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WSRC-TR-94-0554, Rev. 1

Zink Rotary Kiln Seal–Cam Followers (U)

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DOE Contract No. **DE-AC09-89SR18035**

DISCLAIMER

WSRC-TR-94-00554
12/9/94 Rev. 1

KEYWORDS: CIF, ROTARY, KILN,
SEAL, ALIGNMENT.

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December 9, 1994

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SUMMARY

Cam follower misalignment on a John Zink rotary kiln seal caused damage to the seal's rotor. The misalignment was quantified, corrected, and checked to verify straightness. The primary purpose of the correction was to allow seal testing [1] to continue, but the information is applicable to the Consolidated Incineration Facility (CIF) since two large seals of similar design will be installed there.

Cam follower straightness was off as much as 3.5°, causing followers to run untrue on the rotor. High contact forces resulted, removing flakes of metal from the rotor surface. The misalignment caused weight bearing followers on one side of the seal to back out of their threaded mounts. The root cause was poor machining of the follower mounting holes. Correction was accomplished by relieving the holes and installing machined spacers and retaining nuts. Cam followers on the CIF's Zink seals should be inspected for straightness before the seals are installed.

INTRODUCTION

The CIF will treat hazardous and mixed low-level radioactive waste in a rotary kiln and secondary combustion chamber. A high efficiency air pollution control system follows the secondary chamber. The rotary kiln is designed with a gas seal at each end of its rotating barrel which provides a barrier between the interior of the kiln and outside air.

The internal pressure of the rotary kiln will be maintained below atmospheric pressure, so exterior air passing the seals is forced into the kiln's interior. Positive pressure may be applied in the seal labyrinth, adding a barrier to flow. Both CIF seals will be covered entirely with exhaust hoods, drawing air over the outside of the seal and into a HEPA filtered exhaust system.

DISCUSSION

A 45" i.d. replica of the Zink double faced rotary kiln seal was installed on a test stand at TNX (figure 1). During initial run-in, seal plate motion was evident and was accompanied by low frequency noise similar to rail cars rolling over track joints. A cross section of part of the seal (figure 2) shows how the seal plates are carried by rollers (cam followers) riding on the rim of a rotor. The seal plates are fixed, but the rotor turns with the kiln barrel. Followers are evenly spaced at 60° intervals around the seal plates. When the seal plates are installed, opposing followers are staggered 30° to avoid interference.

The plate motion and noise during initial operation indicated a problem at the seal plate/rotor interface. Cam followers apply the weight of the seal plates to the rotor.

