

Suction roll pilot bearing failure due to inadequate lubrication

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Background

After recent replacement of a couch roll back bearing, overall vibration levels increased sharply. This rapid increase caused concern because the previous bearing gave little warning before seizing. Analysis of the vibration signals collected at the bearing proved that this bearing was slightly damaged, but it was not the entire source of the vibration. The smaller pilot bearing supporting the suction box, located within the couch roll, was the source of the high readings.

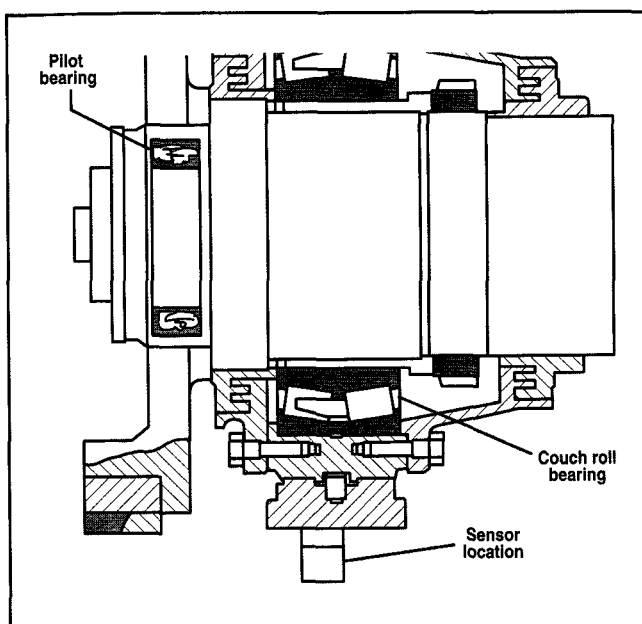
The diagnosis of the inner bearing's failure mode, based on readings taken on the outer housing, follows a classic description, with the presence of multiple bearing defects and side bands. Adding grease dramatically affected the vibration signal's spectrum and overall vibration levels. Subsequent grease analysis revealed high levels of water, iron, and copper, corroborating the diagnosis. The couch roll and its bearings have a history of unexpected failures over the last three years. These failures were all related to improper lubrication or misalignment. Improper lubrication can refer to insufficient, excessive, and, in this case, the incorrect type of lubricant.

The couch roll has a stationary suction box inside the rotating outer roll shell and is supported at each end with 32-in.-diam. outside diameter (OD) spherical roller bearings (SKF 230/560CA). The inner, stationary suction box assembly is rigidly attached at the tending side, while the drive side is supported with a 10-in.-diam. OD spherical roller bearing (SKF 23230CC). The vibration sensor used for this analysis, the IRD 970 accelerometer, was mounted radially in the load zone on the couch roll bearing housing with a magnet. The lump breaker roll, mounted on the couch roll housing, operates loaded against the couch roll. **Figure 1** shows the arrangement of the couch roll back and pilot bearings.

Data was collected using IRD PMPower software and the IRD Fast Track data collector. Several data formats were used in the analysis: overall vibration levels vs. time, overall spike energy vs. time, individual spectra, and vibration spectra vs. time. Vibration data was collected in units of velocity (in./s), acceleration (G), and spike energy (GSE).

A new back bearing was installed on Dec. 22, 1993, and the type of grease was changed at that time. After 14 days of

1. Couch roll drive side assembly



operation, with weekly greasing intervals, the bearing was visually inspected; the grease was determined to be of inadequate quality and quantity prompting a change to heavier-duty grease. This grease was introduced daily for the next six days. Another visual inspection revealed inadequate quality again, prompting another change to a synthetic grease.

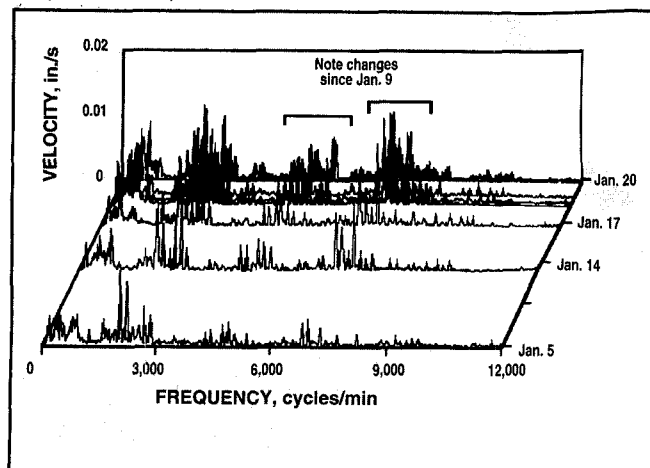
Historical data

On Jan. 14, 1994, a significant elevation of the overall acceleration and overall spike energy vibration levels was recorded. Data was gathered using a permanently installed portable data collector set to record overall levels and spectra at 30-min intervals. Additional data to supplement the 30-min data was collected on a daily basis.

