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# DESIGN AND ANALYSIS OF 12 MM COLLARS FOR SSC ARC QUADRUPOLE MODELS

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## Introduction

Finite Element Analysis was used to predict collars stresses and deflections for 12mm Arc Quadrupole Collars (Ref. 1). Based on this analysis, aluminum was chosen as the collar material primarily due to its tendency to maintain coil prestress during cooldown. This, in turn, requires lower stresses in both coils and collars during the room temperature phase of collaring and assembly. The final collar geometry chosen for use in LBL's 1-M arc quadrupole models is shown in Fig. 1. This geometry incorporates two features not presented in reference 1, namely a 3° taper to the loaded keyway surface and an enlargement or reinforcement of the collar at the keyway. This reinforcement reduces collar stress at the keyway and lowers bearing stress at the sliding key to keyway surface.

The function of the tapered key is to reduce collar springback and coil prestress loss during collaring. During collaring the coil prestress is raised slightly above the required room temperature prestress using the main collar press. As the tapered keys are engaged and pressed in, the collaring press force is reduced to hold the coil stress at a constant value. Recent tests show that when the keys are fully engaged and the collar press is released the drop off of coil prestress is now about 30% from its peak value during collaring as compared to 70% for the conventional non-tapered keying system.

## Analysis Model

The finite element model is shown in Fig. 2. Sliding frictionless

elements were used at the coil collar boundary. The boundaries of the coils were constrained to move symmetrically about the 45° symmetry line. A coil modulus of $1 \times 10^6$ psi was used.

A circumferencial compressive pressure of 4,000 psi was applied to the coils at the coil midplane (45° symmetry line, Fig. 2). A 24,000 psi reaction pressure was required at the keyway to balance the coil pressures. The 4,000 psi applied coil load is a conservative guess at the room temperature coil prestress requirement. It assumes the cold prestress requirement, safety margin, and cooldown prestress loss will be 1700 psi, 1000 psi, and 1300 psi, respectively.

One goal of this design was to keep the bearing load between the key keyway from being concentrated at the root of the keyway. The best case of this would be a uniform load along the key to keyway contract. The final orientation of the keyway face due to the applied uniform pressure will then be the required taper for the key in order to produce a near uniform pressure load along the bearing surface. Analysis results showed that this surface rotates to very nearly 3.5° from its original 3.0° orientation. The tapered key used therefore had a 3.5° taper.

Analysis Results

The stress and deformation results are shown in Fig. 3 and 4. The maximum collar stress of 62 Kpsi is at the loaded keyway corner. This is an 11% reduction from the 70 Kpsi of the non-reinforced collar (Ref. 1, Fig. 8). Collar deflection remains at 0.010 inch on the diameter as also predicted for the non-reinforced collar (Ref. 1, Fig. 9).

Figure 5 and 6 shows the linear relationships between coil prestress and peak collar stress and deflection.

Ref. 1 SSC Mag-Note-85.

