FLUID FLOW ANALYSIS IN THE AIR COOLED CONDENSER SYSTEM

ENGINEERING DEPUTY

MAPNA DEVELOPMENT COMPANY (MD1)

IRAN

PRESENTATION OVERVIEW

Part 1

- **INVESTIGATION OF AIRFLOW OVER AIR COOLED CONDENSER'S TUBE BUNDLE IN ORDER TO IMPROVE COOLING SYSTEM EFFICIENCY**
  - MONA SHOKROLLAH

Part 2

- **TECHNICAL EVALUATION OF THE EFFECTS OF WIND WALL ABSENCE ON ONE SIDE OF THE ACC**
  - MASOUD NIKKHOO

PART I

INVESTIGATION OF AIRFLOW OVER AIR COOLED CONDENSER'S TUBE BUNDLE IN ORDER TO IMPROVE COOLING SYSTEM EFFICIENCY

MAPNA GROUP
MD1 Co.

OUTLINE

1 HIGHLIGHTS FROM 2024 PRESENTATION

Including:

- Objective Of Study
- Our Goal
- Innovative Solution
- Result Comparison

2 EXPRIMENTAL STUDY

Including:

- Measurement system
- Initial Phase
- Upcoming phase

3 FUTURE WORK

Including:

- Next Step
- Final Step

2

HIGHLIGHTS FROM 2024 PRESENTATION

MAPNA GROUP
MD1 Co.

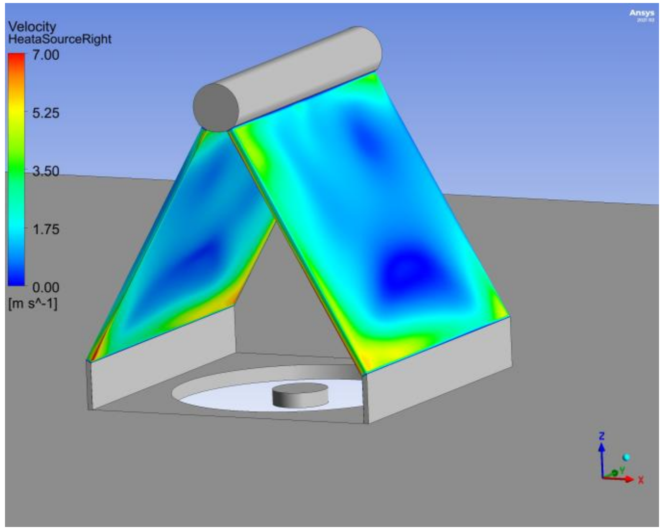
OBJECTIVE OF THE STUDY

- **Review:**
  - The airflow passing through the tube bundle is never uniformly distributed.
  - This non-uniformity leads to a reduction in the thermal efficiency of the cell, uneven thermal stress on the tube bundle, and the formation of unwanted air recirculation zones (bulk airflow pockets) within the tube arrays.

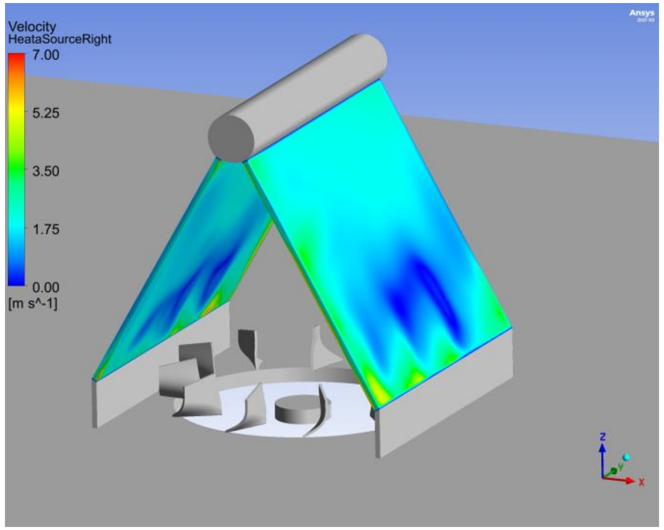
- **Goal:**
  - Find new and innovative method to uniform air distribution over tube bundle to increase ACC Performance with the same fan power.

PROPOSED SOLUTION & SIMULATION RESULTS

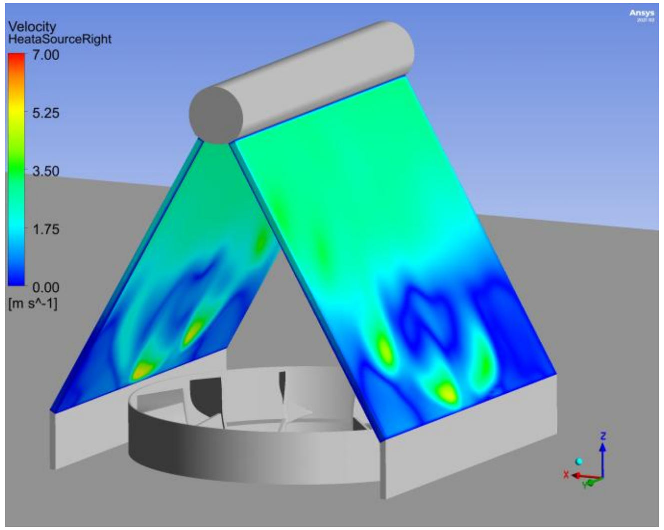
- **Using stator blades (middle picture) results in a more uniform flow compared to the classic case.**
- **When stator blades are combined with a shroud, the flow becomes even more uniform, with a significantly greater amount concentrated in the upper part, compared to the other two cases.**



Without Stator



Stator without Shroud



Stator with Shroud

MAPNA GROUP
MD1 Co.

SOLUTION: RESULT COMPARISON

- **In this slide, it can be observed that the use of a stator with a shroud has led to approximately a 10% increase in the average velocity over the tube bundle. Additionally, the use of a stator and shroud has reduced the deviation of maximum velocity relative to the average speed.**
- **This means that the combination of a stator and shroud produces a more uniform velocity profile and increases the average velocity.**

Variable	No Guide		Stator without Shroud		Stator with Shroud	
	Heat Source Left	Heat Source Right	Heat Source Left	Heat Source Right	Heat Source Left	Heat Source Right
ave Velocity (m/s)	1.78	1.81	1.81	1.80	1.99	1.95
maxVal Velocity (m/s)	10.67	12.64	6.88	9.00	5.54	5.39
minVal Velocity (m/s)	0.07	0.04	0.04	0.03	0.02	0.03
maxVal - ave (m/s)	8.89	10.83	5.07	7.19	3.56	3.44
	Average velocity change percentage relative to the case without stator (%)		1.92	-0.18	11.71	8.18
			0.87		9.95	

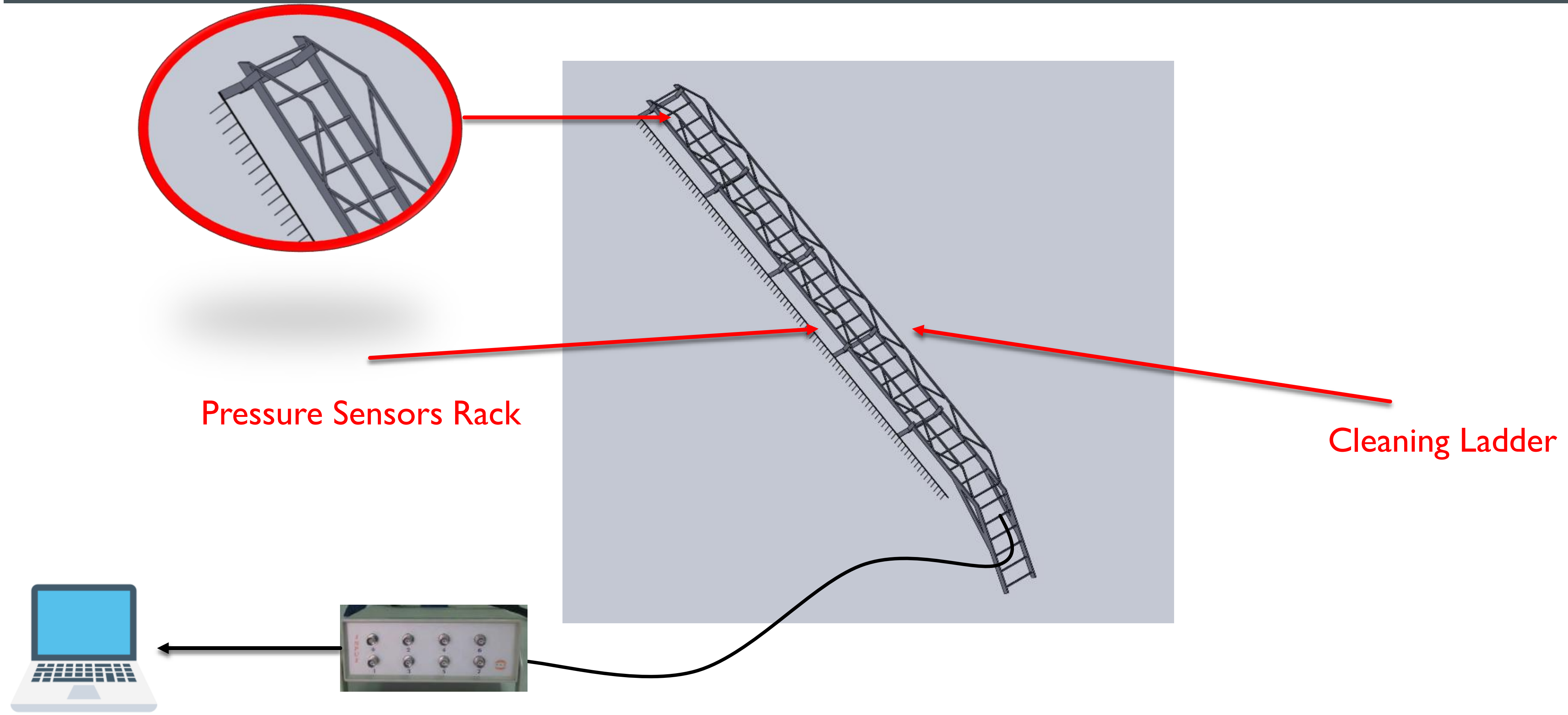
MAPNA GROUP
MD1 Co.

