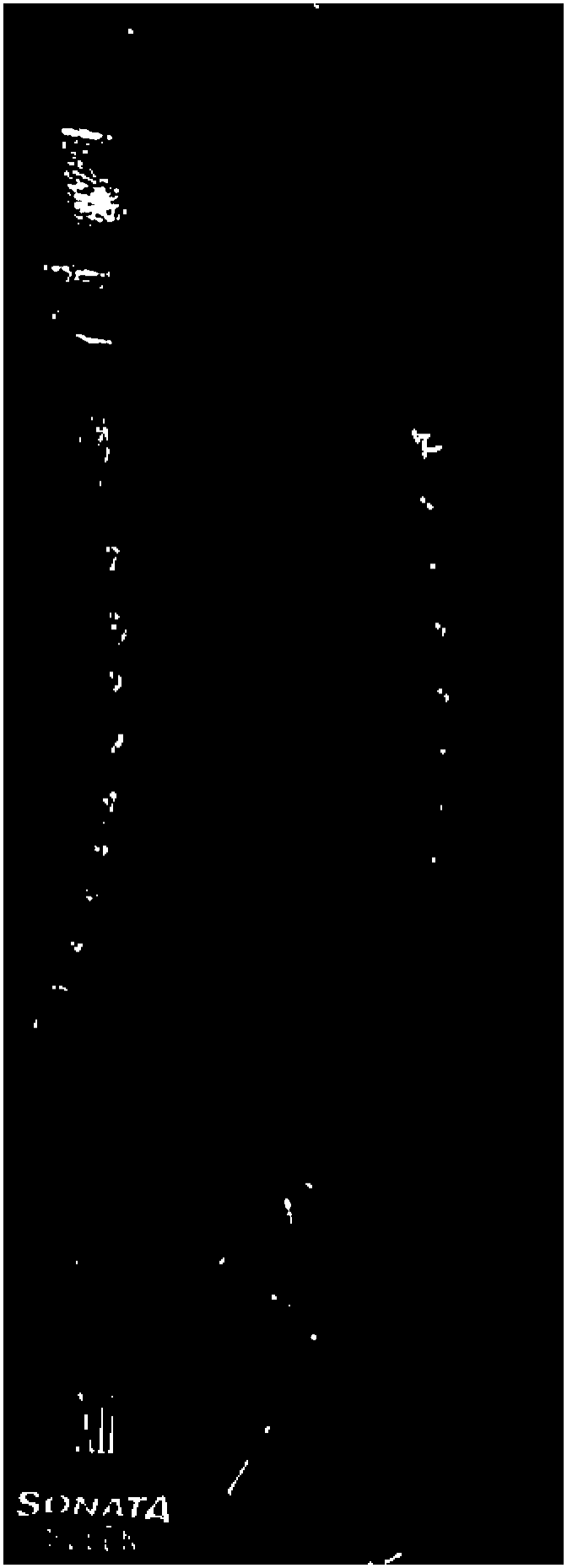


Fig 2: TBC coating in a combustion chamber of a gas turbine after service.

PT involves cleaning of the surface to be inspected, and spreading of the liquid penetrant which then enters open defects due to capillary forces. After removal of excess penetrant from the surface, a developer is added to extract the penetrant from the defects and to spread sufficiently on the surface to visually indicate with enhanced contrast the location, shape and projected size of the defect. PT therefore typically requires the following phases:

1. surface cleaning
2. spreading of the penetrant, with waiting time for entering the defects
3. cleaning of additional liquid from surfaces
4. spreading of the developer
5. surface cleaning under approprite lighting conditions
6. final cleaning of surfaces to avoid corrosion and other damage.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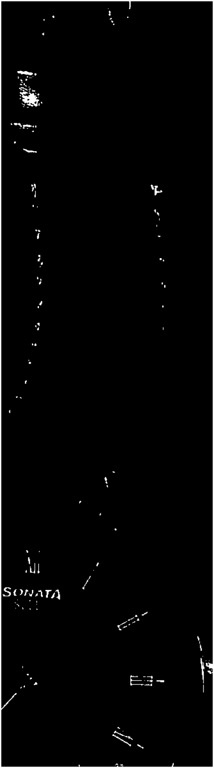
Depending on the way the excess liquid is removed, penetrants are divided into water washable, solvent washable and post emulsifier types. These types show different degrees of sensitivity so that the water washable ones are least sensitive, and post emulsifier types most sensitive ones.

