Modeling of Rotating Magnetic Field Eddy Current Probe for inspection of metallic tubular components

T. V. Shyam, B.S.V.G. Sharma, K. Madhusoodanan
Bhabha Atomic Research Centre, Reactor Engineering Division, Mumbai -400085

Introduction: Pressurized Heavy Water Reactors (PHWRs) have critical component called pressure tubes which carry fuel and coolant of the reactor. Rotating Magnetic Field eddy current technique is a promising technique for inspection of flaws in metallic tubular components. The technique is having advantage of less inspection time due to rotating magnetic field as well as sensitive to both circumferential as well as axial oriented flaws.

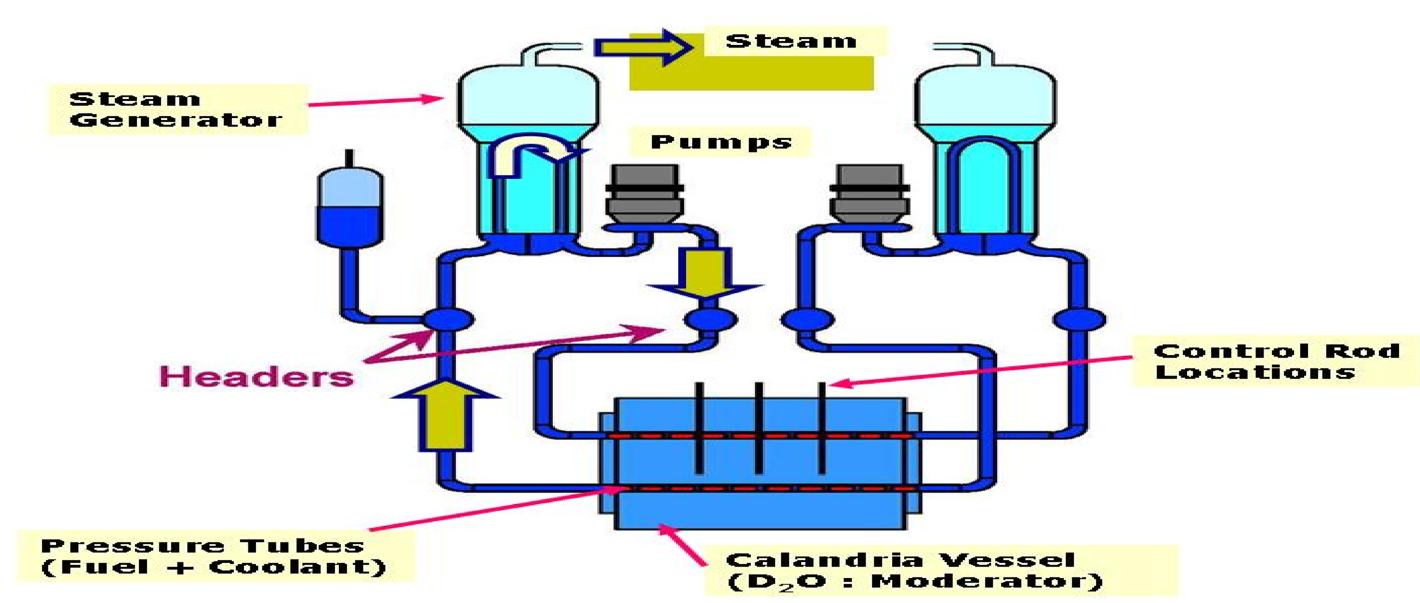

Figure 1. PHWR Layout

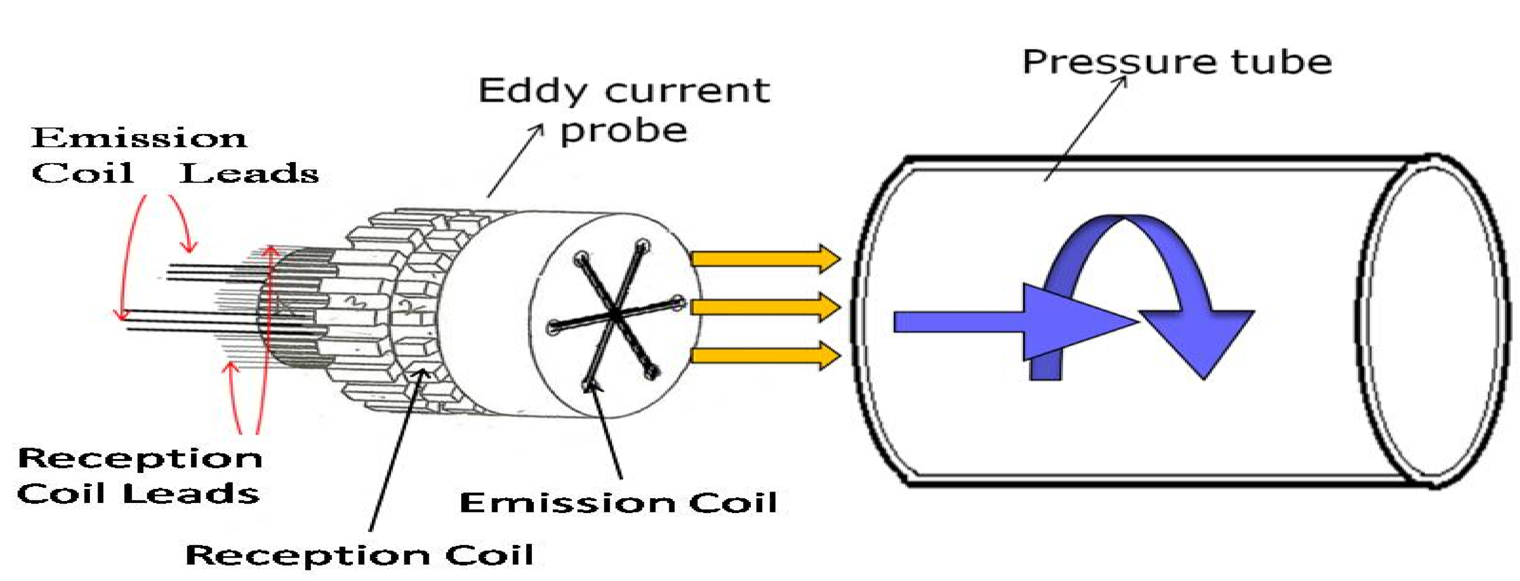

Figure 2. Rotating Magnetic Field Eddy Current Probe

Philosophy: The Rotating Magnetic Field (RMF) eddy current probe consists of three emission coils spatially disposed at 120 degrees and excited with three phase alternating current. Frequency of excitation is selected as per geometry and conductivity properties of the pressure tube. The radial oriented rotating magnetic field generated by the emission coils interacts with the pressure tube and generates circulatory eddy currents in the pressure tube which links with flaws oriented in radial as well as in circumferential direction. The resultant field is picked up by an array of reception coils located circumferentially on the outer body of the inspection tool. Each coil is only sensitive to the circumferential zone of pressure tube to its vicinity.

