1) Test conditions

The test was conducted during coal-fired operation with a constant power generation load of 200 MW.

2) Test details

The temperature, CO, CO_2, and O_2 measurements were conducted at the measurement points at the air inlets and outlets, and gas inlets and outlets of the air heaters according to the NTPC performance test procedure.

3) Consideration regarding the calculation results

Based on the performance test data, we calculated the efficiency and dew-point temperature of the air heaters in the same way as previously described in the above:

6.4.3 Efficiency Improvement Proposals

The result of the above study, candidate units had high air leakage ratios which is about 8% in Japan. Study team is proposed the following improvement items. However, the proposals are not considered high ash content of Indian coal.

Rotating air heaters are characterized by the fact that the rotor rotates and therefore, the gaps are kept as small as possible. For this reason, air leaks into the gas side. The key points in minimizing this leakage are: improved design, installation know-how, and maintenance.

The total leakage increases because the amount of air leaking directly from the air side to the gas side increases. The problems observed with the air heaters in service are as follows:

1) The difference between the designed temperature conditions and actual operating conditions has caused the gaps in the seals to increase.
2) The difference between the actual and designed thermal displacement has caused the gaps to increase.
3) The seals and casing have aged and deformed, corroded, deformed due to heat, and worn out, causing the gaps to increase.
4) The shield came off, causing the gaps to increase.

1) Improvement Proposal: Sector Plate Drive Unit (SDU)

The rotor of an air heater, when it is hot, deforms into a fan shape at the same time it expands toward the high-temperature side. The phenomenon in which the outer periphery of the rotor droops is called turn-down. Generally, the turn-down is greater than the expansion of the rotor shaft, causing a gap between the periphery of the rotor and sector plate on the high-temperature

side (seal gap G). The inner periphery of the sector plate is joined with the rotor shaft and expands as the rotor shaft expands. As a result, the gap between the radial seal installed on the rotor at the high-temperature side and the sector plate forms a long triangle when the rotor is hot. The sector plate drive causes the outer periphery of the sector plate to move according to the degree of the turn-down of the rotor so as to decrease the seal gap.

In Japan, 139 units of power plant equipped with sector plate drives air heaters with a generator output over the 300MW, between 1979 and 2008., It is required that the maintenance supervision by the OEM during every periodical inspection for proper operation of this facilities.

It is expected that the adoption of sector plate drives will reduce leakage from the high temperature-side radial seal and improve the air leakage ratio. There are two type of sector plate drives systems such as sector plate drive Unit (SDU) and sensor drive system (SDS). The SDS added sensor (electromagnetic induction sensor) into SDU in order to measure and adjust the gap between radial seal and sector plate automatically. Study team recommends applying SDU first for leaning of proper maintenance such sensitive system. A detailed study would involve design by the manufacturer of the air heaters. SDU and SDS can be applied suspend type of sector plate AH.

Outline of technical specification is as follows

- System composition: Sector Plate, Actuator and control divies
- Material
  Radial Seal Leaf: Matriarls: CORTEN (Corrosion resistant steel), (Thickness: 1.6 mm)
  Sector Plate: Mild Steel (Thickness: 19-25 mm)
- Control
  SDU is controlled by load (MW) automatically from central control room
  - 100% Rated output: Push-in sector plate (reducing radial seal gap)
  - 100% to 50% Rated output: Push-in sector plate (reducing radial seal gap)
  - Below 50% Rated output: Pullout sector plate

2) Improvement Proposal: Floating Radial Seals (FRS)

It can be expected that the adoption of floating radial seals, which have a simpler function than sector plate drives have, will reduce leakage from the high-temperature radial seal and improve the air leakage ratio. Floating radial seals can be applied non-suspend type of sector plate AH. Floating radial seals use a spring to expand and contract the radial seal and maintain the gap between the rotor and sector plate with the turn-down of the rotor in mind.

It is required that the maintenance supervision by the OEM during every periodical inspection for proper operation of this devices. A detailed study would involve design by the manufacturer of the air heaters (or a Japanese air heater manufacturer).