The materials used for PT (penetrant, cleaning liquid, developer) should be inter- changeably compatible. Typically, chemicals from same series and manufacturer fulfil this condition. The range of application temperatures of liquid penetrants is about 15 - 50 °C. Material to be inspected should not be porous, and the defects should not be closed at the surface; for example, shot peening or comparable surface treatment may close defects at the surface. Furthermore, the defects should not be filled by foreign material such as dirt, oil or grease which may prevent the penetrant from entering the defect.

In manual PT, solvent or water washable penetrant liquids are usually applied. Difficult (e.g. rough) surfaces are better suited for water washable liquids. Small, easily cleaned or corrosion-sensitive components are generally tested by using solvent washable liquids. Emulsifiers are most frequently used in partly automatised inspection stations, used particularly for testing of large amounts of relatively similar components.

Fluorescent penetrants are used similarly as colour dye penetrants, but requires using UV-A light (at least 10 W/cm^2, see EN 571-1) for the inspection. On the other hand, fluorescent PT provides best sensitivity to defects and is widely recommended by manufacturers for gas turbine components.

Fig 3 shows example results from PT of gas turbine blades. Dense field of cracks may induce indications where individual indications cannot be easily discerned. Under such conditions it may be more effective to inspect without developer, although the sensitivity is reduced so that smallest defects are not necessarily indicated.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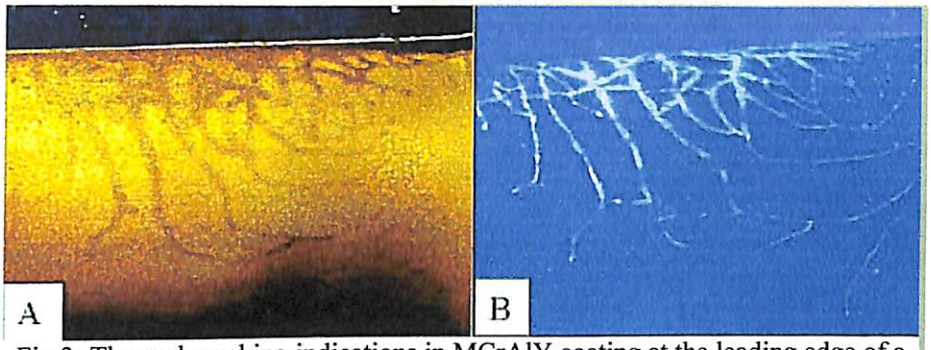
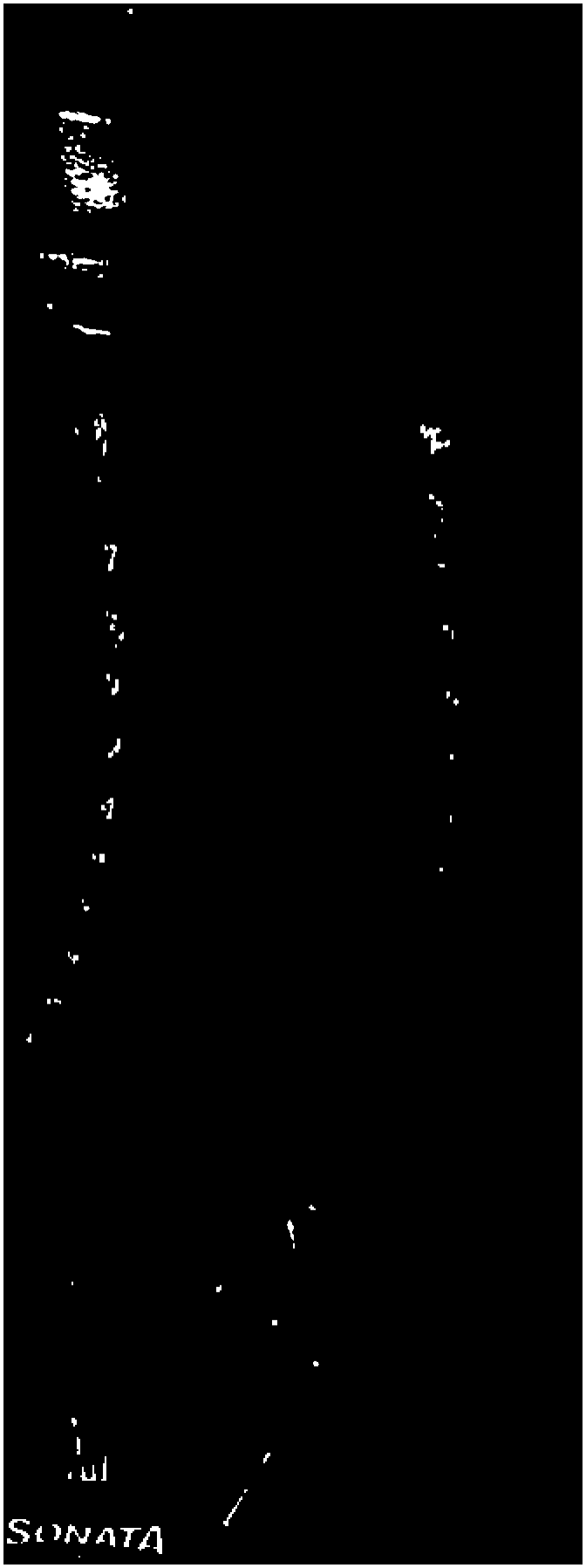


