ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

# Prediction of Blade Resonance of Cooling Tower Fans UsingVibration Analysis

[1] Dr.Yadavalli Basavaraj [2]G Raghavendra Setty [3]Santhosh Naik
[1]Professor& Head [2]Asst. Professor [3]Jr. Manager
[1][2] Department of Mechanical Engineering,
Ballari Institute of Technology & Management, Bellary, Karnataka, India.
[3]Central Maintenance Department, JSW Steel Ltd, Vijayanagar Works, Bellary,Karnataka, India.

***Abstract:*— Cooling towers are a critical component in many power generation, chemical and integrated steel plants.Catastrophic equipment failure can result in safety hazards, lowered production, and expensive repairs. Blades are the important parts of the fan. The main objective of this research work is to find the resonance of cooling tower fan using vibration analysis. This method can eliminate the failures of the cooling tower fan blades, shorten the repair cycle, ensures the smooth production of the enterprise and improve economic efficiency.**

***Keywords:*----- Cooling tower, Vibration analysis, Blade pass frequency, Cooling tower fans (A, B &C).**

## I. INTRODUCTION

A cooling tower is a heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. They represent a relatively inexpensive and dependable means of removing low-grade heat from cooling water. Cooling towers make use of evaporation thereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly.Vibration monitoring of cooling tower fans, gear boxes, shafts, and engines gives early warning of machine failures.

## II. COOLING TOWER OF HOT STRIP MILLIN A STEEL INDUSTRY

Hot Strip Mill consists of ROT (Run Out Table) Cooling Tower (Which cools the sheet metal coming from finishing stand 6 to Coiling box ) so after this cooling process the hot water enters into the induced draft counter flow cooling tower connected to it. It consists of 3 fans namely Fan-A, Fan-B and Fan-C.

***Run Out Table Cooling System***

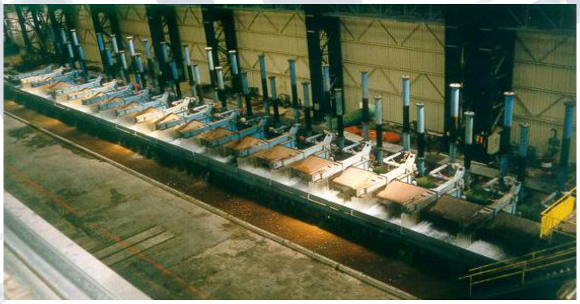

***Fig.1 Run out Table Cooling System***

The ROT cooling system is divided into nineteen (19) cooling zones. Each cooling zone consists of a top water wall header, a bottom spray header and side sweep sprays with additional air blow offs. There are two strip temperature measuring points. The purpose of the ROT cooling system is to cool the strip while it is travelling from the last FM stand to the down coiler pinch roll. The final coiling temperature is controlled in order to achieve the required mechanical properties of the strip.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

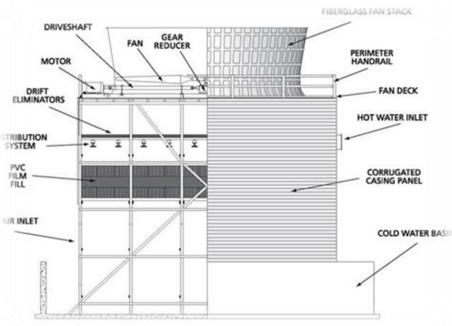


*Fig.2 Structure to indicate the cooling tower fan*

### III. PROBLEMDEFINITION

The ROT Cooling Tower is a newly built structure with 3cells; during the commissioning we faced the problem of high vibration at full speed. Fans were started at predefined set of running speed. These fans were set at 750rpm, 1000rpm, 1300rpm and 1490rpm (Full speed). Department advised to take vibration at these speed. Fans behavior was normal at 750rpm, 1000rpm and 1300rpm. Overall Vibration of all the fans was 1.5mm/sec peak. After 3-4days dept run the fans at 1490rpm (full speed).

