

MECHANICAL MAINTENANCE

Mechanical Maintenance deals with the maintenance of all machineries, vessels, heat exchangers, piping system etc. Basic work area of maintenance is related to maintenance and monitoring of:

1. Static equipments (such as: plugging ,corrosion, erosion, leakage etc of vessels, separators, heat exchangers, agitators, condensers, boilers, reactors, reformers etc)
2. Rotating equipments (such as: Pumps, steam turbines, fans, blowers, compressors etc, rotating equipments need more monitoring and maintenance)
3. Piping network and relevant components (such as: pipes, valves, safety devices, fittings, gaskets etc)
4. Various workshop activities (Fabrication, Welding, Insulation ,Refractory, Mobile equipment shop for all types of automobiles and cranes)

Close monitoring and inspection are required to identify any problem with machinery functions especially when it has passed a certain lifetime. Unusual vibration, noise, temperature etc are the main indicators of malfunctioning of equipment and should be taken care of immediately. The common machinery malfunctions are:

- Unbalance (Mass, Hydraulic and Electrical)
- Bend rotor/Shaft Bow
- Resonance (rotor system, foundation, structural and system components)
- Misalignment (cold as well as Hot condition)
- Loose rotating parts
- Soft foot
- Casing distortion
- Fluid-induced vibration (whirl and whip)
- Sympathetic vibration
- Excessive/insufficient bearing clearance

- Rubbing
- Crack in shaft
- Defective rolling element bearings
- Defective gear box
- Torn belt
- Cavitations
- Vane pass frequency
- Insufficient flow/surging/Stalling

ELECTRICAL MAINTENANCE

Electrical maintenance: For power generation for plant and also for housing colony in total 4 turbines are present in KAFCO. The larger two turbines have the capacity of 10 MW power generations each, though total 14 MW is required and utilized. These are steam driven and the smaller two of 4 MW and 1 MW used for emergency and for start up respectively are driven by diesel motors. The electrical maintenance dept monitor and maintain these power generation devices and quickly solve the problems regarding the distribution of electricity before any hazard occurs.

For the safety and maintenance of the electrical equipments two important devices are used generally:

1. Governor which controls the speed of the rotating shaft of the turbine.
2. Automatic Voltage Regulator

In case of emergency shut down or any serious problem with the plant the load shedding system is then operated on priority basis by Electrical Load Management System (ELMS). The whole plant and housing colony are divided in 8 units. And during emergency load shedding the less important unit is cut out first.

CIVIL MAINTENANCE

Civil Maintenance: The civil maintenance dept. becomes active when it is decided to construct a structure for any new vessel, for rebuilding the outdated and risky structures and especially during the time of natural catastrophe or disasters.

Instrumentation Maintenance: This department deals with the problems with all pressure, temperature, flow and level transmitters. There is a distributed control system (DCS) for controlling all these transmitters. The Flow and level transmitters also indicate them by converting them in terms of pressure.

$\text{Flow} \propto \Delta P$, where orifice meters measure pressure drop and at both sides of the orifice impulse lines are connected. The transmitters are mostly Electronic or Pneumatic. The electronic transmitters are also said to be the smart transmitters, which transmit the process value, and if the values deviate from the set point: for positive deviation direct action taken and for negative deviation reverse action is taken. The following diagram can describe this process:

