

RELIABILITY IMPROVEMENT AND FAILURE REDUCTION OF COOLING TOWER FANS

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INTRODUCTION: COOLING TOWER

- The cooling Tower is commissioned since 2006 and 1st failure was encountered in 2007



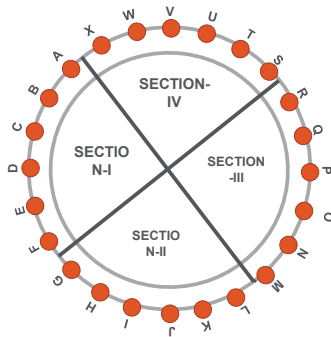
- The cooling tower is designed to cool the sea water coming from various heat exchangers
- The specification of the cooling tower is

Height: 51m
Base diameter: 70m
Water flow at inlet: 67.9 T/hr

Total air flow: 9264 m³/s
Inlet Temperature of water: 45C
Outlet Temperature of water: 36C

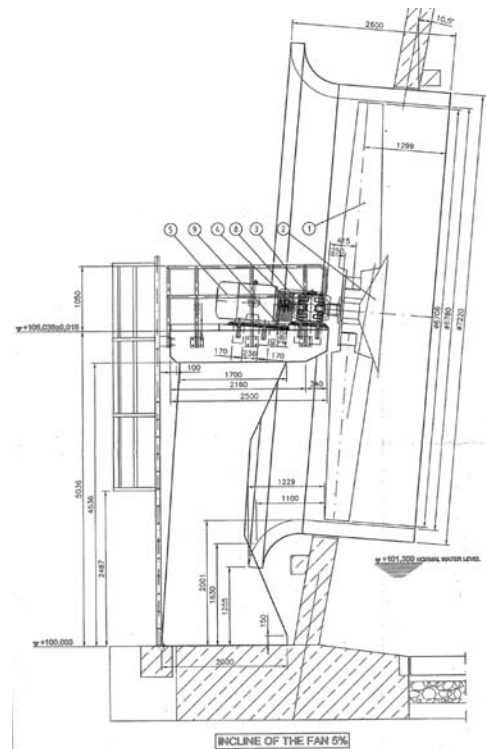
No. 1

INTRODUCTION: COOLING TOWER FANS



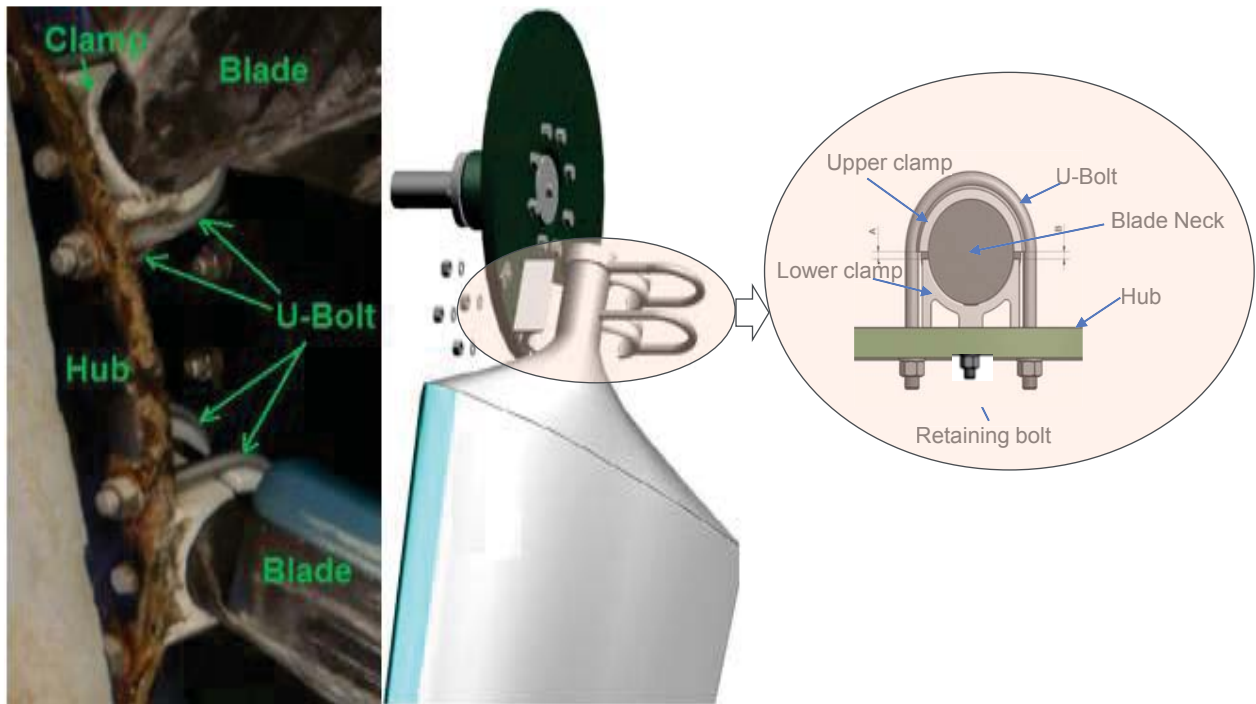
Fan Details:

