WARMAK

Vibration Analysis and Balancing of Cooling Tower Cells

Abstract

Diagnose recurring vibration problems on a 5-cell unit cooling tower. It was determined that fan unbalance was causing the high levels of vibration. The original vibrations at running speed for cooling tower units 1, 2, 3, and 4 were 32 mils, 16 mils, 24 mils, and 60 mils respectively. The vibration levels after balancing for cooling tower units 1, 2, 3, and 4 were 3.75 mils, 3.4 mils, 2.44 mils, and 4 mils respectively at running speed. Measurements were made in the radial direction on the gearbox (90 degrees to the drive shaft). The vibration levels measured after balancing are classified as fair by the General Services Chart for Cooling Tower Fans.

Contents

Scope

To provide labor and equipment for diagnosing a recurring vibration problem on a 5-cell unit cooling tower. The scope was expanded to include balancing.

Background

The Hudson fans had been installed for approximately 12 months and constantly ran at high vibration levels. The fans had required balancing every 3 months.

Machine Configuration & Operating Characteristics

Fan Motor Manufacturer: Reliance
Number of Blades: 6
Fan Speed: 420 RPM
Motor Speed: 1750 RPM
Motor Horsepower: 40
Gear Box (90 Degree): Arrow Gear, Model 3000
Gear Reduction: 4.25/1
Coupling: Dana, Model A5, 4-Bolt

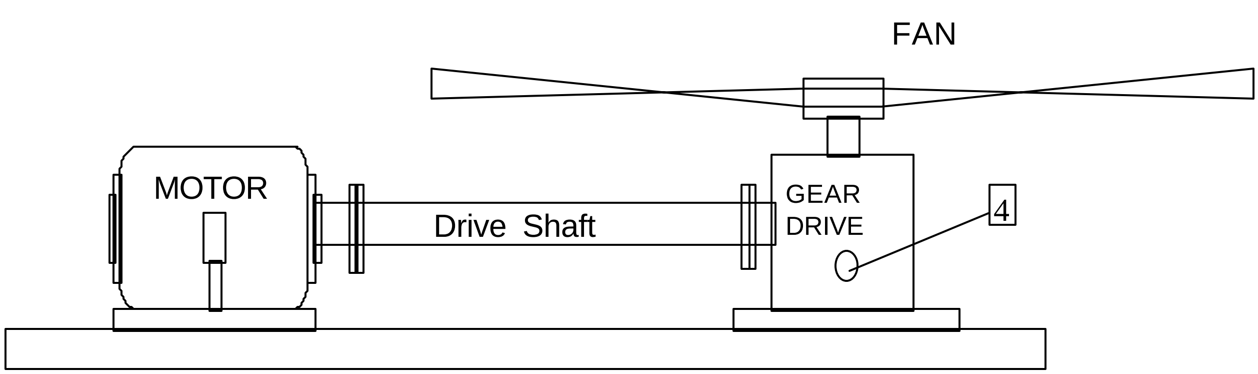

Figure 1: Machine Configuration

Procedure

Analysis of the vibration from the cooling tower fans included a discussion with personnel monitoring the vibration levels of the fans. A trend analysis was reviewed for the fans and it was clear that the fans were experiencing exceptional high vibration (0.5 pk in/sec) and were not responding to balancing over a long time span.

An inspection was made of the fans and it was observed that balancing weights had been placed on the leading edge of the fiberglass blades. It appeared that the balancing method formerly used was strobing a light-sensitive tape on the tip of one blade. Further, it was noticed that the drain holes in the ends of the blades had not been checked and there was build-up of material in the blades that had plugged the drain holes. A hole was drilled in the tower shroud to access the drain holes. The cleaning of each blade in every cell was attempted along with increasing the hole diameter in the end of the blades. Cells 1 and 4 had to be completely disassembled, removing all blades before the internal portion of the blades could be cleaned.

The debris removed from the blades appeared to be straw which was compacted at the tip of the blades. When the fan was running, the straw was absorbing water from the opening at the end of the blade in the hub mounting. This phenomena created a variable weight in the blades which explains why a balanced condition would not persist for any period of time. Cells 2 and 3 were cleaned sufficiently without disassembling by enlarging the drain hole and using a water hose to flush out the blades. After a brief discussion with plant personnel about the installation it was found that the fans sat on site for some time before installation. Several birds apparently built nests in the fan blades.