5

EXPERIMENTAL STUDY

MAPNA GROUP
MD1 Co.

DATA GATHERING SET-UP STRUCTURE



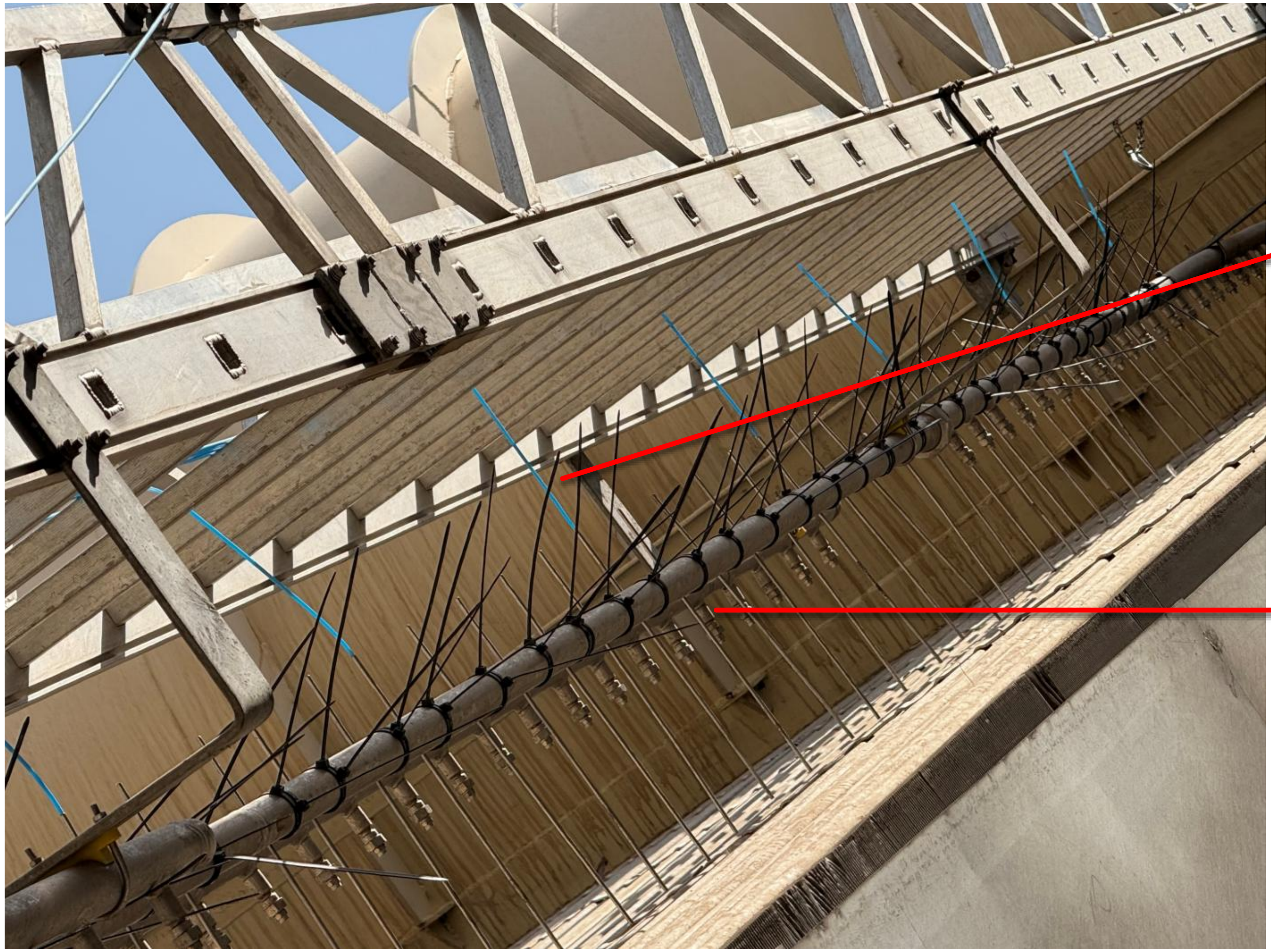
MAPNA GROUP
MD1 Co.

SYSTEM COMPONENT

- **Appropriate air measurement instruments for acquiring pressure and velocity data**
- **Provision of required equipment for analog-to-digital signal conversion and data transmission**
- **Software for real-time visualization and logging of acquired data on Windows-based computers**

MAPNA GROUP
MD1 Co.

DATA GATHERING SET-UP STRUCTURE (PARAND POWERPLANT)



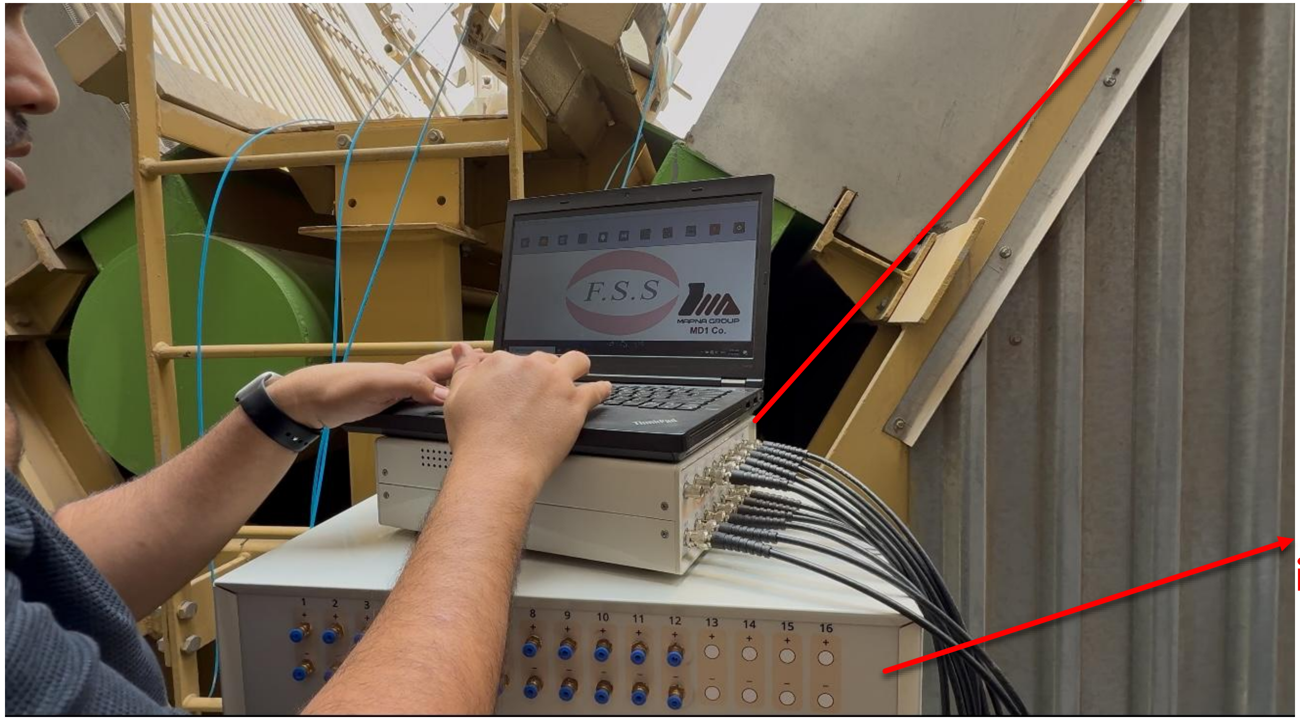
Hose connected to pressure device

Pressure Sensors Rack

MAPNA GROUP
MD1 Co.