- The cooling tower has 24 fans (A-X) distributed around 4 sections
- Specification of the Fans
 - Motor capacity: 160kW
 - Fan speed: 140 RPM
 - Number of blades: 8
 - Diameter of the blade: 6706
 - Diameter of the ring: 6760
 - Distance of the fan from the outer point of the ring: 1229
 - Angle of the gearbox / blade shaft axis: 5°



No. 2

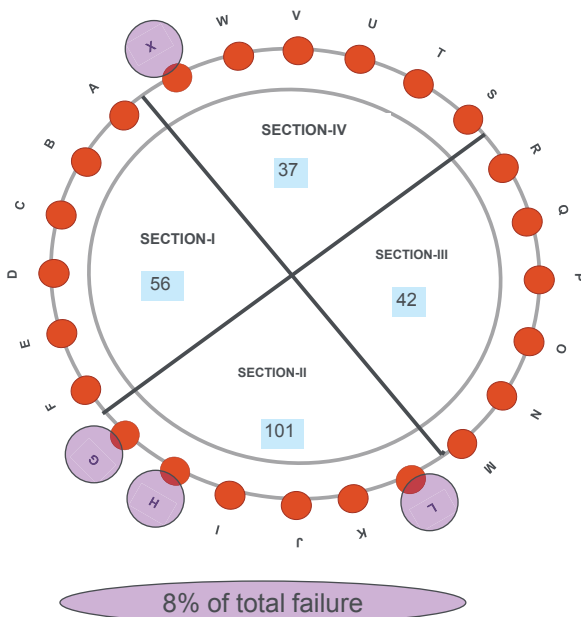
INTRODUCTION: COOLING TOWER FANS



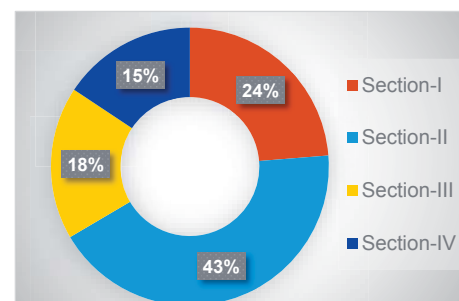
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PROBLEM STATEMENT: FAILURE MODES OF FANS (TILL JUNE'13)

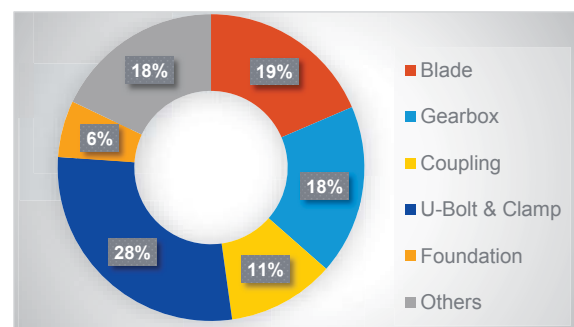
Blade-Wise Failure Distribution



Section-Wise Failure Distribution



Failure Modes Types



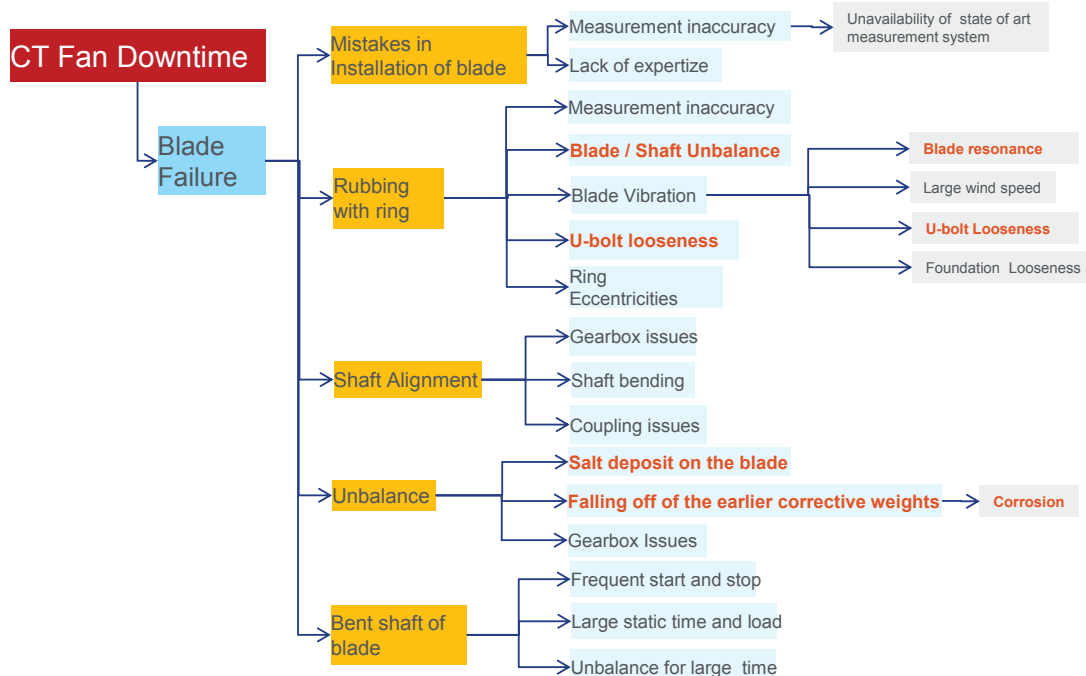
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OBJECTIVE OF THE PROJECT

