DISSEMINATION OF BEST PRACTICES IN THERMAL POWER PLANT
FOR GHG EMISSION REDUCTION

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INTRODUCTION TO MECHWELL INDUSTRIES

CFD & ITS APPLICATION AREA

GENERAL PROBLEMS FACED IN POWER PLANT

SOLUTIONS BY MECHWELL

CURRENT R & D PROJECTS
INTRODUCTION

ESTABLISHED IN 1983, MECHWELL IS A MULTI-DISCIPLINE APPLIED R&D ORIENTED ENGINEERING FIRM.
MECHWELL WAS ESTABLISHED TO PROVIDE SOLUTIONS FOR CEMENT, POWER & ALLIED INDUSTRIES FOR FLOW, EMISSIONS & ENERGY CONSUMPTION PROBLEMS.

BUSINESS:

- **TURNKEY SOLUTION** TO CEMENT, POWER & ALLIED INDUSTRIES INCLUDING CUSTOM ENGINEERING, SPECIALTY SYSTEMS DESIGN (EFIP), MANUFACTURING AND IMPLEMENTATION, AND SUPPORT TO INDUSTRY IN EMISSIONS CONTROL.
- TO ACHIEVE SPM<30MG, HEAT AND MASS TRANSFER, AND APPLIED ENERGY SYSTEMS.
- DESIGN, MANUFACTURE & SUPPLY OF EXPANSION JOINTS, DAMPERS & GATES AND EFIP’S CFD & FEA CONSULTANCY SERVICES

MECHWELL IS WORKING IN COLLABORATION WITH “CASTLE”.

MECHWELL’S TEAM CONSISTS OF THE ENGINEERING EXPERTS FROM IIT, & OTHER REPUTED ENGINEERING INSTITUTES HAVING VAST EXPERIENCE.
INTRODUCING: MECHWELL INDUSTRIES LTD.

Manufacturing

Air pollution control

Testing & commissioning

R&D – Center for Innovation
PRODUCT OFFERING:

EXPANSION JOINT (METALLIC & NON-METALLIC) - DESIGN AND MANUFACTURE

SERVES TO: THERMAL POWER PLANTS, GAS TURBINE POWER PLANTS, CEMENT PLANTS ETC.
DAMPERS & GATES - DESIGN AND MANUFACTURE.

SERVES TO: THERMAL POWER PLANTS, GAS TURBINE POWER STATIONS, CEMENT PLANTS ETC
AIR HEATER BASKETS & SEALS DESIGN AND MANUFACTURE

SERVES TO: THERMAL POWER PLANTS
Air pollution control

ESP’s

Bag Filter

AFGC
Testing Services Provided

• REMAINING LIFE ASSESSMENTS OF BOILERS AS PER IBR 391A
• CLEAN AIR DIRTY AIR TEST
• GD TEST
• APH PERFORMANCE TEST
• ADVANCED NDT SERVICES FOR BOILER & TURBINE DURING AOH

• VISUAL INSPECTION
• ULTRASONIC FLAW DETECTION.
• ULTRASONIC THICKNESS GAUGING.
• MAGNETIC PARTICLE TESTING
• LIQUID / DYE PENETRANT TESTING.
• RADIOGRAPHIC TESTING
• IN SITU FIBEROSCOPY / VIDEOSCOPY INSPECTION
• IN-SITU METALLOGRAPHY & PLASTIC REPLICATION.
• IN-SITU HARDNESS TESTING
• OXIDE SCALE THICKNESS MEASUREMENT
• SAMPLING INSPECTION - THESE TESTS WILL BE CONDUCTED AT IBR / NABL APPROVED LABORATORIES.
THE USE OF A RANGE OF ADVANCED TOOLS INCLUDING COMPUTATIONAL FLUID DYNAMICS (CFD), FINITE ELEMENT ANALYSIS (FEA) COMPUTER AIDED DESIGN (CAD) AND OTHER SIMULATION TECHNOLOGIES.