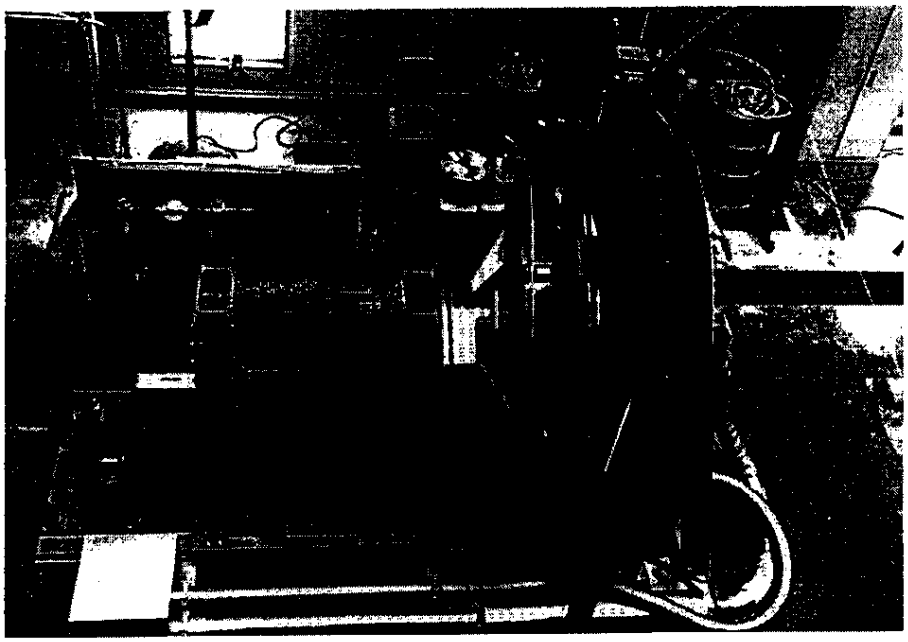

Figure 1. Rotary Seal Test Stand at TNX

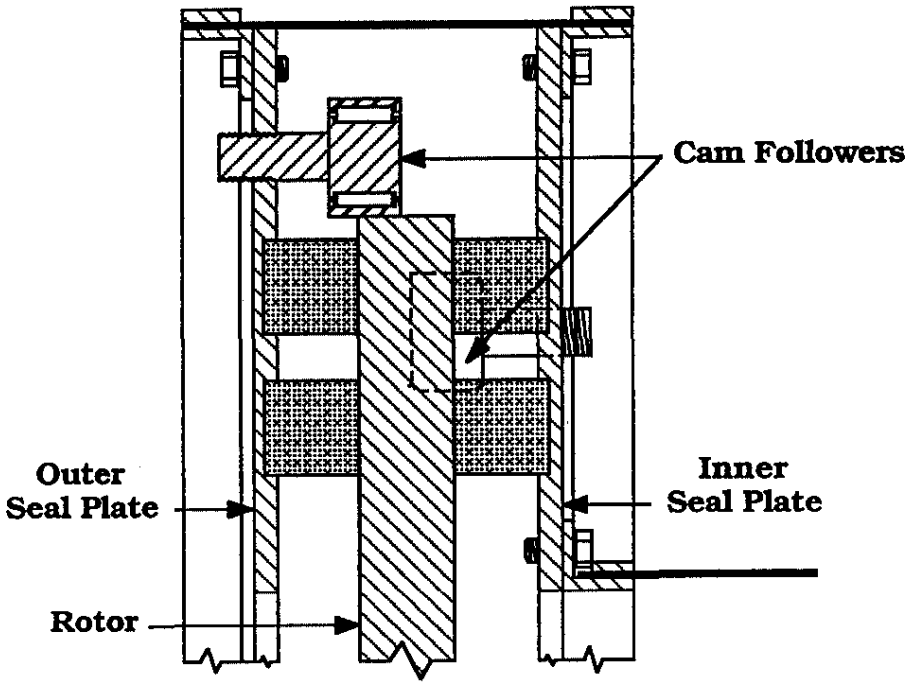

Figure 2. Double Faced Seal - Upper Cross Section

Vertical motion would indicate rotor runout or an offset rotor. Horizontal motion would seem to indicate a warped or incorrectly mounted rotor. The motion was horizontal, but the rotor was neither warped nor incorrectly mounted. No rotor wobble was evident, so the seal plate cover was removed to expose the cam follower/rotor interface.

The outer rim of the rotor had a shallow groove worn in it and one weight-bearing cam follower was nearly backed out of its threaded hole in the seal plate. Shiny areas were visible on the blued surface of the cam followers indicating that they were not running true on the rotor rim (figure 3). Site Services Quality (SSQ) personnel measured the relationship of the cam followers to the seal plates and found that followers were as much as 3.5° off perpendicular. Misalignment was inconsistent from follower to follower. Three factors caused the problem. First, the holes were not drilled straight. Second, the holes were oversized. Finally, the shoulders of the cam follower shafts were butted against the seal plate.