STAGES OF DATA GATHERING

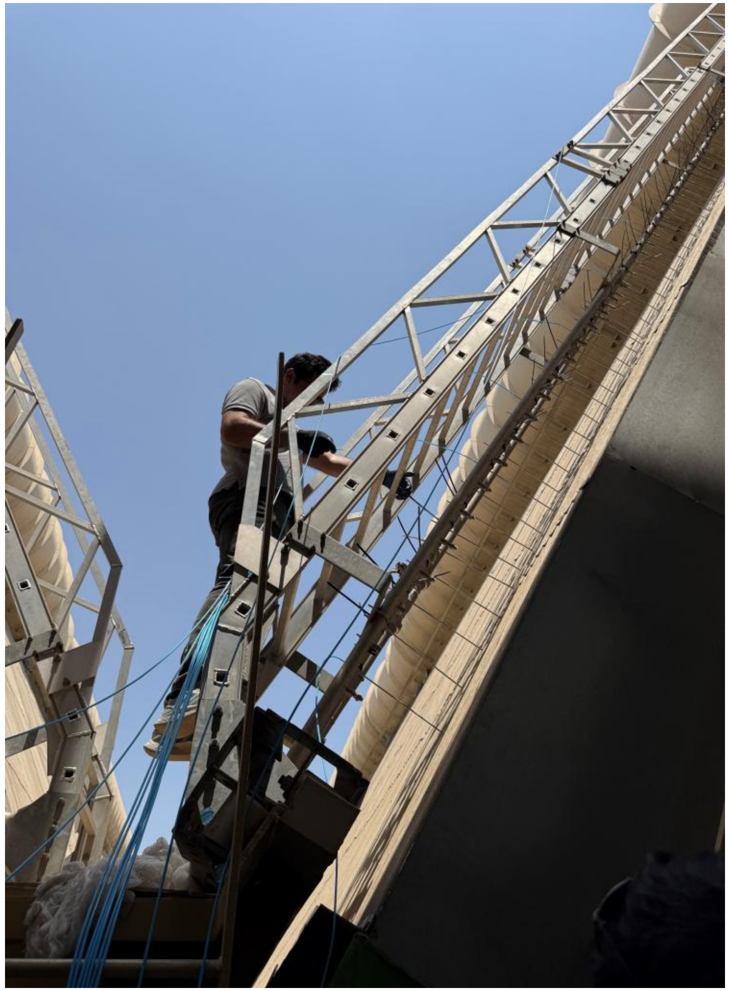
A/D device

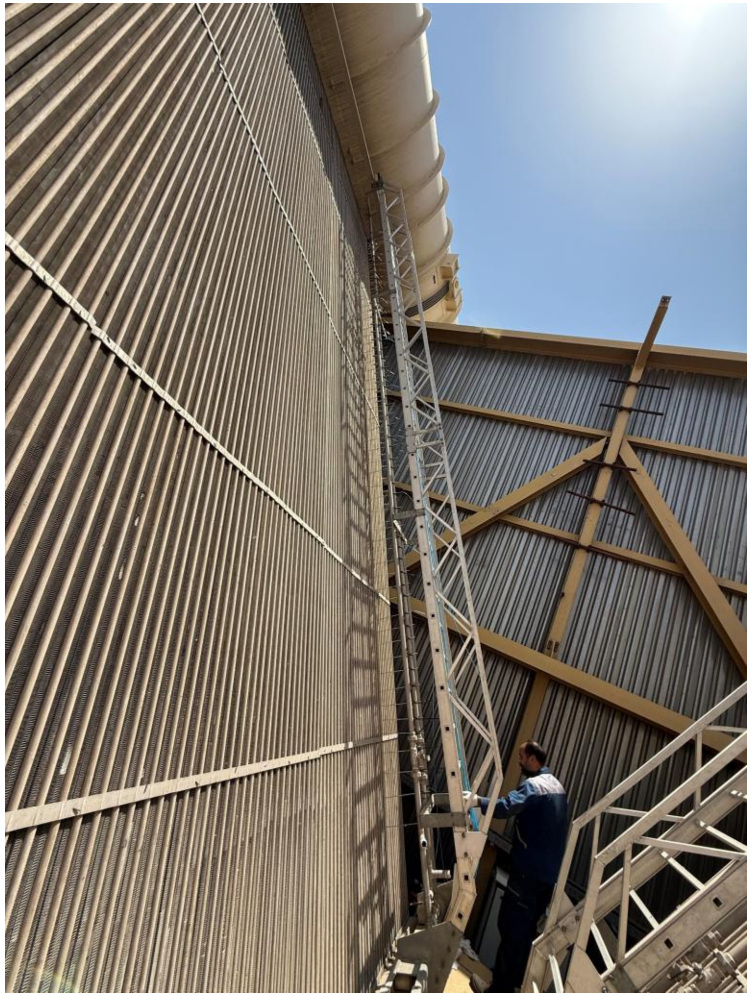


Pressure indicator device

MAPNA GROUP
MD1 Co.

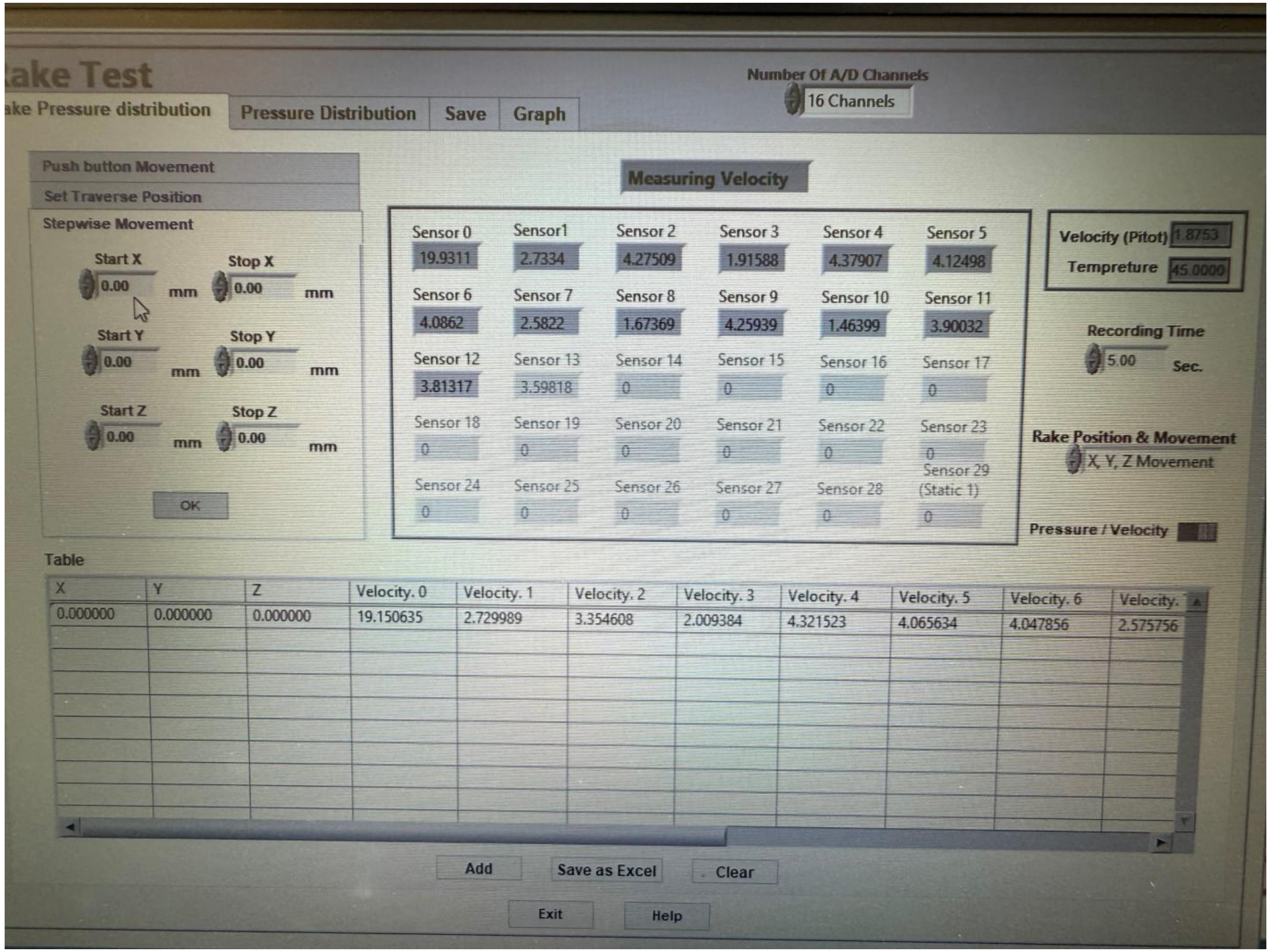
STAGES OF DATA GATHERING





MAPNA GROUP
MD1 Co.

N/I SOFTWARE DISPLAY



EXPERIMENTAL DATA GATHERING PLAN

- **Initial phase:**

  One module has been instrumented and data have been acquired vertically along the full height of the tube bundle at equally spaced intervals

- **Upcoming phases:**
  - A full-height vertical scan of the tube bundle will be repeated to ensure consistency and trend validation.
  - Targeted measurements will be conducted at three specific vertical zones for higher spatial resolution:
  - Bottom third of the tube bundle
  - Middle third
  - Top third
  - **Objective:** To improve accuracy in identifying airflow and thermal performance variations across different

MAPNA GROUP
MD1 Co.

4

FUTURE STUDY

FUTURE STUDY

- **First Step:**
  - Complete the experimental study Validate the findings from our numerical study.

- **Next Steps:**
  - Design and construct stator blades.
  - Install the stator blades in one ACC module.
  - Conduct the experimental study again.
  - Record the results and analyze the findings.

- **Final Steps:**
  - Perform a cost analysis to identify the most effective solution with minimal cost impact.

PART2

TECHNICAL EVALUATION OF THE EFFECTS OF WIND WALL ABSENCE ON ONE SIDE OF THE ACC

MAPNA GROUP
MD1 Co.