Suddenly vibration was shoot up at 1490rpm, with FAN-B vibration was found very high at 9.1mm/sec peak and FAN-A and FAN-C was slightly at lower side compared to FAN-B. It was noted that FFT reveals a High 1.2x peak of running RPM.

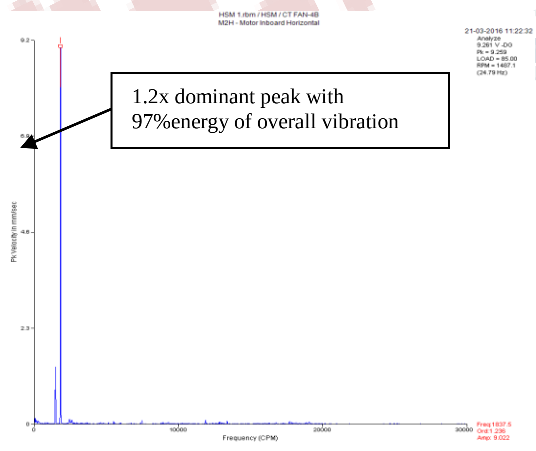


*Fig.3Vibration spectrum of ROT Cooling Tower FAN-B*

1.2x peak was not related to any bearing defects/gear meshing problem. It was certain peak which is causing higher magnitude vibration in the fan. Calculations has been done to find this frequency.

### IV. CALCULATIONS

Motor Speed**:**1490rpm
Gear Ratio**:**12.93
Number of Blades**:**8
Fan Speed**:** 115rpm
Blade Pass Frequency**:** No Of Blades * Fan Speed
= 8*115=920rpm

After these calculations, concluded out that 1.2x peak is the 2x Blade pass frequency. At high speed we got 1.2x as dominant peak in the spectrum and it is seen that it was dominant peak of all the fans. In FAN-A overall vibration was 4.8mm/sec peak and in FAN-C overall vibration was 3.0mm/sec peak but the amplitude of 1.2x is less compared to FAN-B due to high vibration at FAN-B. Subsequently we carried out maintenance and adjusted the track length to 1.5inches and blade angle to $11^0$.

### V. ANALYSIS

Initially data has been collected by attaching accelerometer @ motor bearings and found that 1840cpm as the most significant source of vibration. A 1840cpm will be considered as the 2x blade pass frequency as the fan rotating speed is (115cpm*8) multiplied twice. It should be noted that this frequency and magnitude are representative of the entire blade systems and not any one particular blade. From this information, it is concluded that there is some excitation causing the vibration.

In order to determine the blade vibration, a natural frequency or a resonance test has to be performed. The first set of data has been collected while the fan was in a static condition. In static condition, the transducer was mounted in vertical direction at the fan blade tip so that the sensitive axis would be in line with the flow of air through the fan. Then the data of each blade gathered by exciting by pulling down the blade until it reached approximately 2 inches and then released. This test was performed several times in order to ensure accuracy. The vibration spectrum has been obtained and the plot indicates the predominant frequency of 210-230cpm range. This is the natural resonant frequency of the blade as mounted on the fan.

This peak results multiple of 4times of which is blade pass frequency of the fan, which is related to the fan cell design. The design of the fan cell is made such a way that in normal operating mode, the fan blade loads up as they perform work. This loading up is caused by the movement of air through the cell. The loaded blade condition is constant except when the blade passes through one of the four beams. When the blade positioned over one beam, the movement of air is interrupted. This interruption causes the blade to unload condition which results in resonance of the blade.