MECHWELL PROVIDES COMPUTER AIDED ENGINEERING SERVICES TO A HOST OF INDUSTRIES, MOST NOTABLY THE POWER, CEMENT, AVIATION, OIL AND GAS, RENEWABLE ENERGIES AND AUTOMOTIVE SECTORS.
Why CFD – Computational Fluid Dynamics?

• It’s the numerical analysis method involving large computerized iterations for predicting fluid flow patterns.
• Time efficient & Optimized Solutions

Process for Design Optimization

• Computerized 3D CAD model is developed – with Actual Site Drawings
• High Quality Mesh is prepared for the model
• After confirmation from client fluid flow simulation is proceeded to Analyze flow patterns
• Optimum of design Changes for Ideal fluid flow across the system
BUSINESS DOMAINS

- Cement
- Aerospace
- HVAC
- Power
- Oil & Gas
- Automotive
- Other Process
GENERAL PROBLEMS FACED IN POWER PLANTS

- Unburnt in bottom Ash/Fly ash
- Fire ball Shifting
- Temperature difference in LHS and RHS side of boiler
- Attemperation in 1\textsuperscript{st} and 2\textsuperscript{nd} Pass of the boiler
- Erosion In 2\textsuperscript{nd} pass of the boiler
- Boiler tube Leakages/failure
- Erosion in APH
- Erosion in Flue gas ducts
- High pressure drop across the Flue gas ducts and ESP
- Pent house Leakages
- Higher stack emission
- Corrosion In APH
- Unequal flow distribution inside the ducts
- Ash accumulation in the ducts
- Improper flow inside the ESP
- High ID Fan power consumption
OPTIMIZATION OF OPERATIONS IN POWER PLANTS
COMPUTATIONAL FLUID DYNAMICS: STEPS

- IDENTIFICATION OF PROBLEM
- DATA COLLECTION
- MODELING
- MESH GENERATION
- BOUNDARY CONDITION
- EVALUATION
- MODIFICATION/ANALYSIS
- SIMULATION
- Verification
SOLUTIONS OFFERED BY MWI

- Unburnt in bottom Ash/Fly ash
- Fire ball Shifting
- Temperature difference in LHS and RHS side of boiler
- Attemperation in 1st and 2nd Pass of the boiler

Coal Mill Testing
COAL MILL TESTING

Clean Air Testing

Dirty Air Testing

Iso Kinetic Coal Sampling
SOLUTIONS OFFERED BY MWI

- Erosion in 2\textsuperscript{nd} pass of the boiler
- Boiler tube leakages/failure

- Cold Air Velocity Test
- CFD analysis
Reliability & Availability of the power station is mainly affected by unanticipated boiler tube leakages.

**Root Causes:**
- High velocity fly ash impinge on tubes.
- At critical angle of impingement erosion starts.
- New layer of tubes exposed

**Unanticipated boiler tube leakages lead to:**
- Their failure and replacement.
- Boiler shut downs.
- Eventual generation loss.
Primary contributing Factors:-

• Ash particle velocity & angle of impingement
• Ash flux
• Abrasive contents in ash
• Design & layout of tube bundles

OTHER FACTORS:

• CASSETTE BAFFLES BULGING
• IMPROPER SHIELDING
• FAULTY DESIGNING AND ERECTION OF SCREENS
• CROSS FLOW BETWEEN TUBE BUNDLES
• INDIVIDUAL UNIT PROBLEMS LIKE DIFFERENT FLOW IN GAPS AT LHS & RHS
ASSUMPTIONS & OPERATING CONDITIONS

- UNIFORM FLOW AND TEMPERATURE IS CONSIDERED AT THE INLET
- NO LEAKAGES THROUGHOUT THE SYSTEM
- ISOTHERMAL CONDITIONS ARE CONSIDERED
- DOMAIN IS FOCUSED ON IIND PASS OF THE BOILER
- NO HEAT TRANSFER ANALYSIS IS DONE