OUTLINE

1 • INCIDENT HISTORY

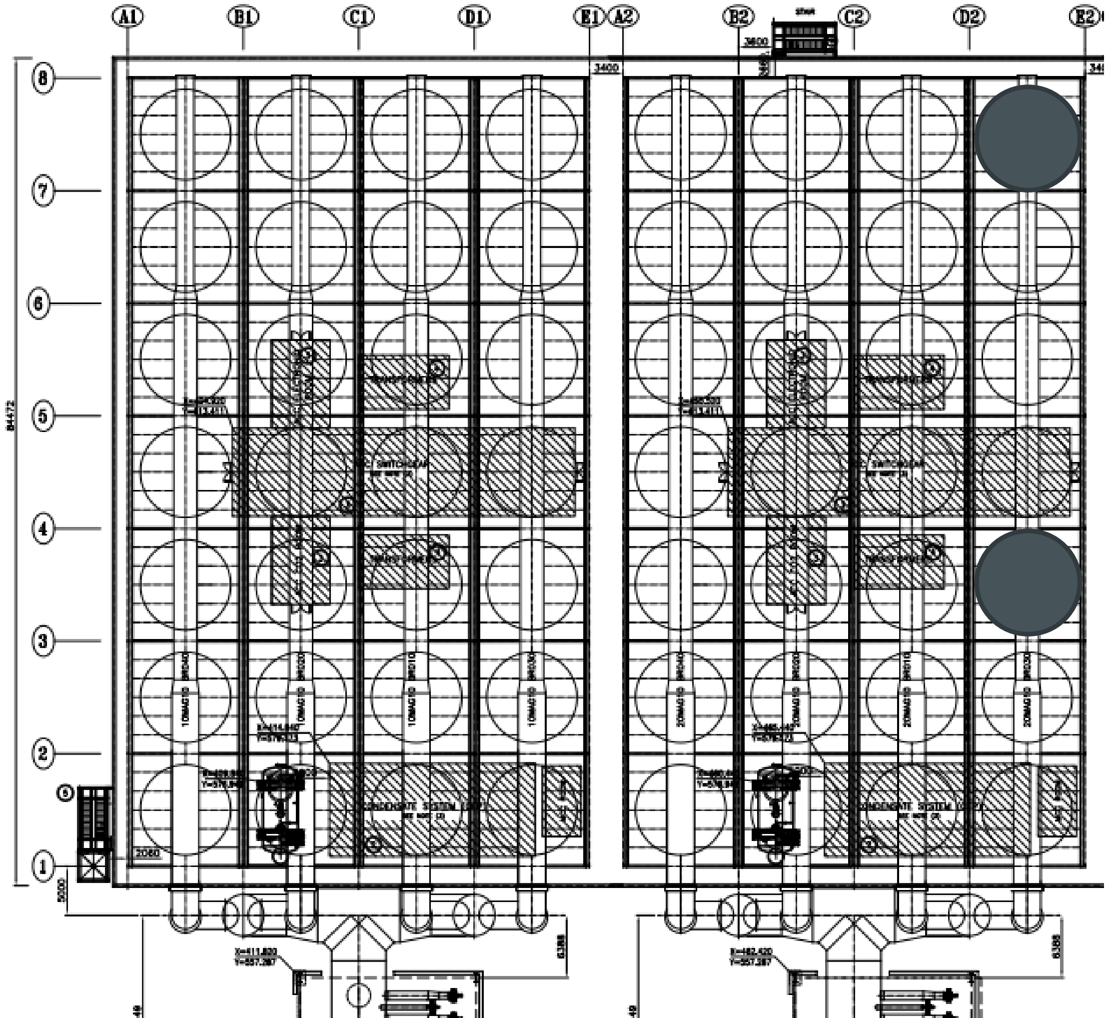
2 • ROOT CAUSE ANALYSIS

3 • RESULT

INCIDENT HISTORY

Failure of Two Fans in the Main Cooling System of Unit 2 at FERDOWSI Power Plant

05/08/2024 & 20/09/2024



MAPNA GROUP
MD1 Co.

INCIDENT HISTORY

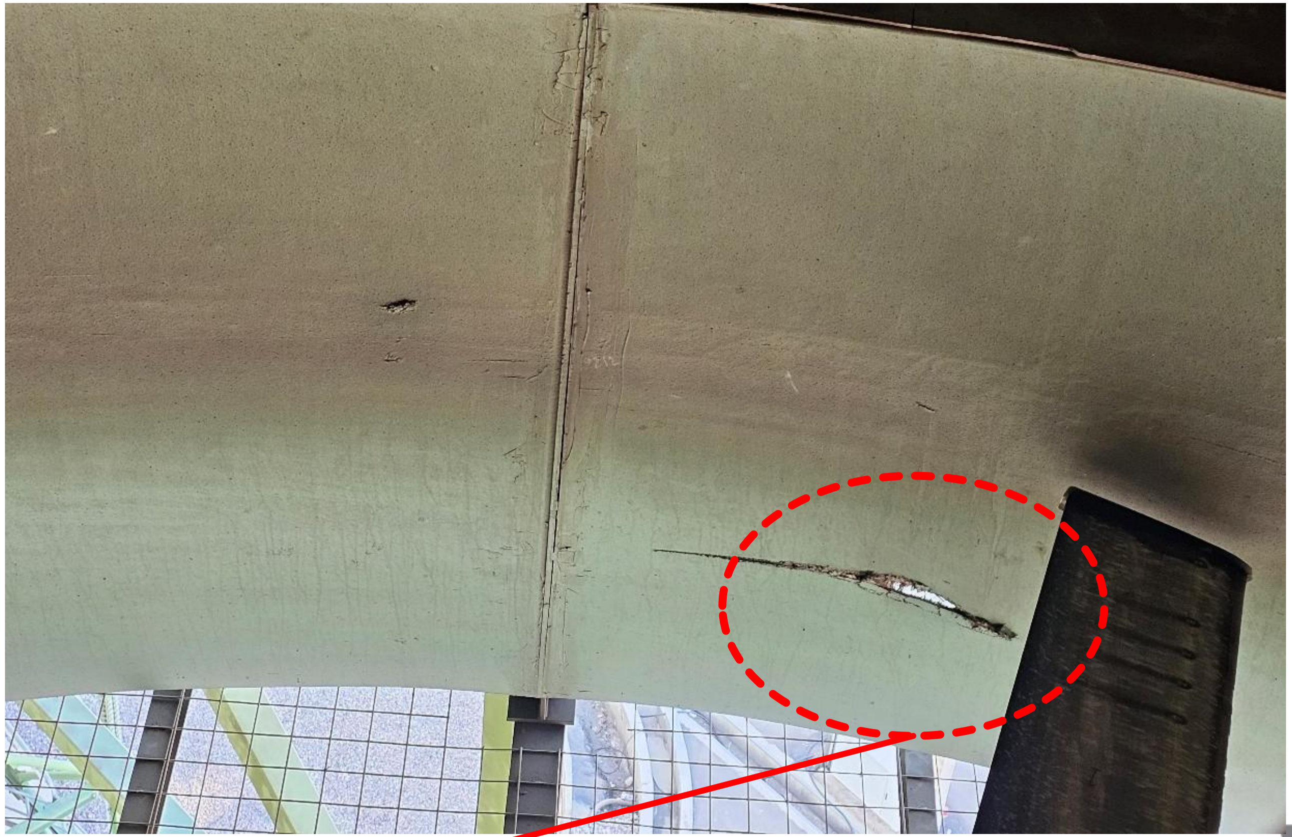
The incident in each case began with the detachment of a single blade from its hub connection

Blade shaft-to-hub connection

MAPNA GROUP
MD1 Co.

INCIDENT HISTORY

Following the initial blade detachment, additional damage occurred to the remaining blades and the fan bell.
Each fan is equipped with six blades.

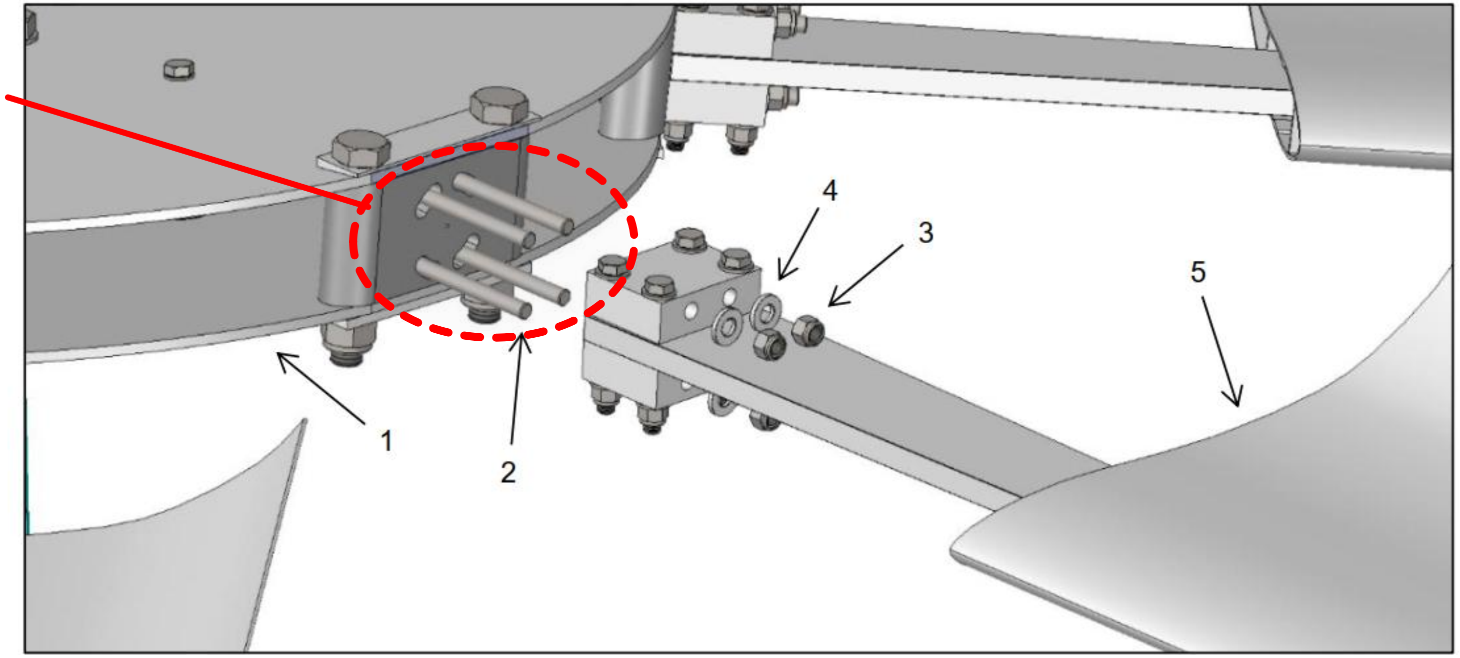


Sample image of the damage sustained by the fan bell

MAPNA GROUP
MD1 Co.