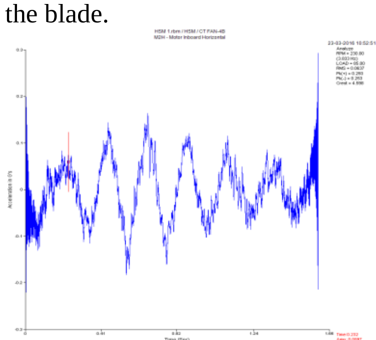

***Fig.4 Acceleration Vs Time Vibration spectrum of ROT Cooling Tower FAN-B***

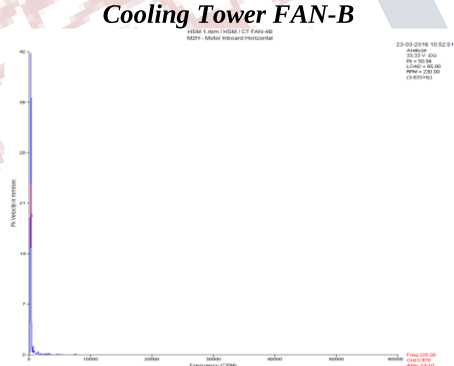

***Fig.5 Amplitude Vs Frequency Vibration spectrum of ROT Cooling Tower FAN-B***

**VI BRATION READINGS OF FAN-B AT 1490 RPM**

| COMPONENT | H | V | A |
|---|---|---|---|
| MOTOR NDE | 6.2 | 4.5 | 2.4 |
| MOTOR DE | 9.2 | 4.7 | 1.6 |

***Table.1 Vibration Readings of Fan-B at 1490 Rpm***
***Note: Readings are in mm/sec peak***

## VI. CONCLUSION

The fan cell design provides an excitation force which is excited to the natural frequency of the blades. This means that the exciting force causes the high vibration throughout the cell, due to the position of FAN-Bbetween the other two cells the excitation has been summed up and amplified the vibration. The obvious solution was to change the resonant frequency of the blades. This could be accomplished by filling each blade by foam or by constructing it with a stiffer, fiberglass configuration. This will increase the natural frequency of the fan blades.

**VIBRATION READINGS OF FAN-BAT 1430RPM(After reducing the speed)**

| COMPONENT | H | V | A |
|---|---|---|---|
| MOTOR NDE | 1.0 | 1.5 | 1.5 |
| MOTOR DE | 1.9 | 1.6 | 1.6 |

***Table. 2 Vibration Readings of Fan-B at 1430 Rpm (After reducing the speed)***
***Note: Readings are in mm/sec peak***

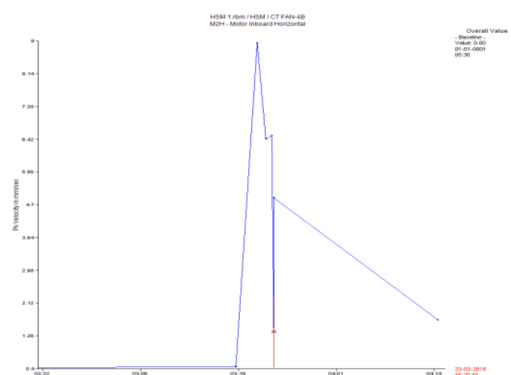

***Fig.6 Amplitude Vs Frequency Vibration spectrum of ROT Cooling Tower FAN-B***

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

***(After reducing the speed)***

In order to achieve this, a significant change in design of the blades or by increasing the number of blades has to be done. It is suggested to the department to run at lesser speed. So by changing the predefined speed the fan has run upto 1430rpm and found vibration to the minimum limits.

## REFERENCES


[1] Li Lei, Qian YanLing, Du Kai and Yang Y ongMin" A Fast Development Framework for Condition-Based Maintenance Systems" Inproc. 2nd International Conference on Mechanical and Electronics Engineering in 2010, vol-2,inc. ICMEE 2010.

[2] Zhang Changxing and Hu Songtao" Simulation of ThermalExchange Process in Counter flow Cooling Tower" vol 1 2010 2nd International Conference, IEEE international conference, inc.2010.