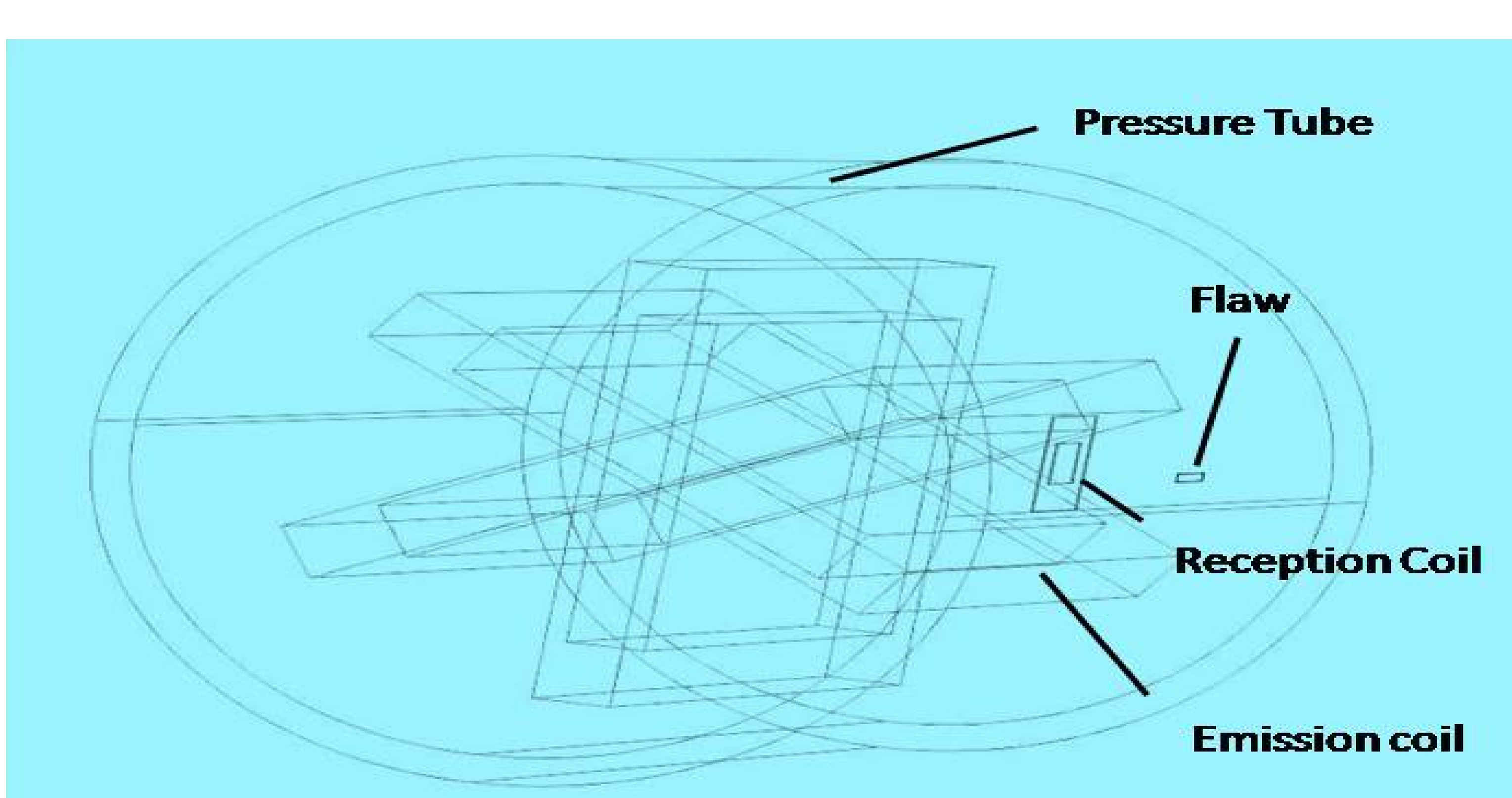

Figure 3. Model of RMF eddy current probe in pressure tube

Results: The modeling was carried out to find out the flux distribution as well as the induced current distribution. The induced current distribution is shown in figure.4. The Magnetic Flux distribution of the Rotating magnetic Field Probe is shown in figure 5. The voltage induced in single turn of pick up coil was derived for extracting amplitude and phase information and correlated it to the flaws modeled with varying sizes and at different depth locations. The table.1 shows the amplitude and phase of the voltage induced in the pickup coil for varying flaw sizes and at different depth locations.