Fig 3: Thermal cracking indications in MCrAlY coating at the leading edge of a blade, as shown by a) colour dye penetrant testing; b) fluorescent penetrant testing.

Eddy current testing

In eddy current testing (ET), a magnetic field is induced by a coil to the conductive material to be tested. The subsequent material response will create an opposing magnetic field that will in turn induce eddy currents in the material. These eddy currents, and the changes in their phase and amplitude can be measured by using a sensor coil.

The impedance of eddy currents is affected by sensor distance, conductivity and permeability of the material, surface defects and input frequency (Fig 4). In addition, the sensor structure will influence the sensitivity of measurement. The sensors can function either by absolute or differential principle. In the absolute method, only one coil is used with possibly a separate induction coil to compensate for the impedance change from coil heating. Absolute sensors are mainly used to find and map widely distributed e.g. corrosion damage and for measuring materials properties. Differential sensors are used for observing local discontinuities such as cracks or pitting damage. ET requires good calibration but has the potential to indicate defect depth at least when the defect density is not overly high. In addition, ET may provide better sensitivity and therefore earlier indications for life assessment of uncoated components than inspections based only on surface techniques.



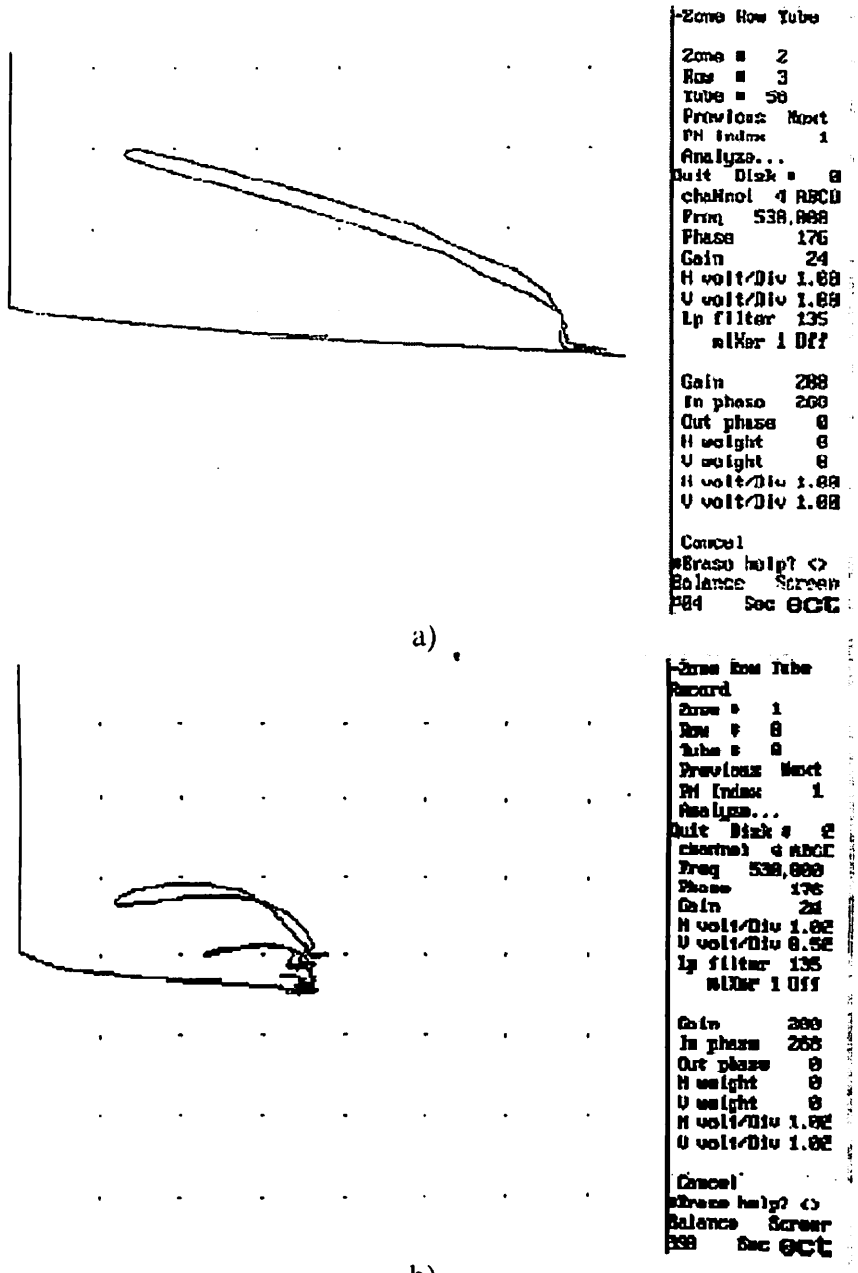