[3] Zhang Changxing, Hu Songtao. "Thermal performance coefficient identification for counterflow cooling towers". Journal of HV&AC (Chinese), Vol. 39, February, 2009, pp. 23-26.

[4] Kalatuzov V. A."A Procedure for constructing the normative characteristics of chimney-type evaporative cooling towers from the results of Field measurements," ISSN 0040-6015, Thermal Engineering, Vol. 54, No. 11, pp. 901–905, inc. 2007

[5] Thermal Engineering S Chand Publication Author Khurmi And Gupta.

[6] McElveen Robbie, Lyles Keith, Martin Bill, WassermanWayne"A new more reliable solution for cooling tower drives," in proc. IEEE paper no.PCIC-AN97, inc.2010

[7] Nelson D.A."The influence of cooling requirements chassis resistance, and fan selection on noise emission", SEMI-THERM. 25th Annual IEEE, 2009

[8] Pariazar M., Shahrabi J., Zaeri M.S.,andParhizi Sh"A combine approach for maintenance selection," journal of Applied Science 8 (23) 4321-4329, inc. 2008 .

[9] Afanasenko V. G., Khafizov F. Sh., Khafizov N. F. I vanov S. P. and Boev E. V."Development of designs for polymeric water traps in cooling towerusing centrifugalseparation forces," journal of Chemical and Petroleum Engineering, Vol. 43, Nos. 11–12, inc. 2007.

[10] Kalatuzov V. A."A Procedure for constructing the no rmative characteristics of chimney-type evaporative cooling towers from the results of Field measurements," ISSN 0040-6015, Thermal Engineering, Vol. 54, No. 11, pp. 901–905, inc. 2007.

[11] Jianfeng Qian, Lina Li, Yankun Tan And Dayu Zheng, "Research And Application Of Closed Cooling Tower",2nd International Conference On Electronic & Mechanical Engineering And Information Technology (Emeit-2012),1-3.

[12] Kungxiong T, Shiming D. A numerical analysis of heat and mass transfer inside a reversibly used water cooling tower. Building and Environment 2003; 38(1):91–7.

[13] Water cooling towers. BS 4485 British Standards Institution, 1988.Publishers, Inc., 1986.

[14] Majumdar AK, Singhal AK, Spalding DB. Numerical modeling of wet cooling towers. Part 1: mathematical and physical model. Journal of Heat Transfer 1983; 105(4):728–35.

[15] Majumdar AK, Singhal AK, Spalding DB. Numerical modeling ofwet cooling towers. Part 2: application to natural and mechanical draft towers. Journal of Heat Transfer 1983; 105(4):736–43.

[16] Neetesh Singh Raghuvanshi, Dr. Alok Singh, "Development of maintenance strategy to improve performance of natural draft cooling tower", international journal of scientific and research publications, vol. 4, no. 8, pp.1-7, august2014.

[17] R. Ramkumar,A. Ragupathy, "Thermal Performance Of Forced Draft Counter Flow Wet Cooling Tower With Expanded Wire Mesh Packing", International Journal On "Technical And Physical Problems Of Engineering" , vol. 3, no. 1,pp.19-24, Mar. 2011.

[18] Pushpa B. S, Vasant Vaze, P. T. Nimbalkar, "Performance Evaluation Of Cooling Tower In Thermal Power Plant -A Case Study Of Rtps,Karnataka",International Journal Of Engineering And Advanced Technology , vol.4, no.2, pp.110-114,December 2014.

[19] S. Parimala Murugaveni, P. Mohamed Shameer, "Analysis of forced draft cooling tower performance using Ansys Fluent software", international journal of research in engineering and technology, vol. 04 no. 04, pp.217-229, apr-2015.

[20] Jianfeng Qian, Lina Li, Yankun Tan And Dayu Zheng, "Research And Application Of Closed Cooling Tower",2nd International Conference On Electronic & Mechanical Engineering And Information Technology (Emeit-2012),1-3.