- **Analyze all the failure modes in details so as to mitigate**
 1. The root causes of the failures
- **Apply preventive maintenance measures so as to improve**
 1. The life of the components
 2. Thus enhancing the reliability of the cooling tower fans
- **Investigate the design and changes the design if required**
- **Analyze the effects of the above changes**

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FAULT TREE ANALYSIS OF COOLING TOWER FANS



Two action plans have been initiated to reduce the root causes:
Design modification and revised PM Plan

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DESIGN MODIFICATION PLAN

- Two Fans (Fan H and Fan L) were selected for designs as there were large failures in these fans

Existing Fans	Prototype -1	Prototype -2
U-Bolt, Nuts and Washers	Duplex U-bolts, Nuts and Washers	Straight Bolts, Nuts and Washers
Blades	Atlac Resin Blades (~7kg lighter than conventional blades)	Blades
Lighter Clamps		Heavier Clamps
1 Hub	Other components same as existing Fan	2 Hubs
2 numbers of U-bolts per blade (16 number of U-bolts)		4 numbers of straight bolts per blade (32 number of U-bolts)
Gearbox		Split Gearbox

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PREVENTIVE MAINTENANCE PLAN INITIATIVES: SOME EXAMPLES

- For further reliability improvements, OEM suggested PM plans were revised using SAFCO's experience and failure mode analysis
 - 15-day PM plan: Regular visual inspection of the fan blades
 - 1-month PM plan:
 - Cleaning the blades : Online washing of blades,
 - Rechecking of blade angle,
 - Integrity checking of U-bolts and clamps
 - Gearbox oil checking
 - Coupling checking
 - 3-month PM plan: Retorquing of the U bolts
 - 1-year PM plan: Replacing the U-bolts and clamps

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RESULTS: DESIGN MODIFICATION

	Prototype - 2	Prototype - 1
# of Failure	1 (Failed since: 23.11.2013)	1 (Two U-bolts on May'15)
Operation time	162 days	763 days
Availability	22.2%	99.7%
Maintenance time	18 hrs	5 hrs
Maintenance Cost	14 times more cost than Prototype 1	

- Failures of two fans have been reduced drastically
 - From 8% of total failures to less than 1% of total failures

Design of Prototype -1 (with change of materials) has been the best design as found from the experimental investigation

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RESULTS: TYPES OF FAILURE IN PROTOTYPE -1 AND -2

Prototype-2 Failure



Prototype-1 (Fan L) Failure



- The rubbing of one blade of Fan H and the ring was found that caused large vibration
- The Fan L was found to have a broken Duplex U-bolt with crack at the threads (corrosion) and inherent defect
- However, it has less failure rate

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RESULTS: PREVENTIVE MAINTENANCE PLAN IMPLEMENTATION

- **Total amount of failures in cooling tower fans has been reduced by 56%**
- **Maximum Failures are in Fan- K of Section -2 (with 10% of total failures)**
- **Failures in Sections as %age of total failures**
 - Section-1: 32%
 - Section-2: 32%
 - Section-3: 19%
 - Section-4: 17%
- Contribution of Section-2 to total number of failures have been reduced due to design modifications of its two important fans (Fan-L and Fan-H)

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CONCLUSION

- The performance of Fan L (Prototype-1) was satisfactory with respect to that of other fans in Section II
 - Higher availability
 - Higher Mean Time Between Failure
- The PM plan has been effective in reducing failures by 56%

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FUTURE PLAN

- The implementation of Fan L design (Prototype-1) in all the fans:
It is expected to further improve the reliability of the fans
 - Fan blades will be changed to lighter Atlac Resin Blade (nearly 7 kg lighter blade)
 - U-bolt material will be changed to Duplex type for reducing the corrosion
- Gearbox and foundation failures are expected to be reduced after the installation of new design due to
 - The new lighter blades (with nearly 56 kg reduction per fan)
 - Lesser unbalance (with PM plan of cleaning of blades)
 - Lesser looseness (with new type of duplex U-bolts and looseness check during PM)
 - Improvement of the structure