BOUNDARY CONDITIONS:

- PRESSURE AT ECONOMIZER OUTLET = -247.89MMWC
- TEMPERATURE IN IIND PASS = 462°C
- MASS FLOW RATE = 657.70 KG/S
CFD STUDY & ANALYSIS

- Building computer model of boiler
- Studying and analyzing existing velocity profile
- Applying various design modifications to model to achieve desired velocity profile
- Finalizing design modifications

The main objective while carrying out CFD analysis in boilers is to reduce tube erosion caused due to impingement of high velocity fly ash particles. This results in minimizing plant shutdowns due to tube leakages in boilers and increasing the availability of the system.
To perform CFD analysis the model has to be split into small ELEMENTS. THE PREDICTION OF THE RESULTS IS HIGHLY DEPENDS ON GRID. WE USED HIGH QUALITY STRUCTURED MESH FOR THE CFD ANALYSIS

NUMBER OF ELEMENTS: 13.4 MILLION
MESH QUALITY: 0.5
MIN ANGLE: 30 DEGREES
CFD ANALYSIS FOR -LANCO POWER ANPARA-660MW

Existing CFD Results

Figure illustrates the gas velocity streamlines at LTSH/LTRH
LTRH CFD RESULTS - STREAM LINE

Modified CFD Results

Figure illustrates the gas velocity streamlines at LTSH/LTRH
3D Model Confirmation

Pre Modified arrangement

Modified arrangement
Erosion Control Devices (ECD)

ECD’s are designed to protect the boiler tube from erosion due to impingement of high velocity ash particles. The C.A.V.T. data and CFD analysis results are used to optimize the design of ECDs to get the best results.

Existing Results

Modified Results
DESIGN, MANUFACTURE, SUPPLY & ERECTION OF FLOW CONTROL DEVICES

- Select proper control for diversion
- Study computer model before recommendations.
- Choose most appropriate controls
- Manufacture the screens whose design is tested on computer.
- Supply & installation at site under expert supervision
- Expanded metal screens are designed to protect the boiler tube from erosion due to impingement of high velocity ash particles. The C.A.V.T. data and CFD analysis results are used to optimize the design of expanded metal screens to get the best results.
Erosion Control Scheme For Boilers

EMS Locations
Erosion Control Scheme For Boilers

Comparison of Pre & Post installation velocities

Bottom of LTSH Lower Bank from FRONT Wall

Bottom of LTSH Lower Bank – From Left Wall
INSTALLED EMS SCREENS
CAVT LOCATION DRAWING – HINDALCO RENUKOOT

CAVT LOCATION

EMS LOCATION
COMPARISON AFTER PRE & POST CAVT

PRE CAVT

POST CAVT
Solutions offered by MWI

- Erosion in Flue gas ducts
- High pressure drop across the Flue gas ducts
- Unequal flow distribution inside the ducts
- Ash accumulation in Ducts
- Unequal flow inside ESP

- Duct Velocity Test
- Gas Distribution Test in ESP
- Computational Fluid Dynamics
**Procedure For Duct Velocity Test**

- Duct Velocity Test is carried out in Flue Gas ducts i.e., From APH O/L to ESP I/I and ESP O/L To ID Fan I/L

- Duct velocity test will be carried out in running plant.

- Depending upon the size of the duct 5 test ports are provided at such locations by OEM.

- By inserting S-type pitot tube in each port pressure difference is measured at 5 transit points in each port.

- The pressure difference is then converted into velocity after implying local parameters like temperature, barometric pressure, and duct size etc.

- The velocity pattern thus generated and will be submitted to you.

- This Duct Testing will be carried out Pre and Post- Installation of diverter plates
3D Model Preparation
Meshing Of the Model

Figure illustrates meshing of the duct
AS-IS Analysis

**CFD RESULTS - EXISTING**

In existing duct arrangement due to sharp corners in duct, flow becomes turbulent and having more recirculation zones which causes high pressure drop as well as ash accumulation problem.