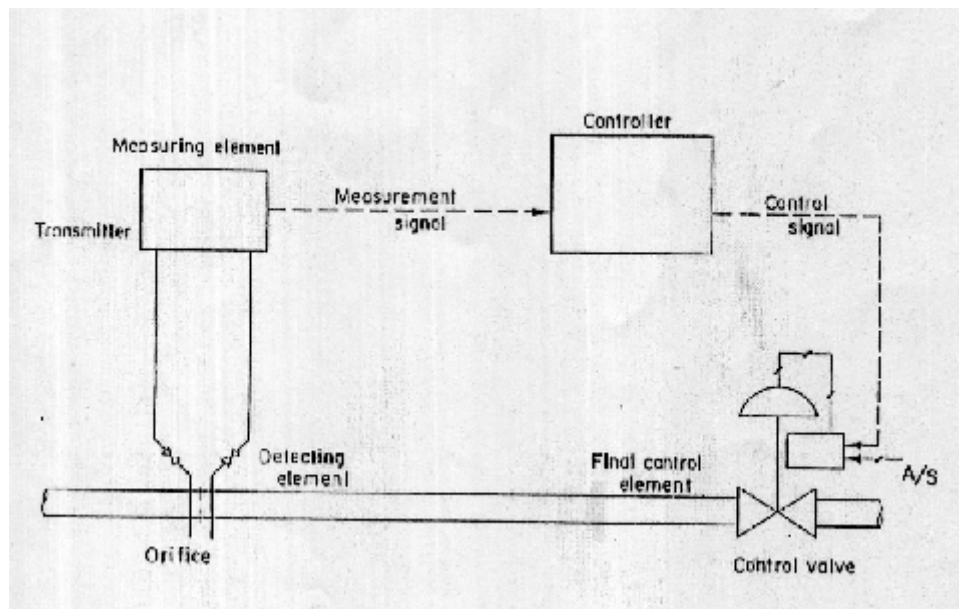


Figure 24: Control Loop with common four elements

Now all the problem regarding these instruments specially the valves are maintained and closely monitored by this dept. in the plant mainly safety- relief valves are used. In only 2 places rupture disks are installed to prevent hazardous explosions of the equipments.

There are other classifications of maintenance works done in KAFCO and many other developed and modern plants in the world according to the time and priority of the work. Basic maintenance activities can be classified as follows:

1. Predictive Maintenance: It deals with the trend analysis, close monitoring of potential problems etc. This kind of maintenance work is done specially for sophisticated and costly equipments. To save equipments from probable malfunctioning, or from any future hazards predictive maintenance works are done before something really happens. These type of maintenance work save huge equipment costs that would have been required for replacing or mending equipment when it is already damaged.

2. Preventive Maintenance: It deals with condition monitoring, greasing, L/O change, Cleaning etc. This is also done to prevent undesired condition or interruption in production process and to protect the equipments thus the whole process from disastrous occurrence and unwanted shut down. This is also done to reduce the loss of production from sudden turndown.

3. Corrective Maintenance: Corrective maintenance work is the general form of maintenance that is usually understood by the word 'maintenance' i.e. identifying and repairing or reconstruction of damaged units upon complete shutdown of the unit. This type of maintenance work involves huge cost normally which are tried to be avoided by the above two maintenance works that could be done by smaller efforts in terms of money also by keeping that part off from the running process.

With time maintenance techniques are changing. And they can be represented as different generations of maintenance techniques. Such as:

1st generation: Fix it when it broke.

2nd generation: Scheduled overhauls, systems for planning and controlling work etc

3rd generation: with modern and new techniques such as:

- ✓ Condition monitoring
- ✓ Design for reliability and maintainability

- ✓ Hazard studies
- ✓ Small, fast computers to control the system and calculate the desired values quickly
- ✓ Failure modes and effects analyses
- ✓ Expert systems
- ✓ Multiskilling and teamwork

In KAFCO most of the 3rd generation techniques are adopted that's why it is said to be very well maintained and safe plant.

The steps that have to be followed to do maintenance job in KAFCO

1. At first a work permit has to be created by the respective department where maintenance work is required. It has to be signed by the supervisor in duty in the production department
2. Then it is passed on to the related maintenance department and
3. Then to the safety department.
4. Being reviewed and approved by all above steps the work permit is delivered to the workers. And before starting the job they have a tool talk, about the whole environment, hazards and the required works to be done about it.
5. Then the work is commenced and the work permit is valid for a shift only. In the next shift another work permit has to be created.

As all these safety measures are taken during a maintenance work KAFCO has become acknowledged as well maintained and less hazardous plant though it handles lots of harmful chemicals at extreme conditions of pressure and temperature.

QUALITY CONTROL

Quality control is required to increase quality of something by analysis. Certified chemical reagents are used. Global passport of international market is quality analysis. The goal of this type of analysis is customer satisfaction.

The qualities or parameters that are to be controlled-

pH: More than 7 is maintained

Conductivity: Materials having high conductivity have lower reactivity and moves faster.

Turbidity: If SiO_2 is present in the water or in steam then it may deposit on turbine blade.