INCIDENT HISTORY

Blade shaft-to-hub connection is made via a Blade Assembly Bolt Group, with four bolts securing each blade to the hub.



MAPNA GROUP
MD1 Co.

INCIDENT HISTORY

The root cause of blade detachment in Ferdowsi Power Plant fans has been identified as the failure of the blade assembly bolts. Evidence indicates that the fracture originated at the bolt head.

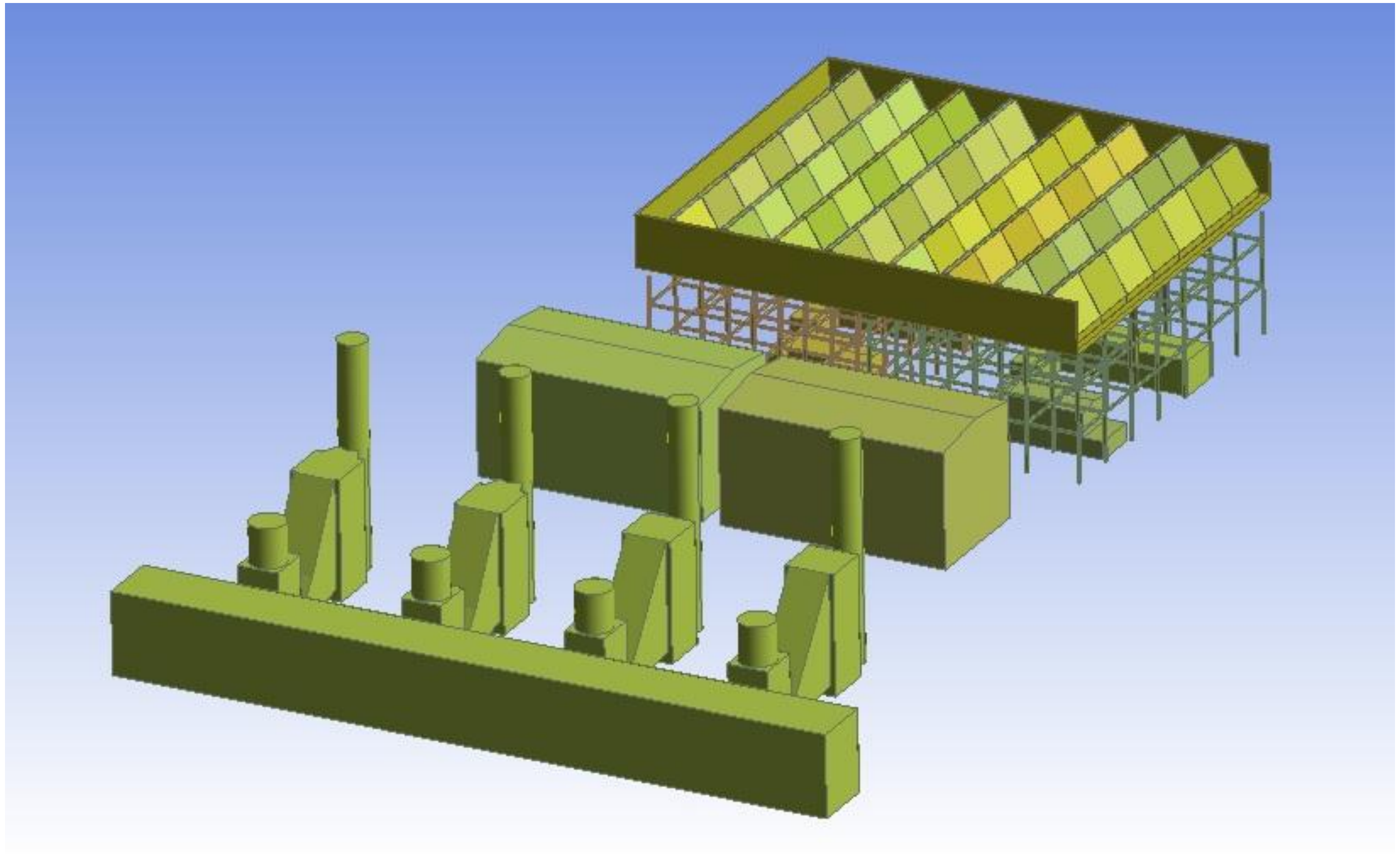
Damaged Bolt

Undamaged Bolt

MAPNA GROUP
MD1 Co.

ROOT CAUSE ANALYSIS

To investigate the malfunction observed in the fans of the main cooling system at Ferdowsi Power Plant, a CFD simulation of the airflow within the main cooling system of the plant's two units was performed.

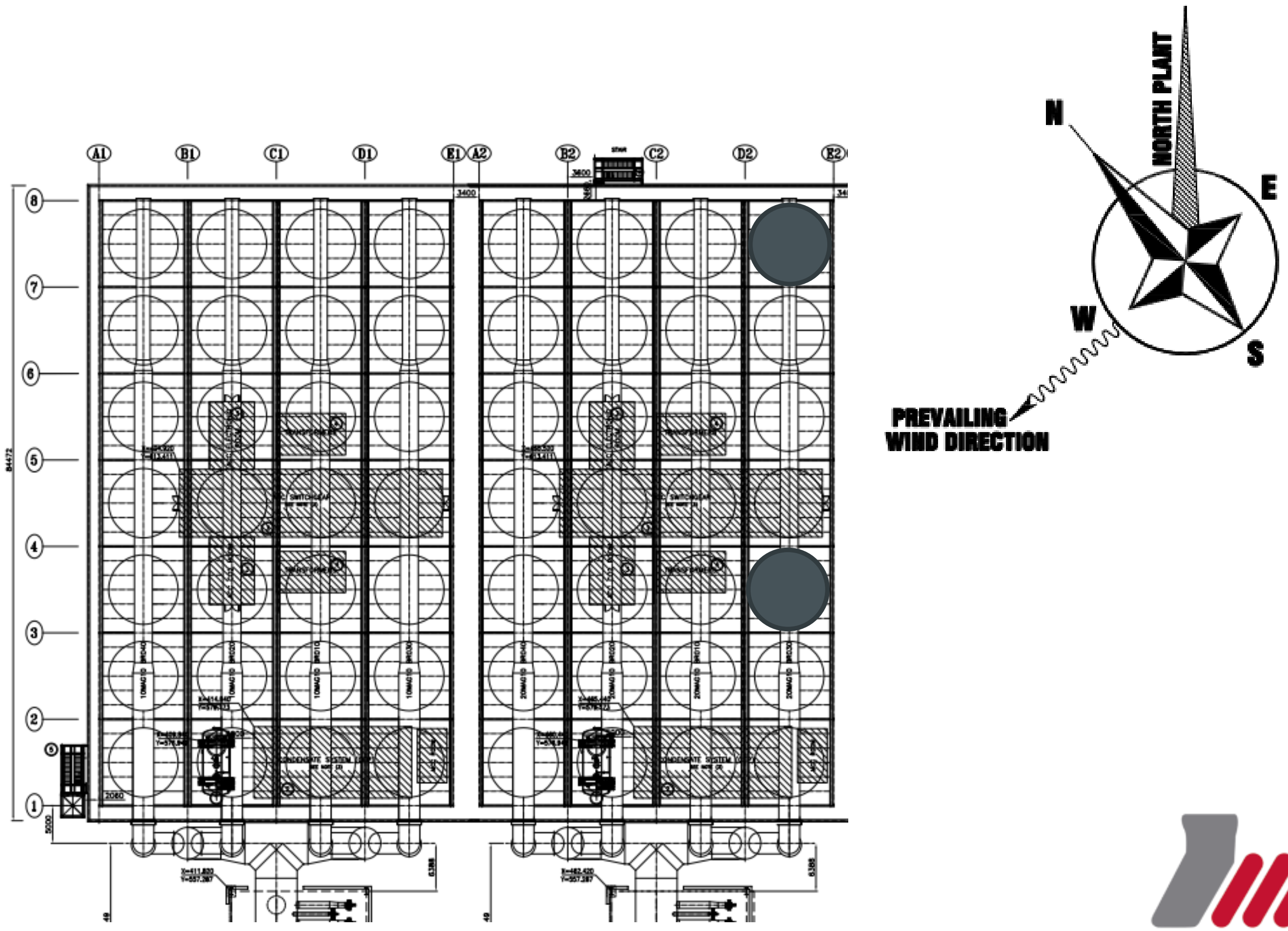


MAPNA GROUP
MD1 Co.

ROOT CAUSE ANALYSIS

The computational domain encompasses the geometry of two Air-Cooled Condenser (ACC) systems, each comprising 4×7 modules, with a platform elevation of 30 meters, including adjacent structures.