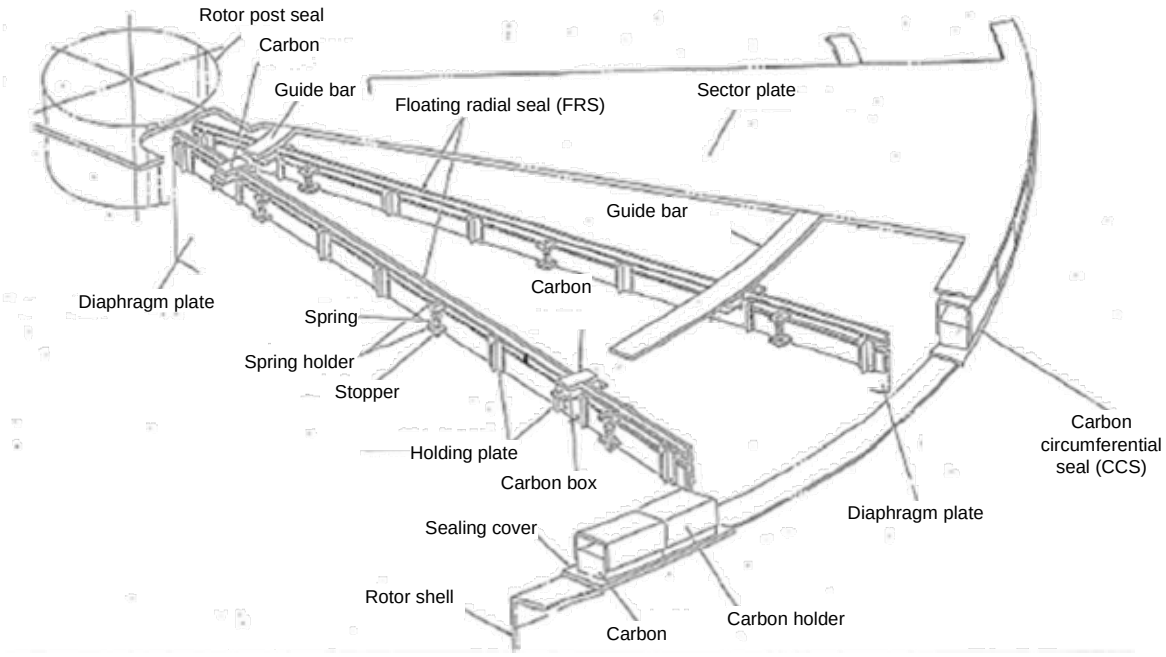

Fig. 6.4-3 Floating Radial Seal

Outline of technical specification is as follows

- System composition: Floating Radial Seal, Spring, Guide bar and Carbon
- Materials
  Radial Seal Leaf: CORTEN (Corrosion resistant steel),(Thickness: 1.6 mm)
  Spring: Inconel 700-750, Guide bar: SS400,
  Carbon: GC-N type (Bulk Specific Gravity: over 1.7kg/cm^3, Shore Hardness (HSD): 55 to 85, Bend Strength: over 450 kg/cm^2, Electric Resistance (μΩcm): less than 3,500)

3) Improvement Proposal: Carbon Circum Seals (CCS)

Study team propose that the metal-touch sealing method using carbon be adopted to prevent air from leaking from circumferential seals at the high-temperature (air outlet, gas inlet) and low-temperature sides (air-inlet, gas outlet) of air heaters. Carbon circum seals are installed between the rotor and housing at the high-temperature and low-temperature sides and allow higher pressure air to flow into the gaps between the rotor and housing so as to prevent air from leaking from these gaps. Carbon circum seals consist mainly of a carbon part, carbon holder, and sealing bar, which move in convert with one another. The carbon part and carbon holder

are divided into several tens of blocks, each of which forms a polygonal shape to fit the outer periphery of the rotor.

It is required that the maintenance supervision by the OEM during every periodical inspection for proper operation of this devices. A detailed study would involve design by the manufacturer of the air heaters (or a Japanese air heater manufacturer).