Fig. 4. a) ET indication from a 1 mm deep crack of a gas turbine blade; b) corresponding indications from EDM calibration notches in the same material.

Ultrasonic testing

Ultrasonic testing (UT) is traditionally even less common for gas turbine inspections than ET, although UT also has the potential to indicate defect depth and is widely applied elsewhere in engineering. Some of the main obstacles for using UT in gas turbines are related to size, geometry, sensor access and applied multiple material systems. However, progress in the UT techniques has made it easier to apply them also in gas turbines.

For best results in ultrasonic immersion testing with focused sensors, the test echo from the target is optimised (defocused). By shifting the sensor closer to the target, the focal point moves deeper into the material. Simultaneously, leaky Rayleigh waves are induced on the material surface. These waves are very sensitive to discontinuities such as cracks, porosity or delaminations close to the surface, up to a depth of about one wavelength which depends on transducer frequency. By using a wide band transducer and sequential filtering of frequencies, the effective sensing depth can be varied to observe the defect structure in the depth direction. The observed signals include a directly refracted longitudinal wave (Ld), wave form change component (transverse to longitudinal wave, S+L), leaky Rayleigh wave (LR) and surface echo (SE).

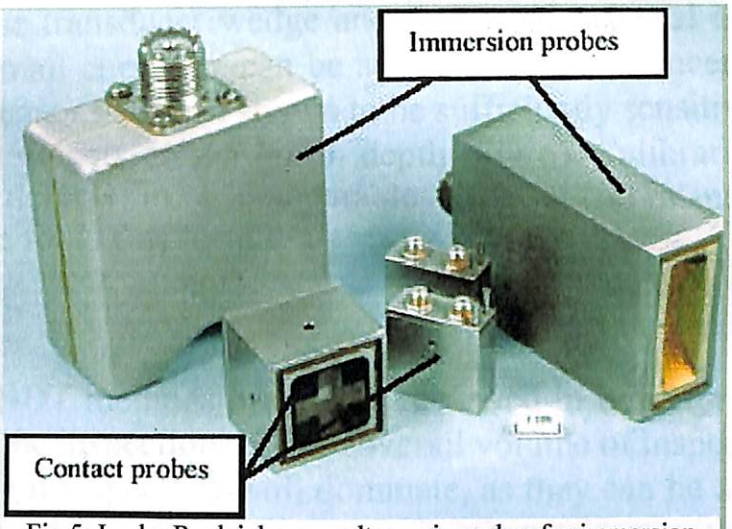


Fig 5: Leaky Rayleigh wave ultrasonic probes for immersion and contact testing.