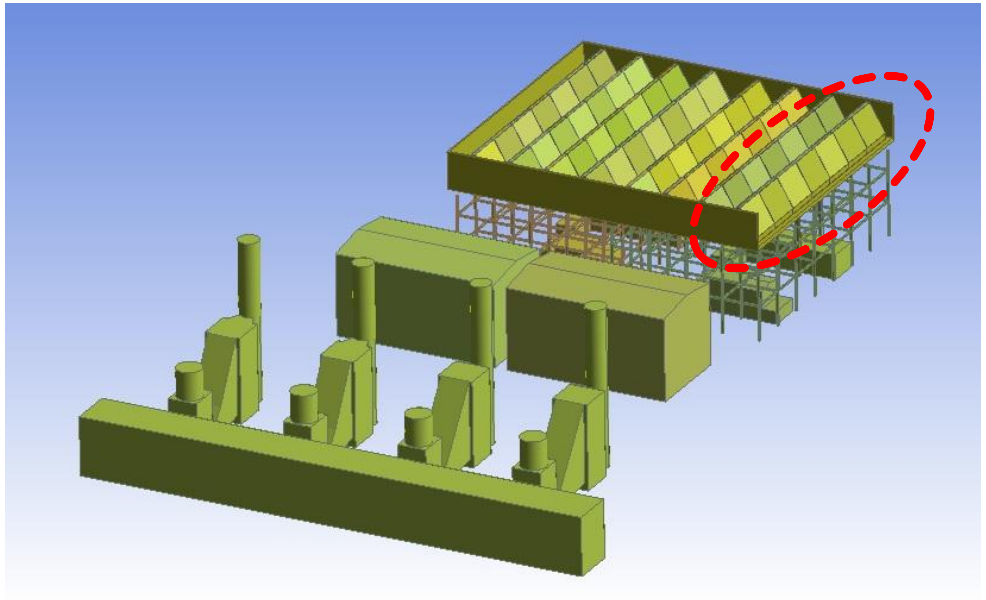
The simulations presented in this report consider a single wind direction (the dominant prevailing wind) and a wind velocity of 3 m/s at a reference height of 10 meters.

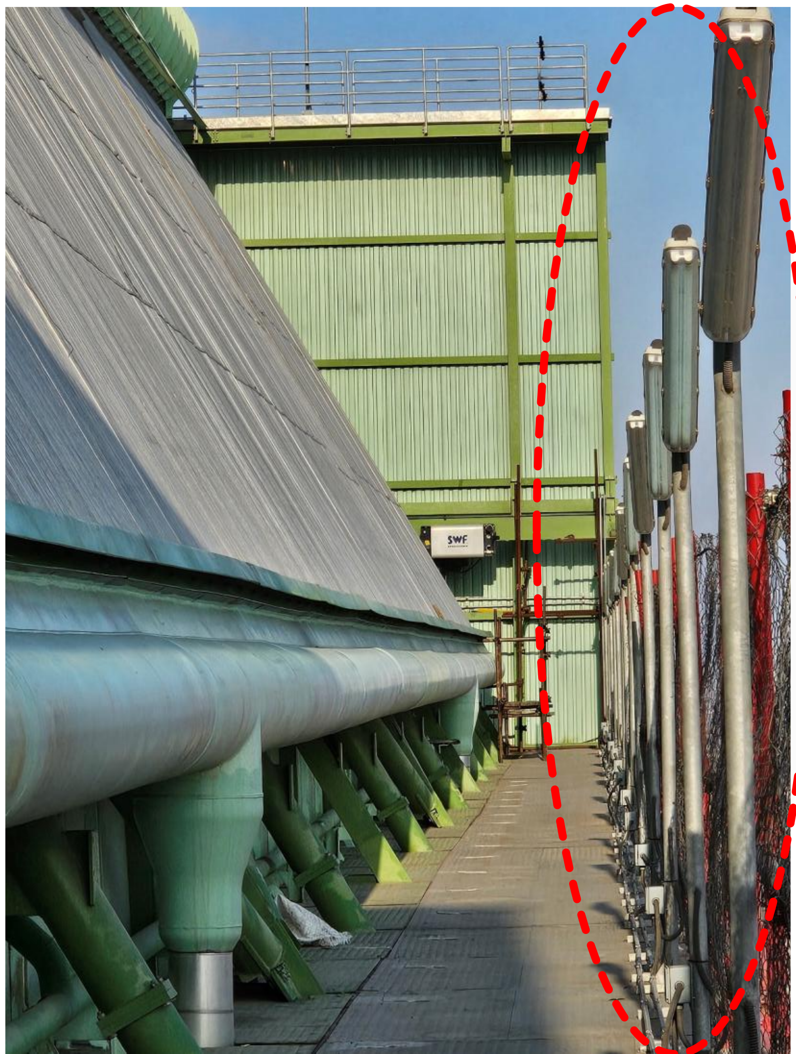


MAPNA GROUP
MD1 Co.

ROOT CAUSE ANALYSIS

Since the power plant is planned to be expanded to three units, a wind wall has not been considered on the eastern side of Unit 2's cooling system.



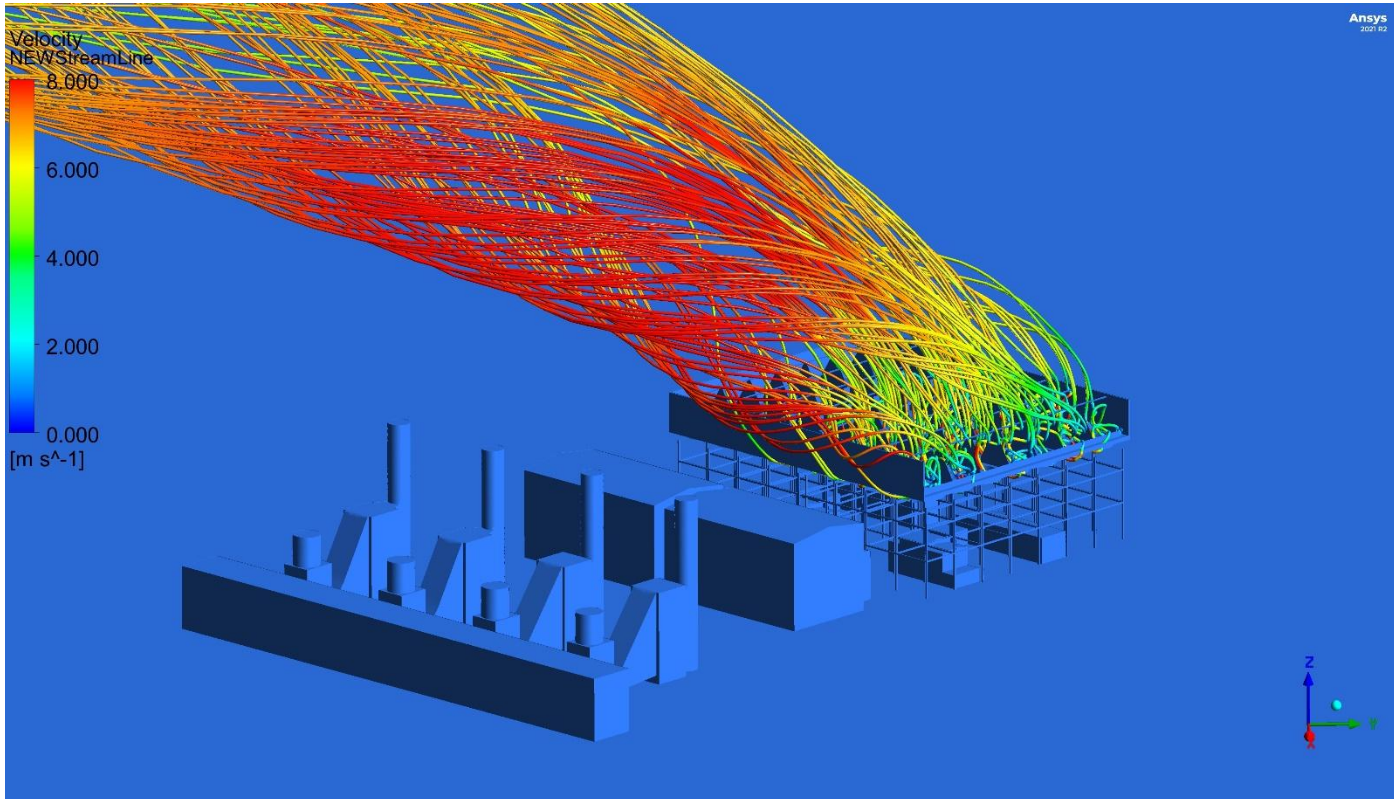


The prevailing wind direction is from the east toward the cooling system of Unit 2 (without a wind wall).

MAPNA GROUP
MD1 Co.

RESULTS

The wind streamlines clearly indicate an east-to-west direction. The damaged fans are located on the row that is directly exposed to the wind due to the absence of a wind wall.