Outline of technical specification is as follows

- System composition: Carbon, Carbon holder and Sealing bar
- Materials
  Carbon: same as FRS, Carbon holder: SUS 304, Sealing bar: SS400

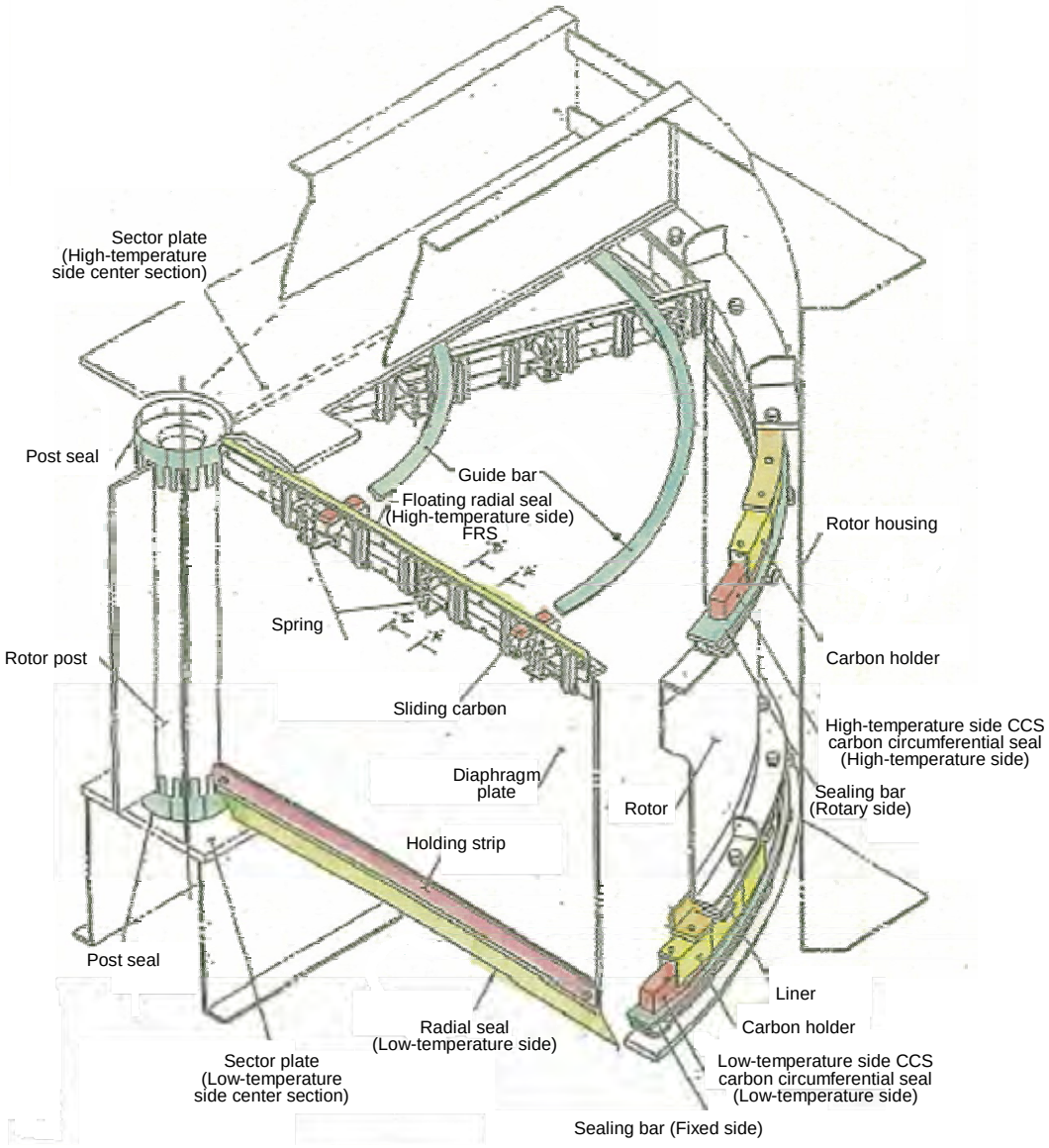

Fig. 6.4-4 Carbon Circum Seal

4) Improvement Proposal: Review of Periodic Inspections for Air Heater Maintenance

One of the causes of the increased leakage is that the gaps between the rotor and casing increase due to deformation with time, corrosion, deformation due to heat, wear, and other casing material defects.