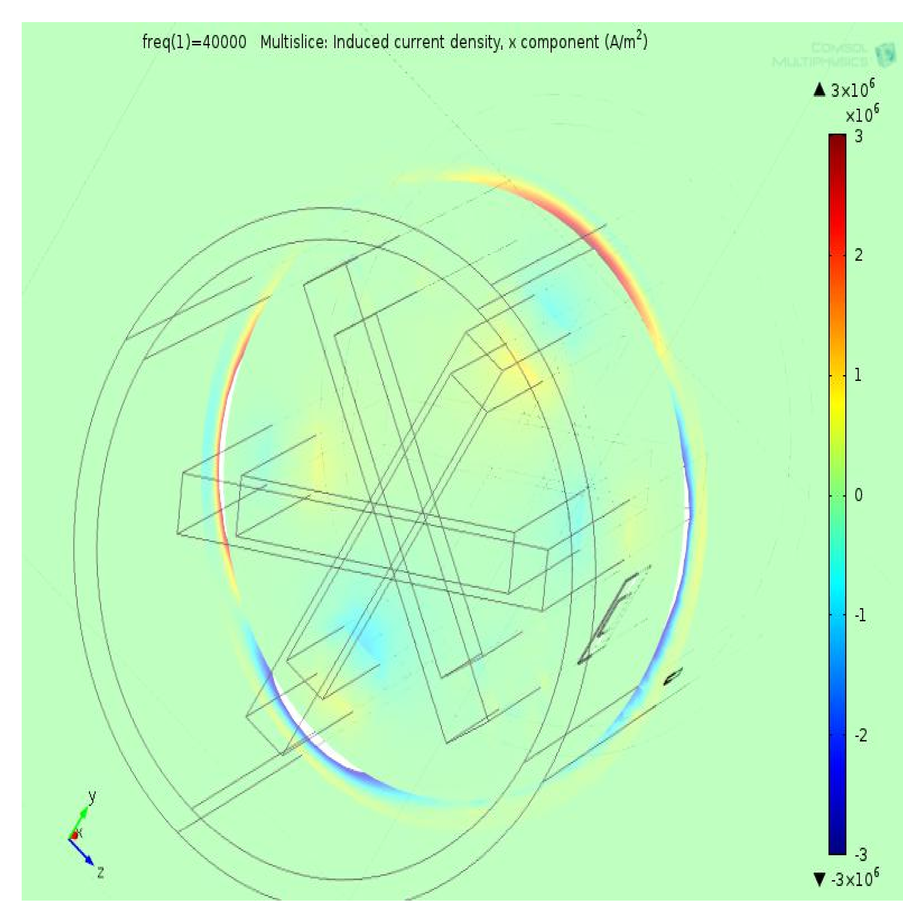

Figure 4. Induced current distribution in Pressure tube

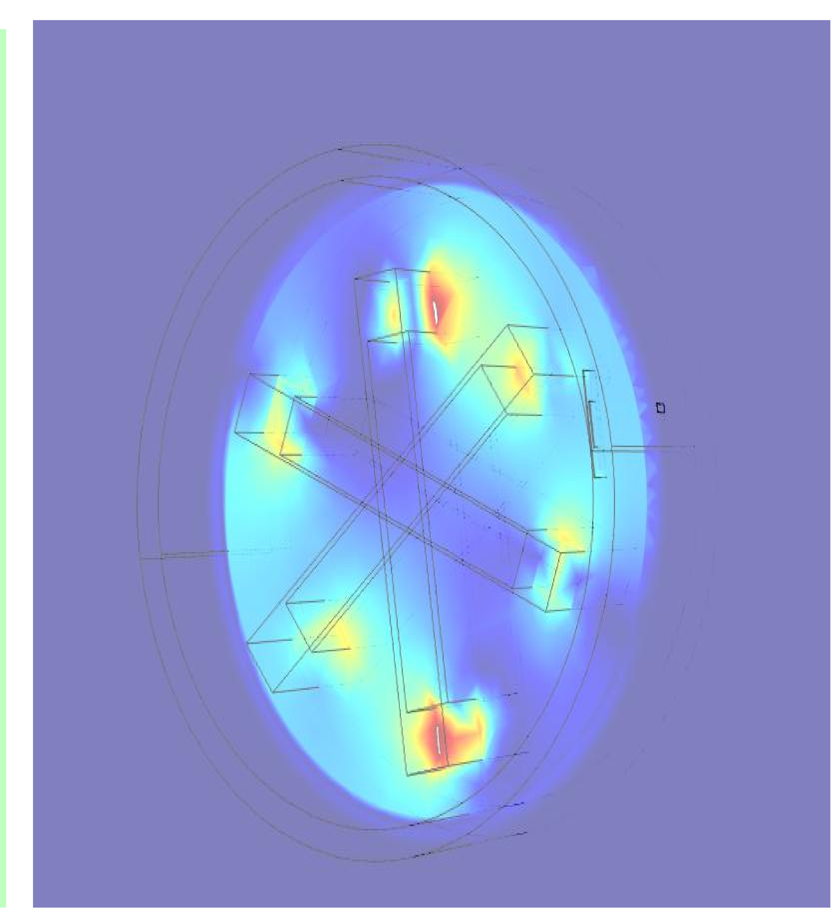

Figure 5. The Magnetic Field density distribution of the Rotating magnetic Field Eddy current probe. current distribution in Pressure tube

Flaw Location	Flaw size 0.1mm	Flaw size 0.2mm	Flaw Size 0.5mm
OD	6.5*10^-8 ang -144.94	5.6*10^-8 ang -143.70	1.45*10^-8 ang -144.29
ID	1.89*10^-10 ang 38.14	1.6*10^-10 ang 36.34	1.44*10^-10 ang 33.52
No Flaw	5.45*10^-3 ang -151.65	5.45*10^-3 ang -151.65	5.45*10^-3 ang -151.65

Table-1. The amplitude and phase information of single turn of pick up coil for varying flaw sizes and at different depth locations.

Conclusion: Rotating Magnetic Field eddy current technique is a promising technique for inspection of metallic tubular components like pressure tubes of Pressurized Heavy Water Reactors (PHWRs). The technique enables to detect flaws in circumferential as well as in axial direction simultaneously. Further with this technique complete circumferential inspection is possible without physical rotation of the probe. The key advantages of the technique are better Signal to Noise ratio, high sensitivity, and good reproducibility.

References:

1. Reliability of automatic eddy current equipment with a rotating magnetic field." ; R. Grimberg, Adriana Savin, O. Mihalache, N. Rezlescu, Elena Bradu, S. Chifan, V. Iftimi and A. Andreescu.; NDT&E International, vol.28, No:5, pp 297-301, 1995.