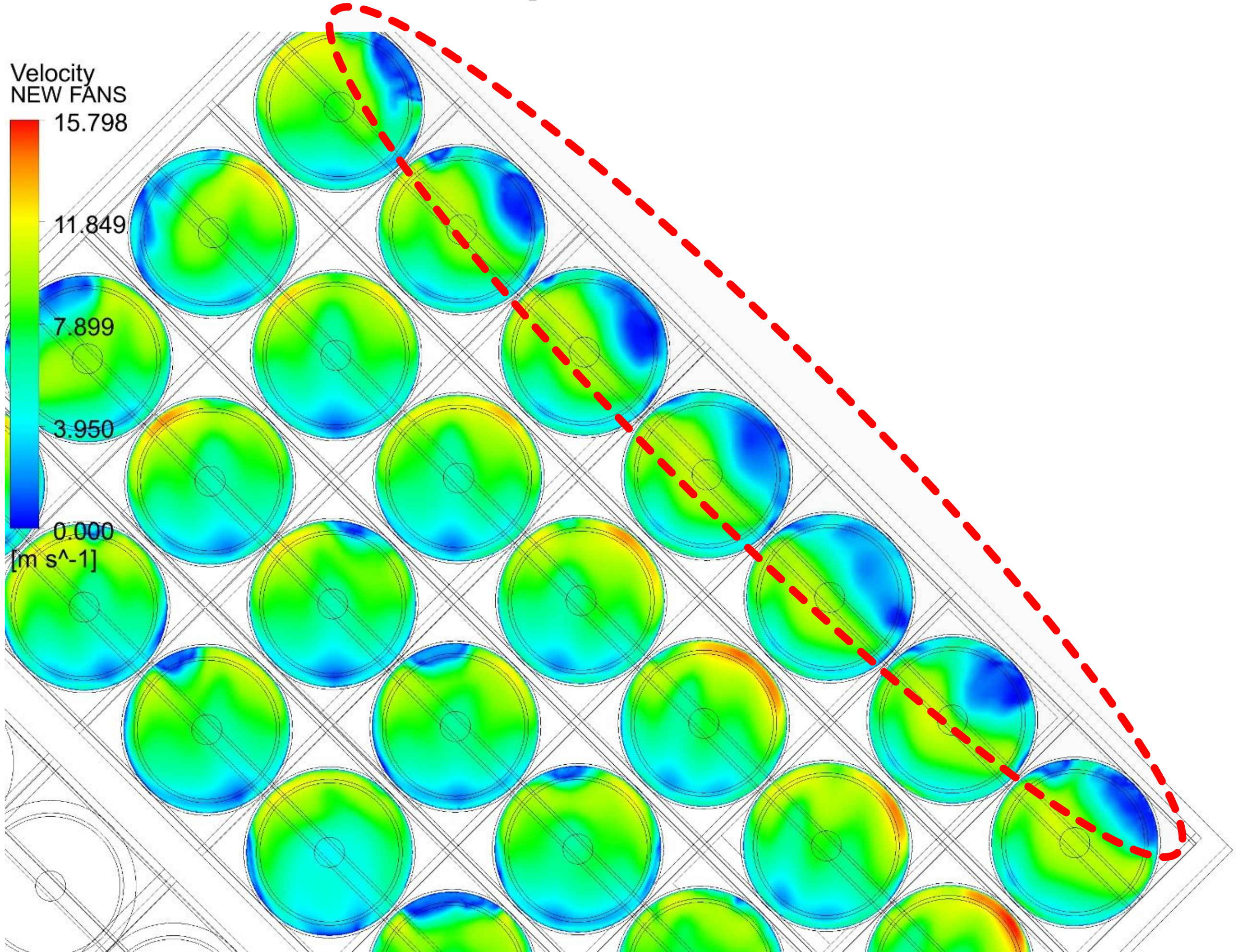


MAPNA GROUP
MD1 Co.

RESULTS

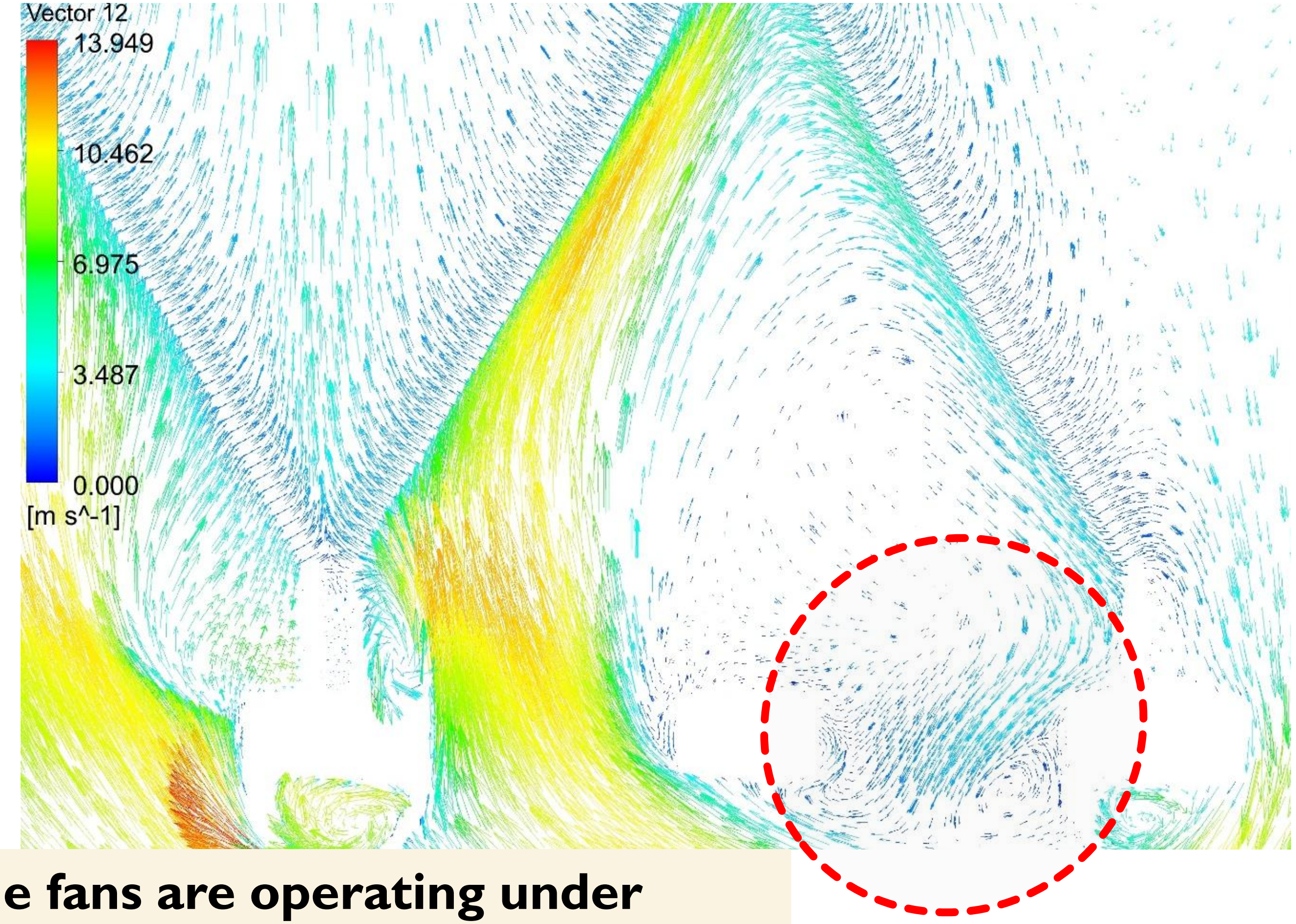
Exposure of the fans to wind causes a deviation in the performance of their cells from the design conditions.

The velocity profile across these fans becomes asymmetric. Direct wind impingement on the tube bundles on one side of the cell has led to a situation where air cannot effectively exit part of the bundle, and even reverse flow may occur.



RESULTS

A portion of the fan is subjected to upward flow velocity, while no airflow passes through another portion. In practice, part of the fan experiences upward air velocity, while in another part, the flow is downward. As a result, during each rotation, the blades are subjected to alternating upward and downward thrust forces.

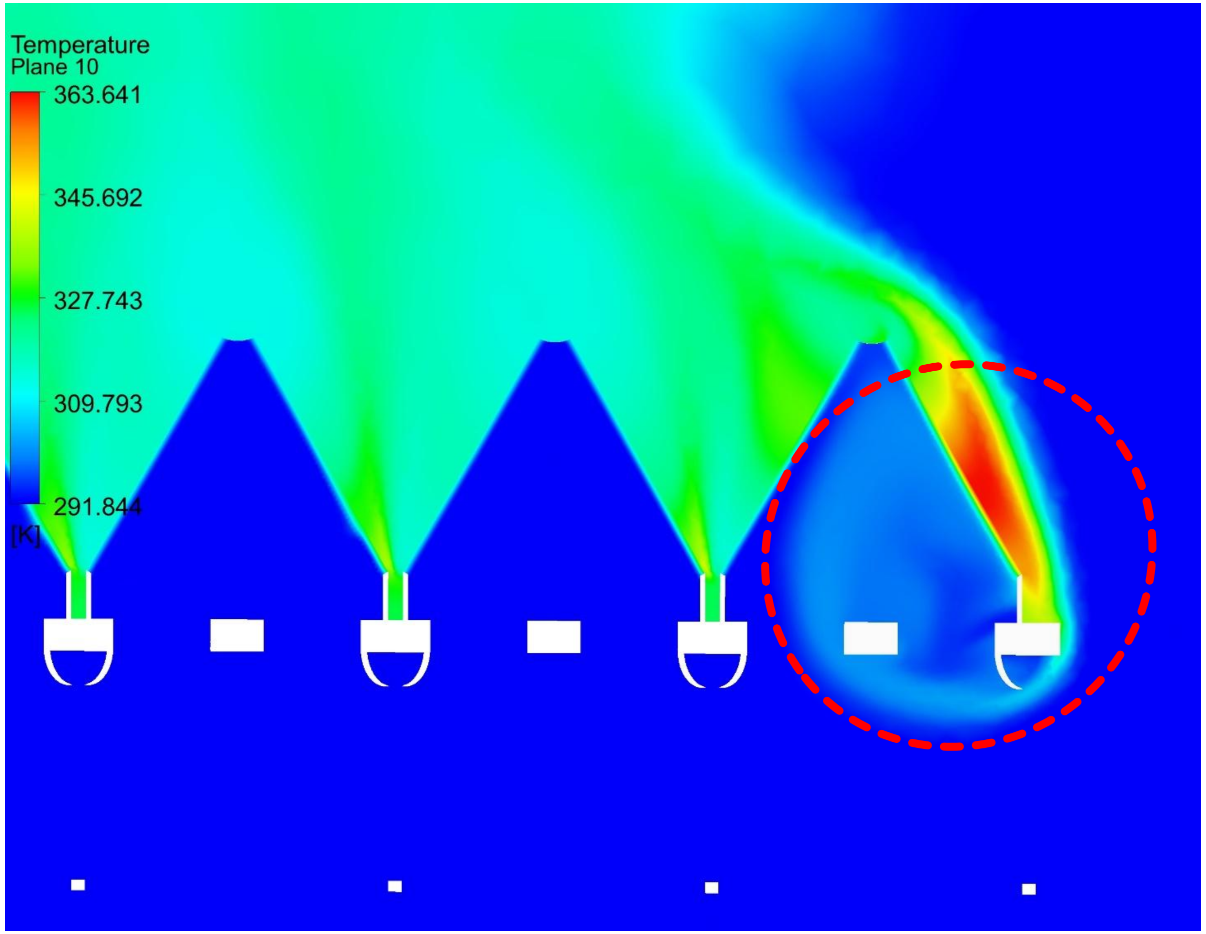


In practice, the fans are operating under dynamically unbalanced conditions.