According to the field work results, NTPC, when it carries out periodic inspection, calls on supervisors from the air heater manufacturer to carry out inspection work, but only when necessary. In other cases, NTPC calls on supervisors who used to work for the air heater manufacturer to carry out inspection work.

In Japan, every time a power station carries out a periodic inspection, they call on supervisors from the air heater manufacturers to inspect or replace the following items to reduce leakage from the air heaters and maintain the efficiency of the air heaters.

Table 6.4-1 AH Annual Inspection Items

Inspection items	Parts to be inspected	Inspection details	Remarks
(1) Rotor system	Rotor post	Visual inspection Liquid Penetrant Testing (PT)	
	Diaphragm	Visual inspection, plate thickness measurement	
	Shell plate	Visual inspection	
	Grating	Visual inspection	
	Pin rack	Visual inspection, pitch measurement, parallelism measurement, roundness measurement, pin wear measurement	
	T bar	Visual inspection, circularity measurement, plate thickness measurement	*
	Rotor tire (SDS)	Visual inspection, flatness measurement	
(2) Rotor support bearing	Bearing	Visual inspection, overhaul (as necessary)	
	Lubricating oil	Replacement of lubricating oil	
	Air seal cover	Replacement of gland packing	
(3) Rotor guide bearing	Bearing	Visual inspection	
	Lubricating oil	Replacement of lubricating oil	
	Air seal cover	Replacement of gland packing	
(4) Lubricating system	Oil pump	Overhaul	
	Accessories	Overhaul	

Inspection items	Parts to be inspected	Inspection details	Remarks
(5) Heating elements	Low-temperature layer	Weight measurement, plate thickness measurement Sampling inspection of baskets Steel element: erosion, cracked, looseness.	*
	Mid-temperature layer	Weight measurement Sampling inspection of baskets Steel element: erosion, cracked, looseness.	*
	High-temperature layer	Weight measurement Sampling inspection of baskets Steel element: erosion, cracked, looseness.	*
(6) Rotor drive system	Reducer	Overhaul	
	Pinion gear	Wear inspection	
	Air motor	Overhaul	
	Air motor coupling	Visual inspection Centering	
	Electric motor coupling	Visual inspection Centering	
	Pinion shaft seal	Visual inspection, or carbon seal replacement	
	Accessories	Air motor filter replacement (as necessary)	
(7) Seals	Radial seal	Visual inspection, measurement, adjustment, replacement (as necessary)	*
	Axial seal	Visual inspection, measurement, adjustment, replacement (as necessary)	*
	Post seal	Visual inspection, hole repair	*
	Bypass seal	Visual inspection, measurement, adjustment, replacement (as necessary)	*
	Static seal	Visual inspection, repair (as necessary)	*
	Sector plate	Visual inspection, parallelism measurement, adjustment, replacement (as necessary)	*
	Axial plate	Visual inspection, roundness measurement, adjustment, replacement (as necessary)	*
(8) AH soot blower	Drive unit	Visual inspection, measurement Gasket replacement	
	Tube	Visual inspection, guide roller inspection	
	Deflector plate	Visual inspection, replacement (as necessary)	
(9) Sensor drive system (SDS)	Drive unit	Overhaul	
	Protection unit	Gas- and air-side side roller inspection, replacement (as necessary)	
	Lower limit detector	Detection roller inspection, replacement (as necessary)	
(10) Other	Casing	Visual inspection (Repair holes due to ash cut)	*

Note: * maintenance point for prevent of leakage

For efficiency improvement, Study team propose that Korba #6 and Singrauli #4, call on supervisors who are well acquainted with the inspections and repairs from original equipment licenser, when NTPC carry out periodic inspections, and have them inspect and repair the air heaters. This is expected to improve leakage reduction.