Figure illustrates velocity streamlines for existing duct.
In existing duct arrangement due to sharp corners in duct, flow becomes turbulent and having more recirculation zones which causes high pressure drop as well as ash accumulation problem.

Figure illustrates velocity streamlines for existing duct.
Modified CFD Results

After proper design of guide plates and removal of sharp corners, flow becomes uniform which leads to the reduction in pressure drop as well as ash accumulation problem.
After proper design of guide plates and removal of sharp corners, flow becomes uniform which leads to the reduction in pressure drop as well as ash accumulation problem.

Figure illustrates velocity streamlines for modified duct.
Comparison Between Pre and Post CFD

In existing duct arrangement, velocity streamlines show that due to sharp corners in duct, flow becomes turbulent and having more recirculation zones which cause high pressure drop.

Figure illustrates velocity streamlines for existing duct.

After proper design of guide plates and removal of sharp corners, flow becomes uniform which leads to the reduction in pressure drop as well as ash accumulation problem.

Figure illustrates velocity streamlines for modified duct.
3D Model With Modifications

MODIFICATIONS

Marked zone shows modifications in duct

Figure illustrates Top View of modified model
From Existing Duct CFD Analysis it can be conclude that there is high flow separation, recalculation & dead zones in the common duct which creates the high pressure drop & ash accumulation & mass imbalance problem. This problems can be optimized by design of proper Guide vanes & Duct cross-sections.

- From Existing Duct Ash particle analysis, it can be observed that CFD & Site photographs shows the similar region of ash accumulation zone due the drop down of velocity.
- By Designing the optimized Guide Vane and Duct Plates using CFD, the flow is nearly uniform with optimum turbulence & completely avoiding recirculation zones, which results in reduction in pressure drop.
- Due to flow improvements in the common duct, ash accumulation has been minimized.
- After modification, the flow in all pass of the duct has been balanced within 2.5% of the avg. flow rate.
- By above all modifications the pressure drop reduction from AH outlet to ID Fan inlet is 35.78 mmWC.

Material required for this modification is as follows:
From APH outlet to ESP inlet duct: 65 tons approx.
From ESP outlet to ID fan inlet duct: 20 tons approx.
Installed Duct plates & Guide Vanes

Fig. shows CFD designed diverter plates after 2 years of our service
Honeycomb structure For Flow Distribution

Fig. shows CFD designed honey comb after 2 years of our service & no erosion is observed yet.
Optimization Of ESP Performance

PDPL - III
PDPL - II
PDPL - I
PDPL - III
PDPL - IV
ESP Analysis

Client – Hamon Shriram Cottrell Pvt. Ltd.
(Original Equipment Manufacturer – OEM for ESP)

Objective – Uniform flow distribution across duct & 2 pass ESP - JSW
- Design PDPL for uniform flow distribution for both ESP
ESP Analysis

Client – Hamon Shriram Cottrell Pvt. Ltd.

(Original Equipment Manufacturer – OEM for ESP)

Objective – Uniform flow distribution across duct & 2 pass Windbox ESP - JSW

- Design PDPL for uniform flow distribution for both ESP
ESP Analysis
Client – Hamon Shriram Cottrell Pvt. Ltd.
(Original Equipment Manufacturer – OEM for ESP)
Objective – Uniform flow distribution across duct & 2 pass Waste Gas ESP
- JSW
  - Design PDPL for uniform flow distribution for both ESP
Solutions offered by MWI

- Pent house Leakages
  - Pent House Sealing

- Higher stack emission
  - Ammonia Flue Gas Conditioning System

- corrosion In APH
- Erosion in APH
  - APH Performance Test
  - CFD analysis of APH
  - APH Baskets
  - APH Seals
### RECENT TURNKEY PROJECTS EXECUTED