The distance between the directly refracted longitudinal wave and the wave form change component remains constant in relation to the surface echo, and independent of the degree of defocusing in the depth direction. The acoustic properties of the material will determine the locations of these signals in time-amplitude display. Selecting appropriate degree of defocusing will position the leaky Rayleigh wave so that signal interference from these other signals can be avoided.

Fig 6: Indications from EDM calibration defects (50 m to 500 m) as detected with leaky Rayleigh wave from a MCrAlY coated vane.

When contact technique is used instead of immersion, testing in the field is easier but the sensor construction has a fixed degree of defocusing (Fig 5). This requires that the difference in sound velocity between the transducer wedge and the tested material is maximised, so that a small curvature can be applied in the tranducer crystal. The resulting sensor has been shown to be sufficiently sensitive to indicate calibration defects only 50 m in depth (Fig 6). Calibration to known reference defects in a comparable material is of nearly similar importance for UT as for ET.

Discussion

Common NDT methods have been reviewed in brief for applications in gas turbine inspections. Of the overall volume of inspections, visual and penetrant inspections still dominate, as they can be applied in the field faster and with relative ease in comparison with most other common NDT methods. Visual and surface methods have one major drawback, however, as they do not provide a reliable indication of the defect depth. In modern gas turbines where critical hot path components rely on coatings to protect the underlying load bearing metal, a growing defect that has penetrated this barrier will pose a direct threat to the availability of the gas turbine plant. Because there is limited access to inspect the critical components between the maintenance periods and because damage can proceed relatively quickly, good performance of NDT is of obvious importance for reliable and economical operation of gas turbines.

To also obtain an indication of defect depth, eddy current and ultrasonic testing show immediate potential. Both require careful calibration to comparable defects and materials, but some limitations remain so that these techniques are less extensively used in the field inspections. In particular, accessibility of the sensors to tight and

intricate details in a gas turbine is often limited. Also, coated multilayer systems are not easily inspected with ET or UT, especially when modern ceramic thermal barrier coatings (TBC) are applied. Finally, coatings in complex internal cooling passages and arrays of tiny cooling holes of modern turbine blading are not easily inspected with traditional NDT methods. Nevertheless, developments in the ET and UT techniques are promising for metallic coated and uncoated systems. Apart for defect depth indication, ET is also likely to provide a better sensitivity and therefore earlier indications for life assessment of uncoated components than inspections based only on surface techniques. Sensor limitations have delayed the parallel developments in UT, but the obstacles do not appear insurmountable.

The difficulties involved in the field inspections may imply that ET and UT techniques will find wider use in the shop applications, for manufacturing, repairs and quality control. However, increasing applications in the field inspections are likely particularly for ET.

Ideally, much or all off-line inspections would be replaced by on-line monitoring, with the potential benefit of much faster reaction to any deviation from expected or desired component behaviour, and to any opportunity that may occur in the market. However, no known monitoring technology is foreseen to have or develop the capability to replace off-line non-destructive inspections entirely.

CONCLUSION

In conclusion, I will like to express my heartiest thanks to all the members of Mechanical maintenance team of Block -3 for such a great support which they extend for me to feel at home in at a very new field of work. To be familiar with such huge machines & carry out their regular maintenance is a great experience. Last but not the least, I will definitely like to express my deep sense of gratitude to my seniors who encouraged & guided me nicely.

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And the help of

Mr.A.k.khandelwal (AGM CFFP)

Mr.amit tiwari (ER.BLOCK 3)

Mr. Rajan angele (MAINTENANCE HEAD BLOCK 3)