The velocity spectra collected from Jan. 9–20, 1994, shows how the vibration changed. **Figure 2** shows that, over time, the spectra became "richer," with more frequencies present on Jan.

Shop Talk

2. Spectral history of couch roll drive side



20 compared with Jan. 9. The spectra show four general regions, depicted in Fig. 3: 0–1100, 1500–3000, 4000–5800, and 6500–8500 cycles/min.

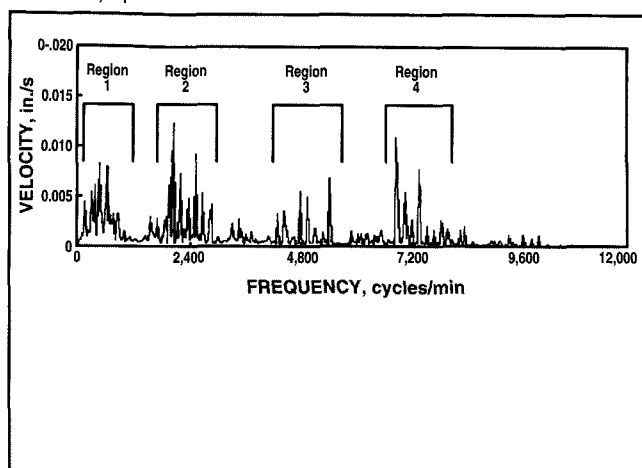
The first region is mostly composed of the couch roll speed and multiples of this fundamental frequency. The second region has frequencies associated with an inner race defect of the couch roll back bearing. Centered within this region is the fundamental inner race defect frequency of 2455 cycles/min for a couch roll speed of 160 rpm. The other frequencies are side bands of the fundamental frequency, with a differential between any two peaks equal to the couch roll speed. Also noted was the presence of the couch roll pilot bearing defect frequency at 1648 cycles/min.

The third region of frequencies is related to the couch roll back bearing inner race defect. The frequency at 4913 cycles/min is the second multiple of the inner race defect frequency associated with the couch roll back bearing. There are also other frequencies that are modulated by the couch roll speed. The 4590 cycles/min frequency is associated with the second multiple of the inner race defect frequency of the lump breaker back bearing. Located within the fourth region is the third multiple of the couch roll back bearing inner race defect frequency. The differential between the other frequencies is the couch roll speed.

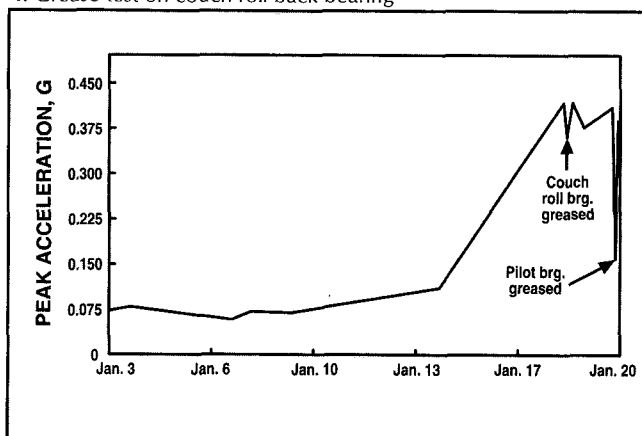
The presence of side bands around the bearing defect frequencies and multiples of defect frequencies indicates advancing deterioration into Stage 3 failure mode. Bearings in this failure mode generally have 2–5% of their L_{10} life remaining.¹ Stage 3 also has an elevated spike energy level associated with it. This analysis indicates that this bearing is nearing the end of its life.

Note that the third and fourth regions have significantly more frequencies after Jan. 14 than existed on Jan. 9. This shows how quickly a race defect can develop and accelerate the deterioration of a bearing.

3. Velocity spectrum



4. Grease test on couch roll back bearing



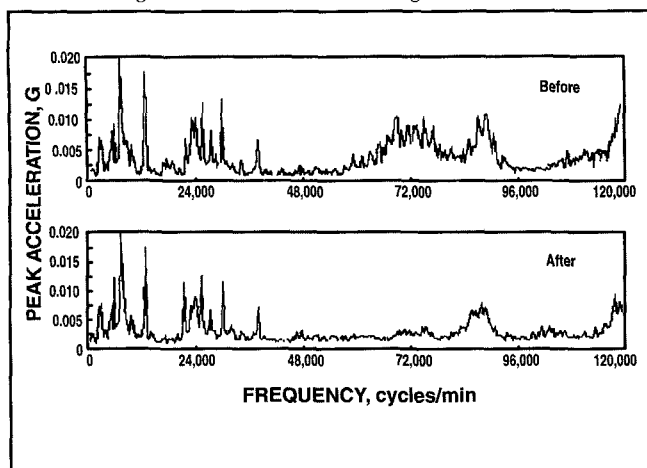
Grease tests

Adding a small amount of grease to the couch roll back bearing reduced the overall vibration for 1–2 hours, as shown in Fig. 4. During this period, the couch roll bearing temperatures increased, as expected. Collected spectra showed the continued presence of couch roll and lump breaker roll bearing defect frequencies identified earlier. Little change was noted as a result of this test, indicating that the effect of the grease was not within the spectral range being monitored.