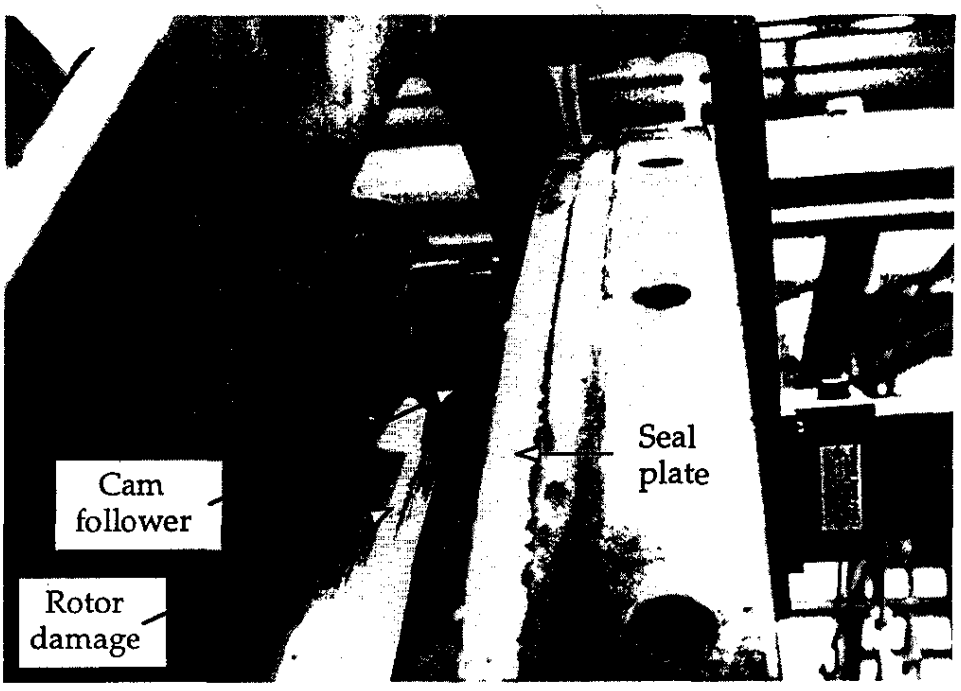

Figure 3. Rotor Damage and Misaligned Cam Follower

The 0.5" thick seal plate was supplied by the manufacturer with cam followers mounted in 1-14 threaded holes. SSQ personnel removed a number of the followers and easily passed a 1-14 no-go gauge through the threaded holes, indicating they were oversized. The McGill cam followers are made to close tolerances (e.g. shaft diameter = 1.000", +.001", -.000"), so were loose in the holes.

As supplied by the seal manufacturer, followers were screwed into the holes until the shoulder of their shafts landed on the seal plate. The orientation of the first thread of the hole influenced the position of the follower (because of the sloppy fit). These factors alone did not produce the large misalignments found. The followers could not be properly aligned when loosened, indicating the holes were crooked before they were tapped.

Since the primary goal of the seal evaluation is to supply operating information for CIF operation, a fast and accurate solution to the misalignment problem was conceived. Spacers (turned on a lathe) were fabricated to closely fit (D = 1.002", -.000", +.003") the cam follower shafts. Individual spacers were parted from a single piece of bar stock in the form of right-circular cylinders. SSQ verified that the opposite faces were parallel within 0.002".[2] The parallel spacer faces hold roller surfaces perpendicular to the seal plate.

The cam follower mounting holes had to be relieved to allow the shaft to be held perpendicular. All were hand fitted so a minimum of material was removed and the cam follower shaft fit closely in the hole. A nut holds the shaft rigidly in position and the follower's inner race tightly against the spacer (figures 4 and 5).

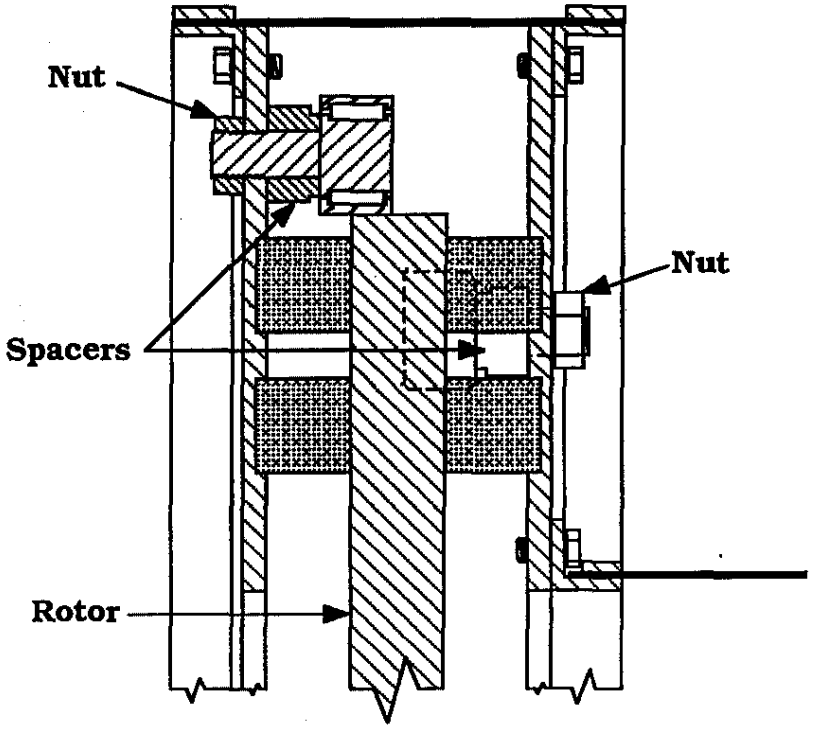

Figure 4. Cam Follower Spacer Installed

RESULTS

The same SSQ inspectors measured the orientation of the cam followers before and after repair (see Table 1), all values fall within McGill's recommended straightness of ≤ 0.5°. The seal has been operated for approximately 100 hours since the cam followers were aligned, the low frequency noise persists but seal motion is absent. The noise is attributed to slight unevenness in the rotor's rim where rotor halves are joined and to indentations (chuck marks) left during machining. As these pass under the weight-bearing followers, a click is audible.