MAPNA GROUP
MD1 Co.

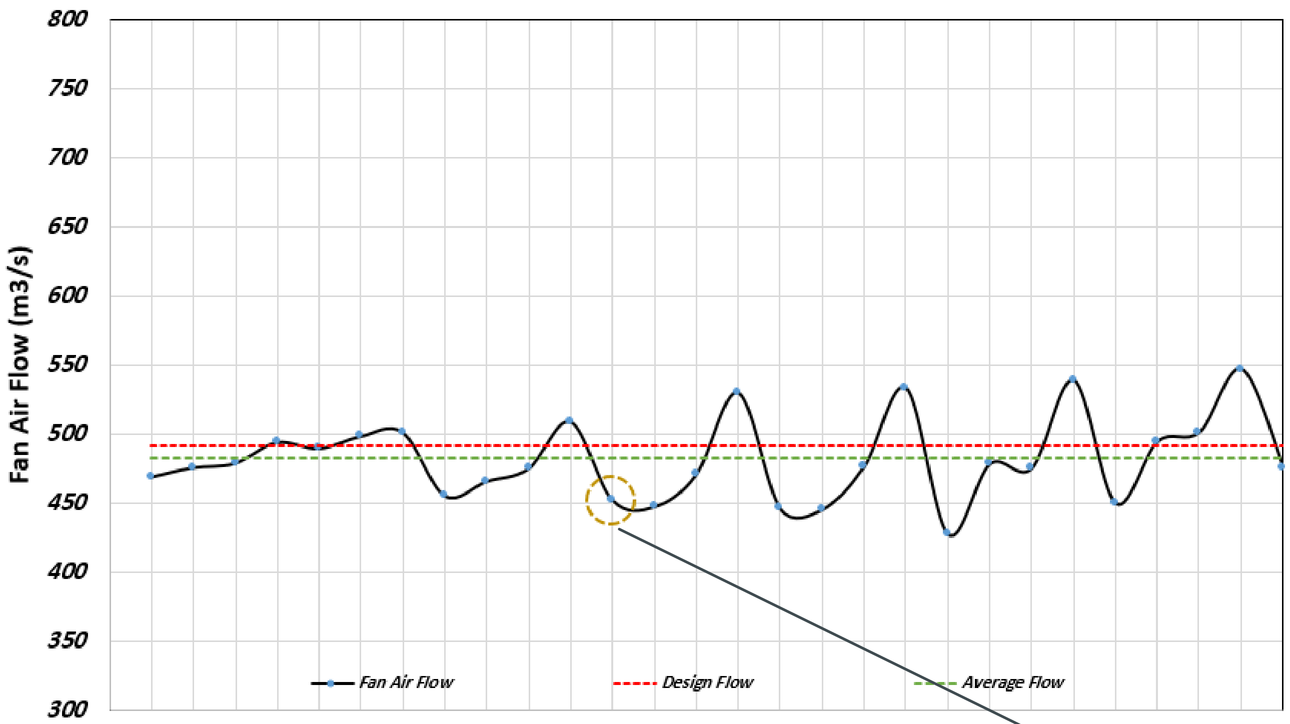
RESULTS

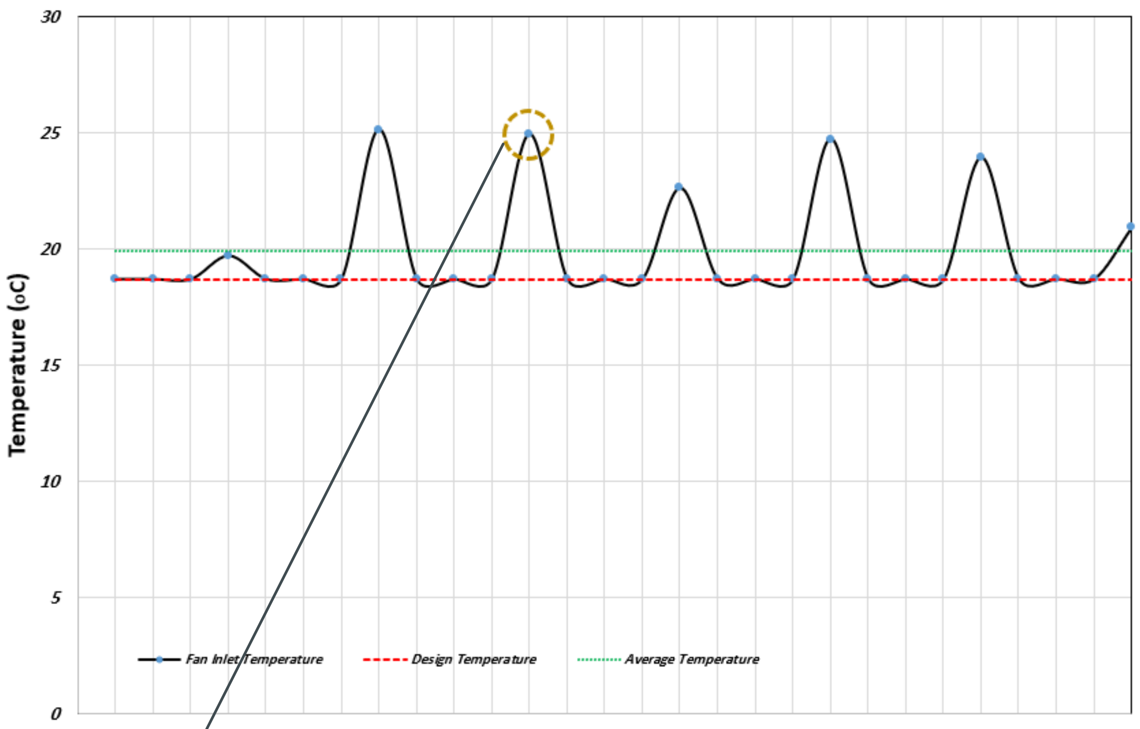
In addition to the mechanical damage to the fan blades, the absence of a wind wall on the eastern side of Unit 2 ACC causes other issues, including reduced airflow through the tube bundles and recirculation of hot exhaust air from the elements back into the fans.

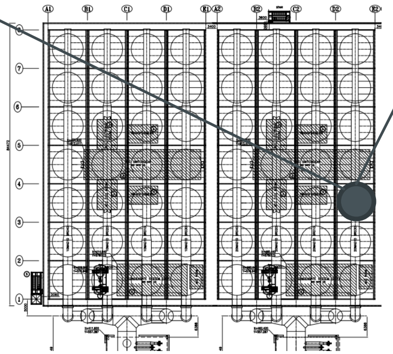


MAPNA GROUP
MD1 Co.

RESULTS







The average airflow rate through the Unit 2 fans is 98.1% of the fan design flow rate.

On average, the inlet air temperature to the Unit 2 fans is 1.15°C higher than the ambient temperature

MAPNA GROUP
MD1 Co.

RESULTS

According to the design, the average inlet temperature to the fans should be no more than 0.45°C above the ambient temperature. However, the deviation in airflow and inlet temperature to the Unit 2 fans (as indicated by the simulation results) will increase the turbine back pressure from 12 kPa to 12.6 kPa under site design temperature conditions. Furthermore, at the site's maximum ambient temperature, the turbine back pressure will rise from 32.8 kPa to 34.3 kPa. Therefore, another consequence of the absence of a wind wall is the reduced performance of the cooling system.

RESULTS

The wind wall plays a crucial role in system performance. Its absence, even temporarily until the new unit is installed, can result in considerable negative impacts on the operation and integrity of the system.

FIND OUR TEAM AT:

TEAM MEMBER	POSITION	LINKEDIN	E-MAIL	PHONE
MONA SHOKROLLAH	Mechanic Expert	linkedin.com/in/mona-shokrollah-569391b2/	shokrollah_m@mapnamd1.com	+98 912 376 36 40
MASOUD NIKKHOO	CFD Expert	linkedin.com/in/masoud-nikkhoo	nikkhoo_m@mapnamd1.com	+98 912 535 91 03
ALI HAMZELOU	Mechanic Expert	linkedin.com/in/hamzehlou-ali-0004088b/	hamzehlou_a@mapnamd1.com	+98 912 734 55 61
MOHAMMADREZA VAGHAR	Energy Efficiency Manager	linkedin.com/in/mohammadreza-vaghar	vaghar_m@mapnamd1.com	+98 912 289 48 77
SHAHIN BAGHERI	Cooling System Design Manager	linkedin.com/in/shahin-bagheri-1a752539/	bagheri_s@mapnamd1.com	+98 915 188 99 61
ALI GHOLAMREZAEI	Mechanic Manager	linkedin.com/in/ali-gholamrezaei-877410a4	gholamrezaei_a@mapnamd1.com	+98 912 534 61 45
NADER KAYVAN	Design & Engineering Deputy	linkedin.com/in/kayvan-nader-381a8899	kayvan@mapnamd1.com	+98 912 507 00 62

Thank you

MAPNA GROUP
MD1 Co.