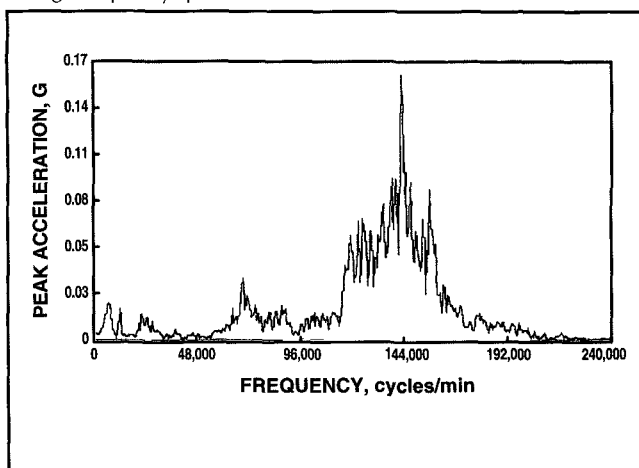
A review of the machine construction identified that the couch roll pilot bearing was close enough to the back bearing to be influencing the vibration signals. Adding this bearing to the computer software model database provided the information needed to identify the pilot bearing defect frequency. Injecting grease into the pilot bearing dramatically affected the overall vibration levels and spectra, as described by Berry.¹ The intro-

¹ Berry, James E. P.E., "How to Track Rolling Elements Bearing Health with Vibrations Signature Analysis", *Sound and Vibration*, Vol. 25, No. 11, No. 1991.

5. Pilot bearing evaluation before and after grease insertion



6. High-frequency spectrum



I. Vibration data before and after grease insertion

Characteristic	Time		
	0600	0830	1030
Velocity, in./s	0.041	0.036	0.037
Acceleration, G	0.414	0.163	0.389
Spike energy, GSE	0.184	0.182	0.159

duction of 2 oz. of grease, at 0830 hours, into the pilot bearing on Jan. 20 is reflected by the data shown in Table I. A noticeable decline of the overall acceleration values along with slight decreases in the velocity and spike energy readings confirmed that the pilot bearing was responsible for much of the measured vibration levels.

Figure 5 shows the acceleration spectra collected before and after the grease insertion. The spectra reveal that a smaller "haystack" of frequencies, centered around 72,000 cycles/min, virtually disappeared after greasing and reappeared after a few hours of operation. This analysis also revealed a change at the upper limit of the acceleration frequency display (120,000 cycles/min), confirming that the frequency range required an increase. A very slight decrease in the velocity spectra was noted, with no additional frequencies developing as a result of this test. Spike energy levels decreased when the grease was injected and returned to original levels after several hours of operation.

High-frequency analysis

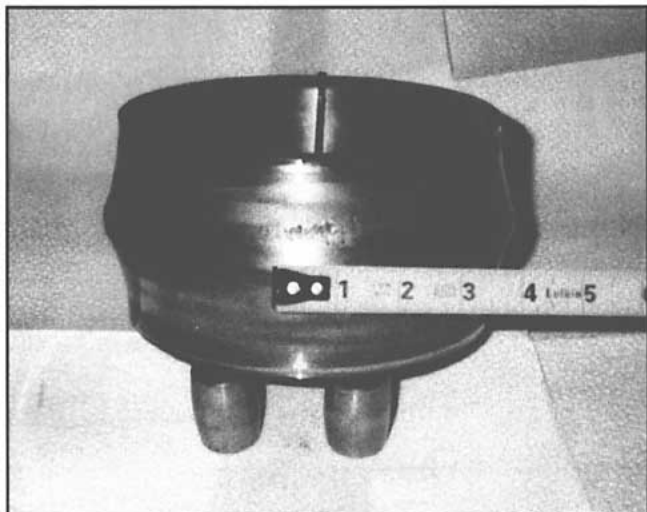
Increasing the acceleration spectra maximum frequency range revealed a large frequency "haystack" that was significantly reduced when the bearing was greased. Figure 6 shows the acceleration spectra collected before the couch roll pilot bearing was greased. After greasing the large haystack centered at 144,000 cycles/min was reduced to two small humps, with a maximum amplitude of 0.03 G, as the grease damped the high frequency vibration signals emanating from the pilot bearing.

