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North Fume Collector Fan Failure

Date: 9/7/06
Company: [redacted]
Contact: [redacted]
PMT Representative: D Williamson

It is reported that the North Fume Collector Fan has had an ongoing vibration problem for years. It apparently was running the original impeller but there are no maintenance records for this fan. But, anecdotal evidence says the bearings had been changed more than once over the years. The last week in August was a very bad week for this fan as I found it literally beating it's self apart on a "Walk Around", (sounds like a machine gun).

The dominant frequency was 1 X RPM or 1200 CPM. The vibration amplitudes were as follows. All data is in IPS or Inches Per Second.

	Motor Endbell End	Motor Coupling End	Fan Coupling End	Fan Impeller End
Vertical	0.03	0.15	0.5	0.6
Horizontal	0.2	0.17	**2.0**	**1.6**
Axial		0.01	**0.9**	

The plant's practice has been to call their motor shop balance contractor when the fan appeared to be shaking excessively, he would then clean and balance it. He was called and was going to attempt to balance it once again until he was stopped as it obviously was not a balance problem. Your balance contractor was ill-equipped to diagnose vibration problems; his only instrument is an automatic balancer that can only balance.

The centrifugal force generated by unbalance will cause the shaft centerline to attempt to traces an orbit as it rotates. If all is well, it should be basically round. For example, if we have a horizontal of 1 IPS we should have a vertical of ~.8 or .9 IPS. But in this case, note the shafts orbit is very flat, with a large horizontal and a much smaller vertical. Your fan did not have the correct amplitude relationship of horizontal to vertical to be a balance problem.

We inspected the fan running and found that the base was solidly anchored on the Northside but all 3 anchors were loose on the Southside. I asked your mechanic to tighten this up which proved to be the wrong thing to do as the horizontal amplitudes jumped up to 3.0 IPS. At this point, it was obvious we needed to start taking things apart to understand this fans issues.

Impeller- The fan housing inspection doors were opened to inspect the impeller and it was obvious this has been a problem fan for a long time. The fan wheel is approximately 5 ½ ft diameter and has 3 major groupings of balance weights on it, each located about a 1/3 of the way around the impeller from the last. Then there is a

random spread of individual weights scattered about the impeller. They are mostly attached to the shroud (or front plate) with some attached to the vanes and vane stiffeners.

The balance contractor has either attempted to balance the impeller while it was dirty many times or he has been trying to balance out vibration problems that weren't balance problems. The former does not work well, the later never works. See Picture #1, it was typical all the way around.

Picture #1

Good balance practice dictates that balance weights be attached to the impeller back plate which has a direct connection to the shaft. If excessive unbalance weight is attached to the impeller shroud and it's spun up to RPM, the cantilevered load causes the back plate to flex. Over time it will fatigue and crack. This excessive unbalance can be from misplaced balance weights or dirt left caked on the impeller shaking off.

The only time we should attach weight to the front plate is if we find that we have a couple unbalance. A couple unbalance causes the shaft to adopt a whirling motion rather than the tight rotation around the axis that we would expect and want. A couple unbalance can normally be taken out of a rotor like this with a single smallish weight on the shroud.

Bearings- The plant elected to contract out this work. The contractor attempted to do a lift check to test for excess bearing clearance but it was inconclusive. This was done with a dial indicator and by lifting the shaft with a long prybar. This is seldom an effective test but is standard with mechanics.

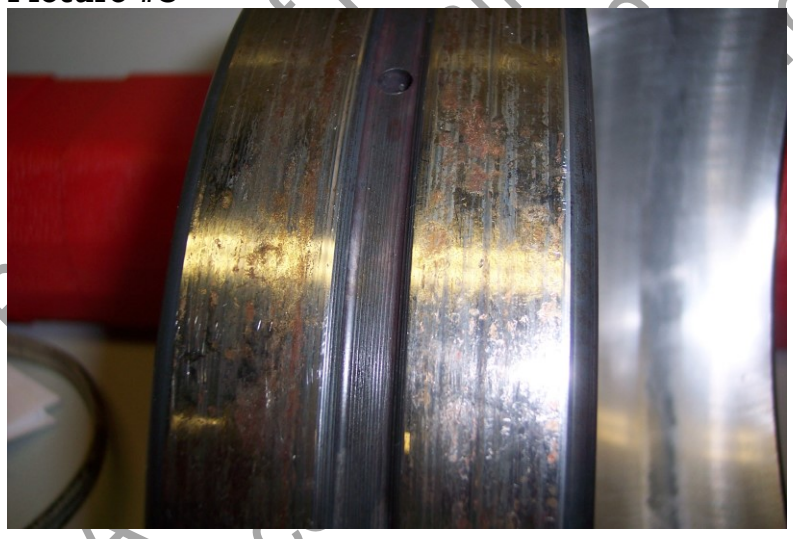
The bearing caps were removed one at a time for inspection to check bearing condition. Both bearings were found to be turned the wrong way on the shaft. This is not detrimental to their operation or life but it can make replacement much more difficult.

We observed small flecks of metal around the seal area of the impeller end bearing and so we expected to find that bearing failed, but when it was opened there was no metal flecks found inside. I believe the flecks were from misaligned aluminum labyrinth seal, rubbing on the housing under the extreme vibration.

Both bearings outer races had spun in the housings and fretting corrosion was present in both housing bores. See Picture #2 of the coupling end bearing. Picture #3 is of the impeller end bearing. Clearance was measured with feeler gages and was found to be >.004 at the coupling end and >.006 at the impeller end. This is excessive clearance as it normally is about half these amounts. The bearing adapters were both mounted solidly to the shaft and had not spun on it. The coupling end bearing was set up as the fixed bearing.