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<th>Client</th>
<th>Project Description</th>
<th>Contact Person</th>
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<tr>
<td>1</td>
<td>Adani Power Ltd-Tiroda</td>
<td>CFD Analysis of Duct from APH Outlet &amp; ESP to ID Fan inlet</td>
<td>Mr. Raju Gortekar : 97654 90874</td>
</tr>
<tr>
<td>2</td>
<td>Adani Power Ltd-Rajasthan</td>
<td>CFD Analysis of Duct from APH Outlet &amp; ESP to ID Fan inlet</td>
<td>Mr. Anant Wagh : 08696931820</td>
</tr>
<tr>
<td>3</td>
<td>CESC Limited</td>
<td>CFD Analysis of Duct from APH Outlet &amp; ESP to ID Fan inlet.</td>
<td>Mr. Souvik Dutta : 09831054639</td>
</tr>
<tr>
<td>4</td>
<td>GND TP Bathinda</td>
<td>CFD Analysis of Duct from APH Outlet &amp; ESP to ID Fan inlet.</td>
<td>Mr. Darshan Singh: 09646107129</td>
</tr>
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<td>5</td>
<td>Lanco Power Anpara</td>
<td>CFD Analysis of 500 MW boiler</td>
<td>Mr. Amol Mahale : 0956032334</td>
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<td>6</td>
<td>Hindalco Renusagar</td>
<td>CFD analysis of Boiler</td>
<td>Mr Gopal Gupta : 09598652390</td>
</tr>
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CURRENT R&D PROJECT (1): JINDAL STEEL AND POWER LTD.

DESCRIPTION:

1. DEVELOP 3D MODEL OF CFBC BOILER WITH TOTAL TUBES CONSIDERING MIX GAS FIRINGS STRUCTURES WITH THE HELP OF THE DETAIL DRAWINGS PROVIDED BY JSPL

2. ASSESSING IMPACT OF GAS FIRING ON NOX AND SOX EMISSION.

3. EVALUATION OF GCV RANGE OF MIX GAS FIRING IN BOILER.

4. EVALUATION OF MAXIMUM AND MINIMUM FLOW OF MIX GAS (BF AND CO GAS) FIRING IN BOILER AND STUDY OF BOILER CRITICAL PARAMETERS

5. THERMAL MODELING OF CFBC BOILER

6. EVALUATION OF REDUCTION OF COAL CONSUMPTION WITH UTILIZATION OF MIX GAS IN BOILER
JSPL, ANGUL 135MW, U#3 - CFBC BOILER

Cyclone

Cad Model – CFBC Boiler

Cold Flow Simulation
CURRENT R&D PROJECT (2) : ADANI POWER LIMITED

- CFD ANALYSIS FOR BOILER U# 660 MW
  a) TO STUDY THE FLUE GAS FLOW PATH, PATTERN AND DISTRIBUTION INSIDE THE BOILER 2ND PASS AND LTRH HEAT TRANSFER UNDER VARIOUS CONDITIONS OF BOILER COMBUSTION / PERFORMANCE WHILE FIRING THE CURRENT COAL CONFIGURATION

a) REMEDIAL MEASURES TO EQUALLY DISTRIBUTE & IMPROVE GAS FLOW DISTRIBUTION FOR UNIFORM HEAT TRANSFER IN LTRH SHALL ALSO FORM PART OF THE SCOPE OF WORK.
ADANI POWER LTD, MUNDRA 660MW BOILER
Various planes in furnace for Visualization of Flow profile in furnace
THESE CUSTOMERS TRUST US

- BHEL
- THERMAX
- L&T MHI Boilers Pvt. Ltd.
- ISGEC Heavy Engineering Ltd.
- DOOSAN
- NTPC
- MAHAGENCO
- adani
- JINDAL POWER
- TATA
- PSPCL
- CESC LIMITED
- BALCO
- ESSAR POWER
- WBSEB
- HINDALCO
- ADITYA BIRLA GROUP
THANK-YOU!!

R&D Center for Innovation

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