Hardness: Tested for regeneration purpose

Iron (Fe): If corrosion or scaling takes place then it can be detected .Samples are collected from different part and source of this unwanted material can be identified.

Chloride (Cl): High amount can cause corrosion and less than the desired amount raise a possibility of bacteria and un-oxidized Mn^{2+} .

Equipments for quality controlling:

- ✓ **Gas Chromatographer (GC):** It is used to analyze process gas and raw gas (natural gas). 10 components in natural gas are analyzed which are argon(Ar), nitrogen(N_2), methane(CH_4), carbon monoxide(CO), carbon dioxide(CO_2) and higher hydrocarbons up to n-heptane. These qualities are tested twice a month and are reported to technical department and also to the Bakhrabad Gas Company by quality control (QC) department of KAFCO.
- ✓ **Flame Ionization Detector (FID):** FID detects the amount of CO. CO_2 in methanator.
- ✓ **Thermal Conductivity Detector (TCD):** If concentration of CO_2 and
- ✓ **Spectrophotometer:** It is used to analyze oil.
- ✓ **Furnace:** To heat up or burn something up to $800\text{-}1000^\circ\text{C}$. CO is so low that FID cannot detect it then it is used.
- ✓ **Oven:** Used to remove H_2O from SiO_2 gel.

- ✓ **Fume chamber:** If sample consists of hazardous fume then it is used.
- ✓ **Viscosity bath:** Viscosity bath analyzes the quality of UF-85, lube oil etc.
- ✓ **Corrosion coupon:** Used to measure corrosion.

INSPECTION SECTION

The Inspection section which is concerned with the properties, production, and purification of metals is called metallurgy.

Types of metallurgical inspection

- ✓ Online metallurgical inspection (Visual and non-destructive)
- ✓ Offline metallurgical inspection (Both destructive and non-destructive)

The following tools are used for on-line and off-line (shut down) metallurgical inspection-

- Metallurgical microscope
- Metallographic (Surface preparation) equipment
- Replica making equipment
- Hardness tester
- Thickness meter
- Depth gauge
- Alloy analyzer
- Other destructive testing equipment with the help of BUET

Activities of Metallurgical inspection in KAFCO

- ✓ Metallurgical inspection of different metallurgical equipments and their structural function and properties and decision making according to these equipments' longevity and performance.
- ✓ To analysis of different metallurgical or material failures and provide expert advice in need of replacement and rectification.
- ✓ To determine the future metallurgical inspection, planning & recommendation for repair and replacement of different static equipment.
- ✓ To perform the RISK BASED INSPECTION (RBI) activities from the metallurgical

point of view in the ammonia plant.

- ✓ To check the quality of welders for any new project, repair works and select the qualified welders and their welding from metallurgical point of view.
- ✓ To check the quality and composition of incoming material of different parts of the equipment.
- ✓ To organize different nondestructive metallurgical inspection such as Metallographic & replica analysis.
- ✓ Online corrosion monitoring of pressure vessel, tanks, heat exchangers and piping such as for painting, atmospheric corrosion, structural stress and weldments for external stress corrosion cracking of Stainless steel.
- ✓ Thickness monitoring for piping & equipment, cladding & overlay welds by ultrasonic Thickness meter.
- ✓ Hardness monitoring; pre-weld and post-weld hardness monitoring of weld and heat affected zone.
- ✓ Replica analysis of Boiler Super heater tubes, Boiler Water Tubes, Boiler Bank Tubes, Economizer Tubes and Steam Header, Primary Reformer catalyst tubes, Convection coils to assess the remaining life.

Benefits of Metallurgical inspection

Metallurgical inspection is mainly responsible for determining the relationship between mechanical behavior and structure (both macroscopic and microscopic). When mechanical behavior is understood in terms of Metallurgical structure, it can be possible to improve the mechanical properties or to control them.