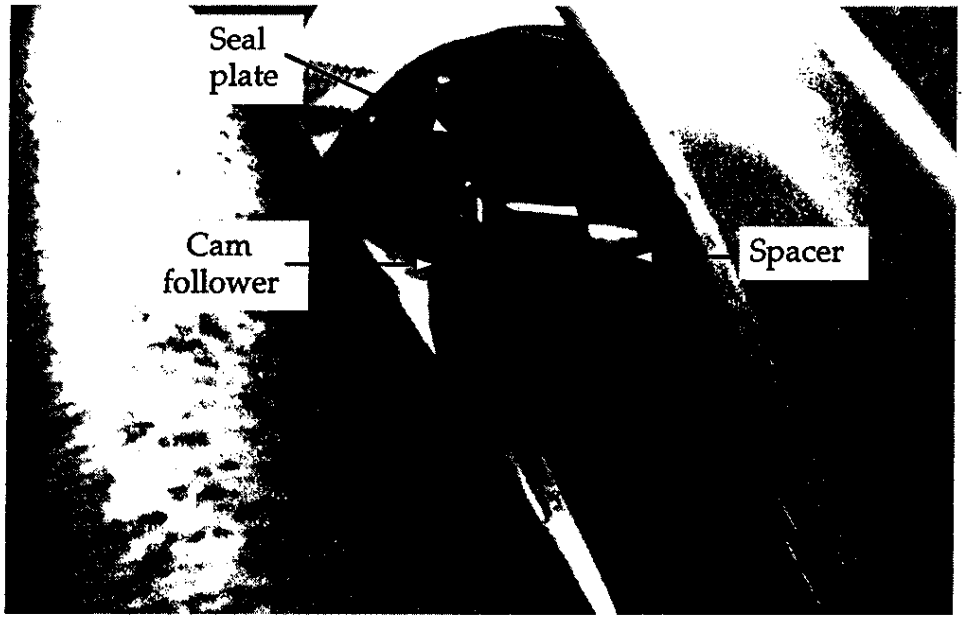

Figure 5. View of Cam Follower with Spacer

Table 1. Cam Follower Deflections (from perpendicular)

Cam Follower #	Outer Seal Plate		Inner Seal Plate	
	Initial	Final	Initial	Final
1	3.5°	0.1°	1.2°	0.1°
2	0.9	0.1	0.2	0.0
3	1.8	0.2	0.7	0.1
4	1.5	0.1	2.9	0.3
5	1.8	0.2	1.5	0.1
6	1.5	0.1	-	0.1

Cam followers were sequentially numbered by the SSQ inspectors. Their positions are indicated on attachments to the inspection reports. [2]

CONCLUSIONS

The replica seal's cam follower mountings caused problems because they were poorly machined. Relieving the mounting holes and fitting the followers with machined spacers and retaining nuts improved the straightness of their mounting. Straightness within the follower manufacturer's recommended range (≤0.5°) was easily achieved and is reasonable to expect from careful machining operations. Inspection of the cam followers and mountings on the CIF Zink kiln seals is recommended before they are assembled. These questions should be answered during the inspection:

- Are the cam followers securely mounted ?
- Is there a retaining device (such as a nut) to keep the follower from backing out of its mounting hole ?
- Are the cam follower surfaces perpendicular to the seal mounting plate ? (≤0.5°)
- Are the cam followers properly lubricated ?
- Do the cam followers rotate freely (i.e., did deterioration occur during storage) ?

If the answers are affirmative, CIF Operations can avert problems encountered with the replica seal (and more). Dwayne Michaels of McGill's Engineering Department provided more follower information which may be useful at the CIF:

- The straight cylindrical cam follower will tolerate misalignment of 0.5°.
- McGill makes a crowned follower which will tolerate misalignment up to 1.5°.
- The crown radius of the 2" McGill follower (same size as CIF followers) is 24", which maintains good surface contact while tolerating the specified misalignment.
- The crowned follower is a sealed unit with an operating temperature of 250°F (275°F intermittent). The seals and grease will be ineffective if these temperatures are exceeded.
- The follower surfaces are hardened to Rockwell C 58 to 60.

PATH FORWARD

Seal tests began in October with seal characteristic baselining. Optimization of seal operating parameters has begun and will continue through January 1995. The seal test program is explained in WSRC-RP-93-1605. Information produced from each segment of testing is given informally to the customer and will be formally reported midway through the test sequence and at the completion of all tests.

QUALITY ASSURANCE

Site Services Quality personnel performed and documented [2] their inspections of the cam followers. Calibrated and uniquely identified measuring and test equipment was used for all measurements.

REFERENCES

1. D. L. Fisher. *Task Plan - John Zink Rotary Kiln Seal Test (U)*, U. S. Department of Energy Report WSRC-RP-93-1605 Rev. 0, Savannah River Site, Aiken SC 29808 (1993).

2. SSQ Inspection reports (OSR 28-63): 94-IR-06-7447, 94-IR-06-7453, and 94-IR-06-7602, Central Files 773-52A, Savannah River Site, Aiken SC 29808 (1994).