Chapter 36

Pulsed Magnetic Field Application in Garter Springs Repositioning

––M.R. Kulkarni, Hitesh Choudhary

In Pressurized Heavy Water Rectors (PHWRs) the pressure tubes and calandria tubes are separated by the annular rings called garter springs. To maintain coaxial configuration of pressure and calandria tubes, Garter spring is used. Due to hot conditioning of reactor and the vibration during construction these springs get displaced. Due to Garter spring displacement, pressure tube and calandria tube come in contact during reactor operation, resulting rupture of pressure tube. This cause requires repositioning of Garter spring. In this context reposition the garter springs in reactors under construction, a program was initiated in BARC by electromagnetic and vibration movement techniques in BARC. The NtPD, BARC took the lead in development of “Electromagnetic Garter Spring Repositioning System” in early nineties. In this technique non-contact axial electromagnetic force (J x B) is generated in garter spring using high strength coil, when stored capacitive energy is discharged in the coil.

36.1. Scheme of operation

The electromagnetic garter ring repositioning system consisted of 85 kJ, 20 kV Energy Storage Capacitor Bank, strong single layer helical coil to generate the field, HV DC Power

Supply, energy dump system. Double triggered spark gaps are triggered by command pulse to discharge its energy into garter spring repositioning coil through transmission cable. Figure 36.1 shows scheme of electromagnetic pulse method. Figure 36.1 indicates the schematic sketch indicating the relative position of the calendria tube, displacement coil, garter spring and pressure tube.

The capacitors are charged by DC power supply. When command pulse is initiated, the double triggered spark gaps are triggered and discharge the energy stored in the capacitor bank in to G/S repositioning coil through cable transmission line.

The coil produces more than 15 T, at the centre. This field diffuses through pressure tube and induces a current in the G/S griddle wire. If the axial component of force is greater than static friction, G/s moved in axial direction. The force produced will be maximum when the spring is at the ends of the coil and zero when it is at the middle.The coil utilized to displace G/s is named displacement coil. Another challenge is to tilt the G/s for which forces in top and bottom of G/s must be in opposite direction. Tilt coil is designed and developed for this purpose which generates opposite force on top and bottom of G/s, hence G/s tilts.

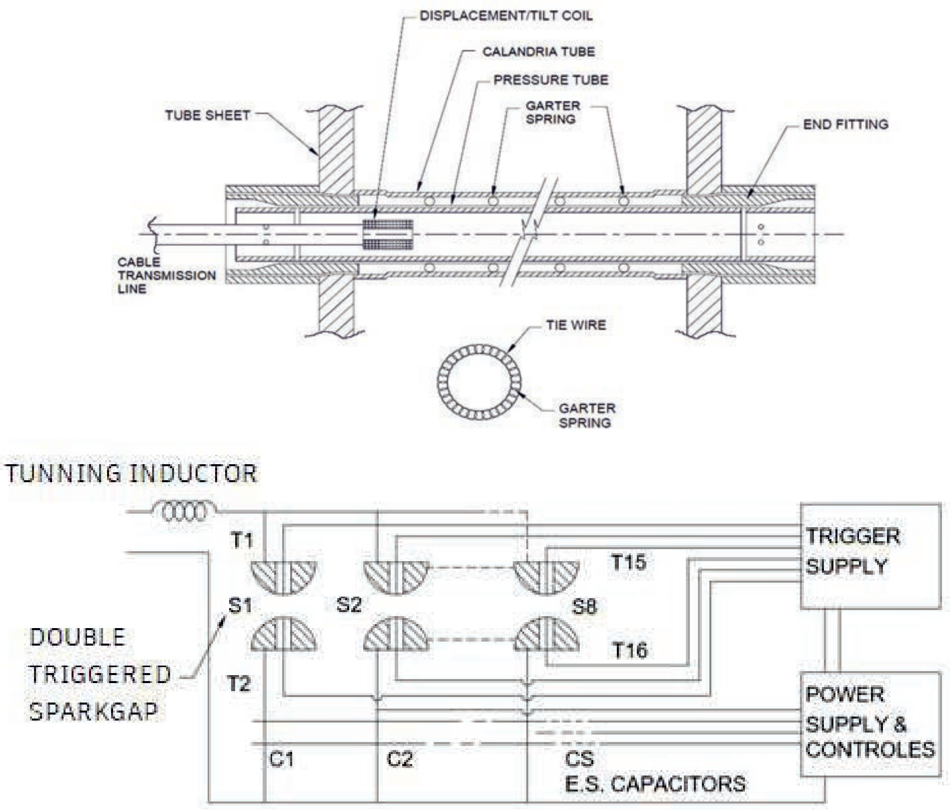

Figure 36.1(a). Calandria tube, Pressure tube and Garter spring with displacement coil (top) and (b). Scheme of electromagnetic pulse generator (bottom).