CODES AND STANDARDS

The following codes and standards has followed in KAFCO for different pressure vessel, reactors, reformers, heat exchangers and piping according to different -

Equipments	Codes and standards
Pressure Vessels	
(a) Design, Fabrication and Inspection	ASME VIII Div. 1 or Div. 2 or AD-Merkblatter
(b) Material	ASTM, JIS, DIN and/or material of MFR's country of origin
(c) Welding Procedure Qualification	ASME Section IX or AD-Merkblatter
(d) Welder and Welding Operator Qualification	ASME Section IX or AD-Merkblatter
(e) Technique of Non Destructive Testing	ASME Section V or AD-Merkblatter
(f) Flanges	ANSI B16.5
(g) Trays	ASME VIII Div. 1
Heat Exchangers	
(a) Design, Fabrication and Inspection	ASME VIII Div.1 or Div.2 Or AD-markblatter TEMA class-B
(b) Material	ASTM, JIS, DIN and/or material of MFR's country of origin
(c) Welding Procedure Qualification	ASME Section IX or AD-Merkblatter
(d) Welder and Welding Operator	ASME,Section IX

Qualification	or "tD-Merkblatter
(e) Technique of Non-Destructive Testing	ASME Section V or AD-Merkblatter
(f) Flanges	ANSI B16.5
(g) Air Coolers	ASME VIII Div. 1 and API 661
(h) Double Pipe or Multi-Tube	ASME VIII Div. 1, and MFR's Standard;
(i) Steam Condensers	HEI

Storage Tanks

(a) Design, Fabrication and Erection	API 620 or API 650
(b) Material	ASTM, JIS, DIN and/or material of MFR's country of origin
(c) Tank Venting	API STD 2000

Civil Works

(a) Concrete Design and Construction	ACI
(b) Design Load	ANSI or UBC
(d) Test Method	ASTM
(e) Material	Locally available material and/or others

Piping

(a) Design	ANSI B31.1, B31.3 816.5, ASME, API, MSS
(b) Material	ASTM, JIS, DIN and/or material of MFR's

- country of origin
- (c) Pressure Piping Flange
ANSI B16.5 (except for
lens ring gasket)
ANSI or MSS
- e) Valve (face-to-face
dimension)

Fired Heaters

- (a) design of pressure parts
API RP 530 (except for
Reformer Cat Tubes)
- (b) Material
ASTM, JIS or others of
MFR's country of origin

Package boilers

- (a) Design
ASME
- (b) Material
ASTM, BS or others of
MFR's country of origin

Cooling tower

- (a) Design
CTI
- (b) Material
JIS or MFR's standards

Fire fighting

- (a) Design
NEPA
- (b) Material
Material of MFR's country of origin

The following defines abbreviations used to designate codes and standards-

ALMA	American Gear Manufacturers Association
ASME -	American Society Mechanical Engineers
ASTM -	American Society for Testing Materials
ANSI -	American National Standard Institute
API	American Petroleum Institute
ASA	American Standards Association
ACI	American Concrete Institute
AI	The Asphalt Institute
AISC	American Institute of Steel Construction
AGA	American Gas Association
ASHVE	American Association of Heating and Ventilating engineers
ASHRAE	American Association of Heating Refrigeration and Air conditioning Engineers
CTI	Cooling Tower Institute
CEMA	Conveying Equipment Manufacturers Association
DN	Deutsche Normen
JIS	Japanese Industrial Standard
JCS	Japanese Cable Makers' Association
SJEC	Standard of Japanese Electrical Committee
HEI	Heat Exchanger Institute
IEC	International Electrical Code
ISO	International Standards Organization
ISA	Instrument Society of America
IEEE	Institute of Electrical and Electronic Engineering
MSS	Manufacturers Standardization Society of the Valves and Fittings Industry
NEMA	National Electrical Manufacturer Association
NEC	National Electrical Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association.
SSPC	Steel Structures Painting Council
TEMA	Tubular Exchanger Manufacturers Association

CONCLUSION

KAFCO is one of the leading Chemical plants in Bangladesh and we are lucky enough that we get an opportunity to have an industrial attachment in KAFCO. This tour helped us to enrich our knowledge about industrial operations and to have a comparative view of our theoretical studies with the practical field of chemical engineering. But we only had a visual idea about the unit operations and chemical processes as it is quite difficult to know the ins and outs of the whole process. It will be more effective if the duration of the tour can be extended for a month or twice in the four years undergraduate course. It will be helpful if we can get a chance to have a look on the internal parts of some equipment like Turbines, Compressors and Pumps. It will be possible if the duration of the tour is extensive.