Picture #2

Picture #3

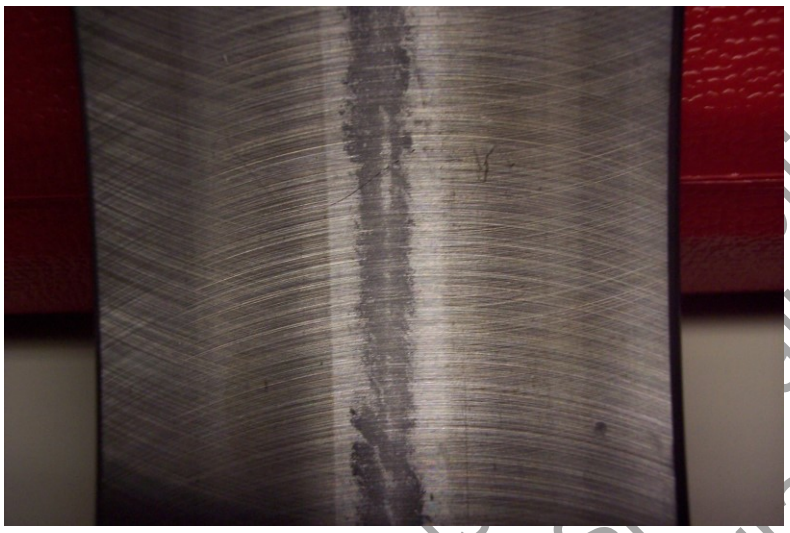


Both bearings were lubricated with Permas but they had 2 types of grease mixed in them, (you can tell by the color). Delo #2 was the most recently used and is the correct grease, but the bulk of the grease in the bearings was MolyMax #2. This is not the correct grease for rolling element bearings and should never be used in them.

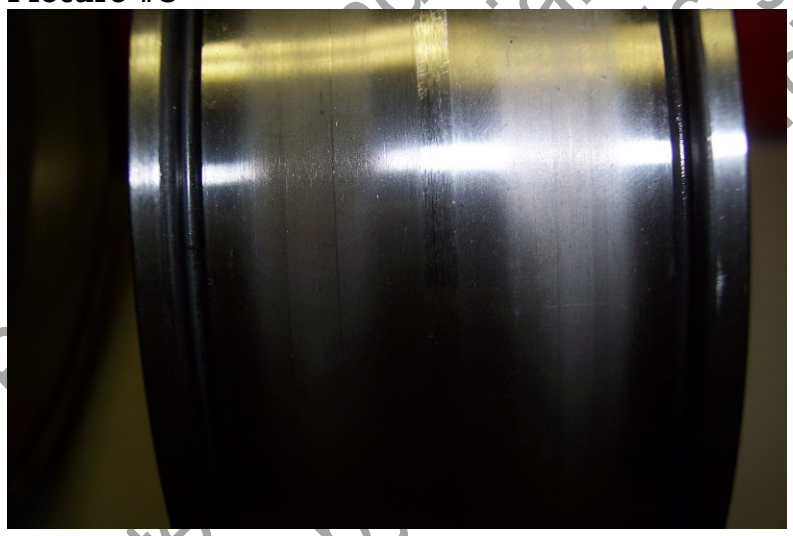
The races and rollers all appeared to still be visually in fair shape. The outer race looked new as it still had grinding marks from the manufacturing process in it. The cage was bronze and not noticeably worn. Picture #4 is the outer race on the impeller end bearing.

The inner race was frosted on the wear track. This is probably an indication of a lubrication issue at some time in its life. There were signs of contamination within the wear track. Picture #5 is the inner race. The small dark specs that can barely be seen on the inner race picture are the result of contamination embedding in the bearing race.

Picture #4



Picture #5



Impeller - Though we had found several things that were definitely wrong with the fan, we had not found a 3 IPS problem. The only part of the rotor that had not been carefully inspected was the impeller to shaft fit. That didn't appear to be a problem though as the fan did not make the classic rumbling noise that a loose fit typically makes and we could feel no movement as we tried to rock the impeller with the shaft locked.

We decided to remove the quarter panel to check the fit better. Even if the fit was found to be good, removing the quarter panel would make installing the new bearings much easier. With the quarter panel removed we were able to see a crack in the impeller back plate about ½ way around the shaft. See Picture #5. This crack is about 1 1/2" out from the shaft and in the area where the hub was welded to the back plate.

I can't say for sure that all those balance weights that were welded to the shroud caused this crack, but those weights were generating forces that would have been trying to flex the back plate in this manner. The flexing of the back plate is most likely the driver of the .9 IPS axial vibration.

A new wheel and shaft was ordered to replace this failed rotor. The shaft is to be 1045 Turned Ground & Polished or better, +.000 -.003. Balance spec is G2.5 or better.

When the new rotor arrives, I'll use this opportunity to hold a clinic on the installation and setup of this type of fan and bearings for the contractor you have chosen to use. Even though you have chosen to contract this type of work, I also recommend we run some plant people through it as well, contractors aren't always available. I'll also document the installation and put it in a hardcopy SOP format for your future use.

Picture #5 **Crack**

I normally would not file a Service Report until the job has been completed but the new rotor has a long lead time and I needed to inform the plant of the status of their fan and why it was necessary to replace the rotor. After the new rotor is installed and running I will file a postscript with the results.

Dave Williamson
Senior Reliability Engineer
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