Based on this information, the paper machine was stopped, and the couch roll pilot bearing was replaced. Visual inspection of the bearing revealed advanced spalling of the inner race in the load zone (see Fig. 7). The spall area, located in the first quarter of the load zone, was 1.5 in. long. Grease samples from the couch roll pilot bearing were sent for analysis, which revealed an iron content of 845 ppm, a copper content of 370 ppm, and a water content of 28%. This confirmed that major damage was present in the pilot bearing and that the grease quality was inadequate, permitting the bearing deterioration.

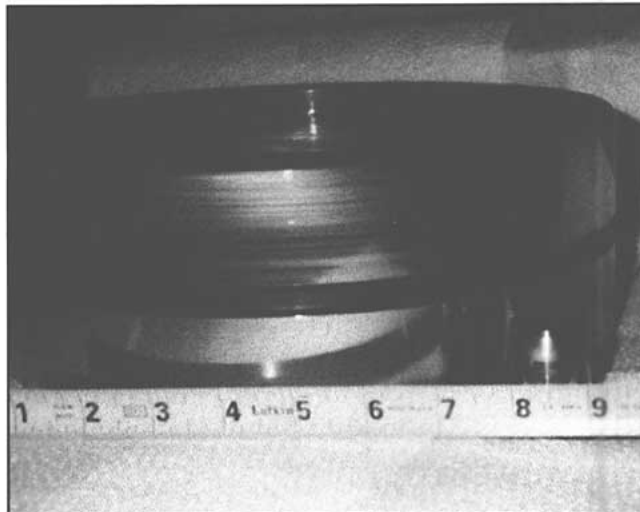
The OD of the bearing was polished, indicating that the outer race had been spinning in its fit (see Fig. 8). The OD fit to the housing was -0.005 in. (loose) instead of +0.002 in. (tight) as specified by the bearing manufacturer. This fact probably accounts for the lack of bearing defect frequencies. Once a bearing spins within its fit, the defect calculations are no longer valid. Excessive roller-to-race clearance was found, and the outer race was rough due to fragment denting.² Additionally, significant wear was found at the outer edges of the inner race (see Fig. 9). This wear, along with the other wear identified, accounts for the high level of iron found in the grease. This was the result of the bearing cage rubbing the inner race.

² SKF Industries, "Bearing Installation and Maintenance Guide," Reg. No. 76, Apr. 1986.

7. Inner race spalling



8. Polished outside diameter

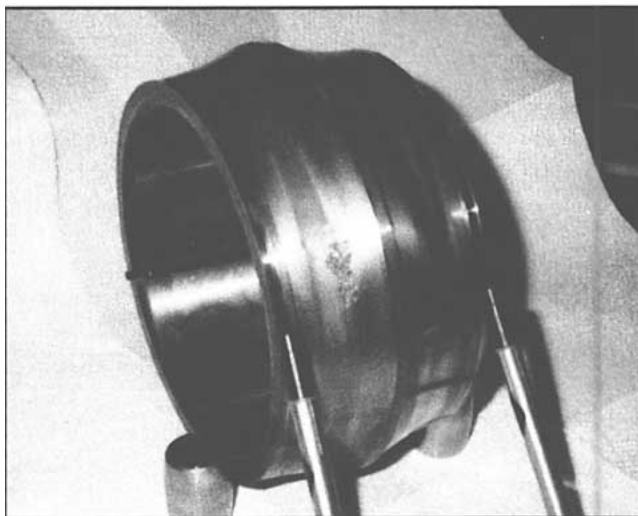


Conclusions

The historical spectra from Jan. 9–20, 1994, show that the smaller “haystack” centered at 72,000 cycles/min was not present on Jan. 9 and grew rapidly after Jan. 14. The damage, identified by bearing disassembly, was accelerated between Dec. 22, 1993, and Jan. 14, 1994. Historical velocity spectra collected from October–November 1993 revealed the presence of couch roll pilot bearing defect frequencies, indicating a slightly distressed bearing. This bearing could have been operated for several more months, provided it was properly lubricated. The introduction of off-specification greases doomed this bearing to early failure.

The defects on the couch roll pilot bearing were found utilizing a readily available vibration data collector and associated software with a transducer mounted on the couch roll bearing housing. The paper machine was operating at the time of the machinery vibration analysis, and was shut down in a planned fashion reducing the impact on production. The pilot bearing was repacked, and the machine was brought back into production in timely manner. The damage to the machine was limited to the couch roll pilot bearing, thus averting and catastrophic damage to the paper machine. 

9. Inner race edge damage



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