36.1.1. Displacement coil

To displace G/s, displacement coil (single layer) is designed and its cross section is shown in Figure 36.2. Inter-turn insulation is provided by Nomex insulation and inter-turn strength is provided by fibre glass rings. To contain radial forces polyglass banding is provided. The peak current flow in the coil is 55 kA for displacement of 200-300 mm.

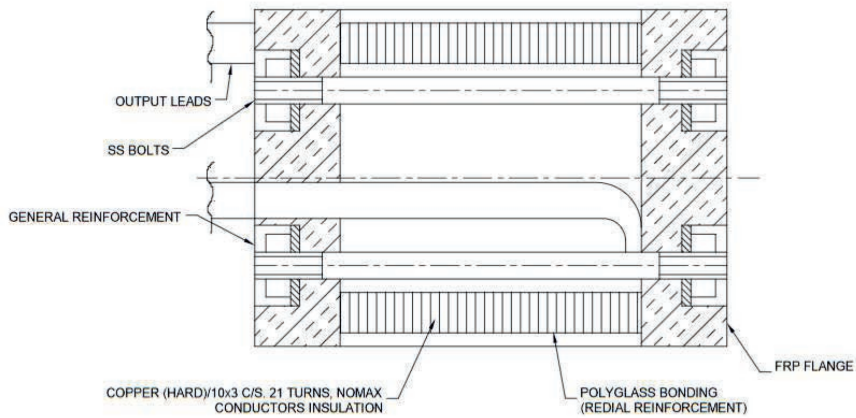

Figure 36.2. Single layer displacement coil.

36.1.2. Tilt coil

The tilt coil utilizes two coils with radial offset of 20 mm and axial offset of 15 mm. The cross section of optimized tilt coil is shown in Figure 36.3. These coils produce a force which moves the spring away from the respective coils, in this process the G/s tilts from one orientation to exactly opposite orientation. To obtain optimum frequency external inductor of 22 μH is utilized with coil. The tilt has been obtained in three shots.

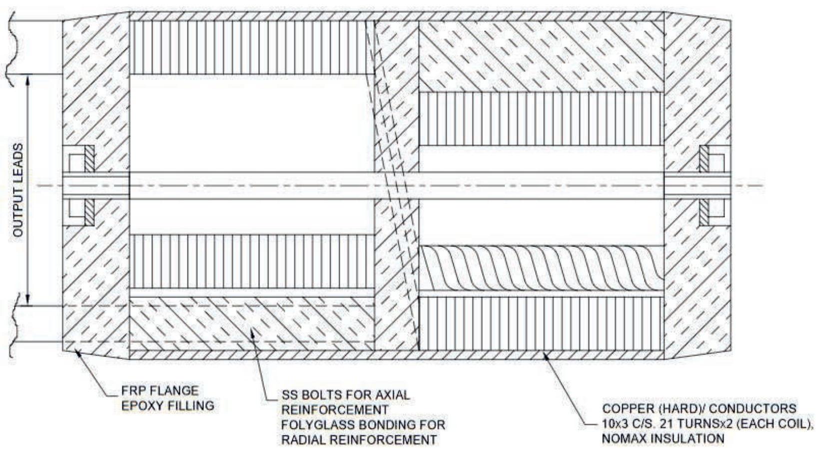

Figure 36.3. Single layer tilt coil.

36.1.3. Repositioning in Indian PHWR

The “Electromagnetic Garter Spring Repositioning System” was successfully used to correct the tilted and relocate displaced garter ring repositioned in several pressure tube and life of the coolant channels in Narora (NAPP-2) and Kakrapar (KAPP) Nuclear Power Plants and life was extended for considerable period. This technique is now not required as the designer of the garter springs have been modified to mitigate the displacement from their designated places.

Acknowledgments

Authors duly acknowledges the all team members of APPD who participated in design and development of magnetic pulse based garter spring repositioning and executing in Indian PHWR reactors. This article is an attempt to just highlight the application of magnetic pulse in nuclear industry.