A vibration amplitude spectra was taken on the fans using a low frequency transducer (see equipment section in appendix) mounted to the gear box in the radial direction (90° to the drive shaft). This is shown as position "4" in Figure 1. In all cases, vibration levels were high (pk/pk mils 17, 25, 32, 60) and the time wave form along with the high spike in the spectrum at the running speed of the fan indicated that the fans were unbalanced.

All weights were removed from the fiberglass blades and initial readings were made. A no-phase balancing method was used in which a known trial weight was moved on each succeeding run to a new location on the fan rotor.

The result of the four runs was used to calculate a correction weight amount and position on the lower plate of the rotor (eight holes had been provided by the manufacturer for attaching the weights).

The field data and vibration analysis results are shown in the following section.

Results

Fan #1 Field Data

Trial Weight = 177 grams

Run	Vibration Level (mils)	Trial Weight Position	Hole Number
1	31.6		
2	23.3	0°	1
3	41.1	135°	4
4	26.2	270°	7

Correction Weight Quantity & Locations:

- 461 grams @ Hole 8 or 315^o
- 123 grams @ Hole 1 or 0^o

Final Vibration Amplitude: 3.75 mils

Fan #2 Field Data

Trial Weight = 177 grams

Run	Vibration Level (mils)	Trial Weight Position	Hole Number
1	16		
2	21.6	0°	1
3	7.3	135°	4
4	16.9	270°	7

Correction Weight Quantity & Locations:

- 105.3 grams @ Hole 4 or 135^o
- 308.6 grams @ Hole 5 or 180^o

Final Vibration Amplitude: 3.40 mils

Fan #3 Field Data

Trial Weight = 193.2 grams

Run	Vibration Level (mils)	Trial Weight Position	Hole Number
1	24.1		
2	31.6	0°	1
3	21.7	135°	4
4	24.2	270°	7

Correction Weight Quantity & Locations:

- 495 grams @ Hole 5 or 185°
- 193.1 grams @ Hole 6 or 225°

NOTE: This fan would not balance before blades were disassembled and cleaned.

Final Vibration Amplitude: 2.50 mils - Trimmed to 2.44 mils by slightly changing weight.

Fan #4 Field Data

Trial Weight = 177 grams

Run	Vibration Level (mils)	Trial Weight Position	Hole Number
1	20		
2	32.3	0°	1
3	24.8	135°	4
4	14.5	270°	7

Correction Weight Quantity & Locations:

- 240.4 grams @ Hole 6 or 225°

Final Vibration Amplitude: 4.00 mils

Conclusions

The cooling tower fans of Cells 1,2,3,4 were balanced to acceptable levels.
There are many different types of cooling tower fans in many operational conditions and environments. A general condition assessment of smooth, fair or rough will have to take into account those conditions.

All fans appear to have most of the unbalance removed. Fans 1 and 4 have vibration from another source than unbalance. Some looseness and motor problems may be present.

Recommendations

The following is recommended for predictive maintenance on the cooling tower fans:

Short Term

1. Machine a plastic or fiberglass plug to cap the circular hole where the fan blade is attached to the rotor hub. A thin disk of 3/8 inches thick with a 3/16 inch shoulder to fit snugly in the opening and attached with epoxy adhesive or a suitable equivalent is recommended.

2. Clean the remaining cooling tower(s) blades by disassembling the blades and removing all foreign matter from the blades.

3. Check the vibration levels with a low frequency sensor that has a good frequency response down to 150 cpm. If balancing is required, then balance the fans to an acceptable level.

4. On a monthly basis, shut down the fans and check for loose gear box mounting bolts, loose coupling bolts, loose motor mounting bolts and check the torque on blade mounting bolts at the rotor.

Appendix A (Instrumentation Used)

IRD 890 Data Collector and Balancing Software

IRD 560 Accelerometer

WMK No Phase Balancing Program

Entek Vibration Analysis Software