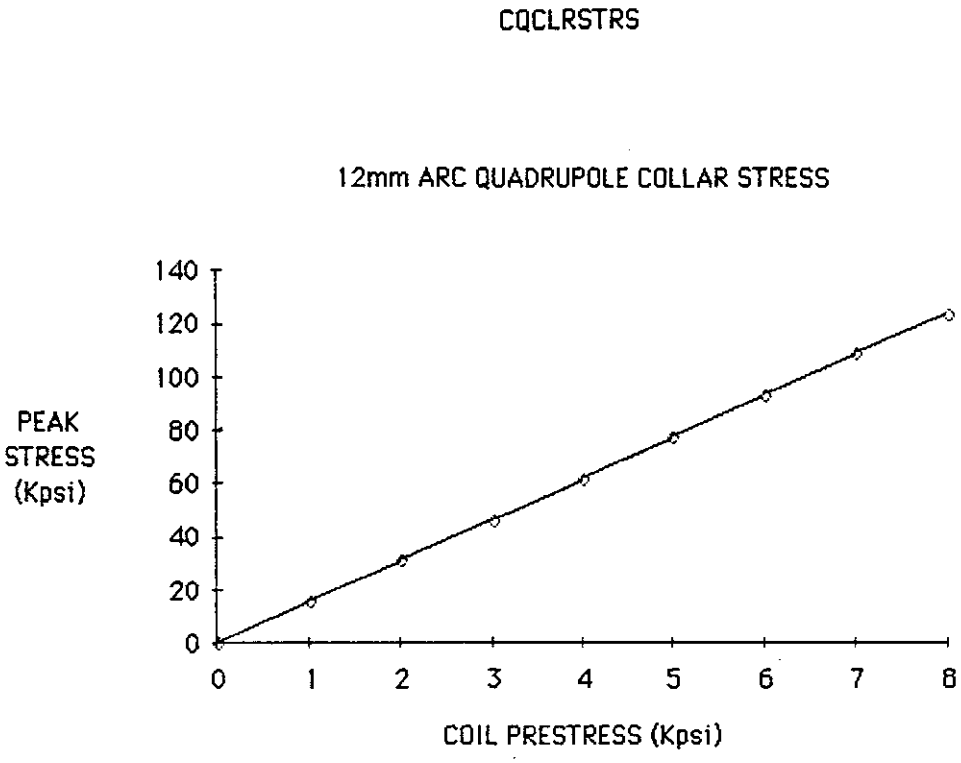


Fig. 5. 12 mm Arc Quadrupole Collar Stress

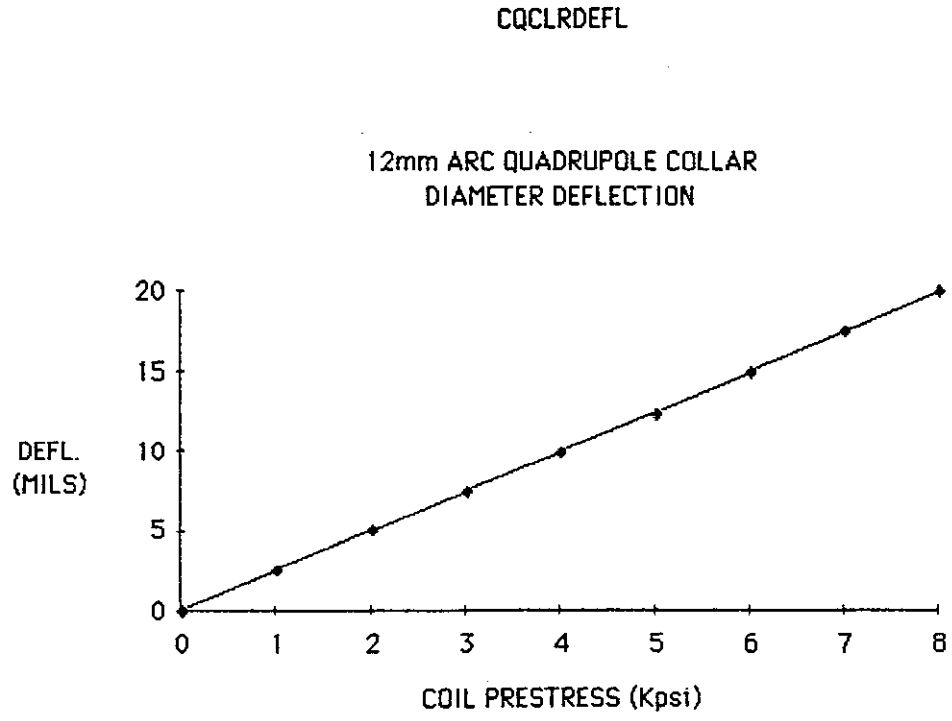


Fig. 6. 12 mm Arc Quadrupole Collar Deflections

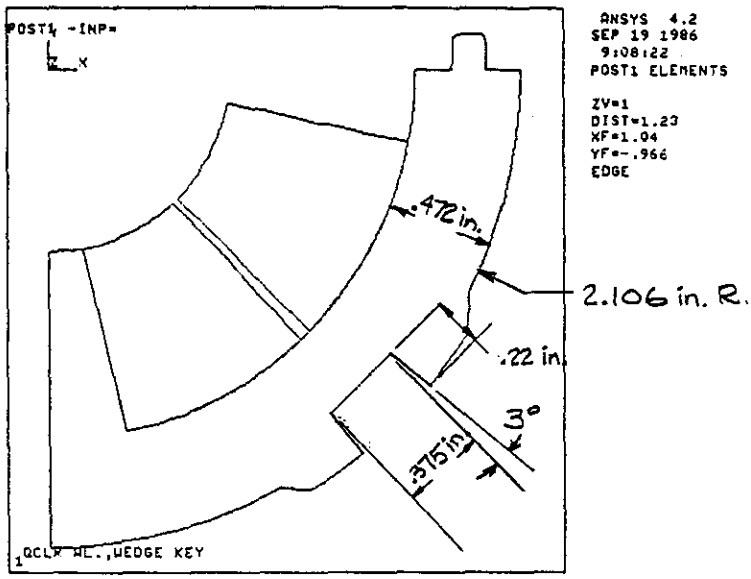


Fig. 1. 12 mm Arc Quadrupole Collar Geometry

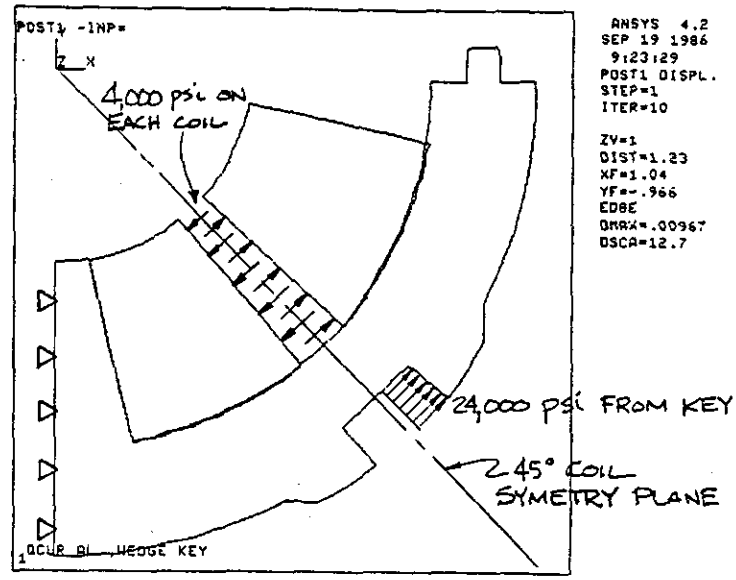


Fig. 2. 12 mm Arc Quadrupole Collar FEA Model

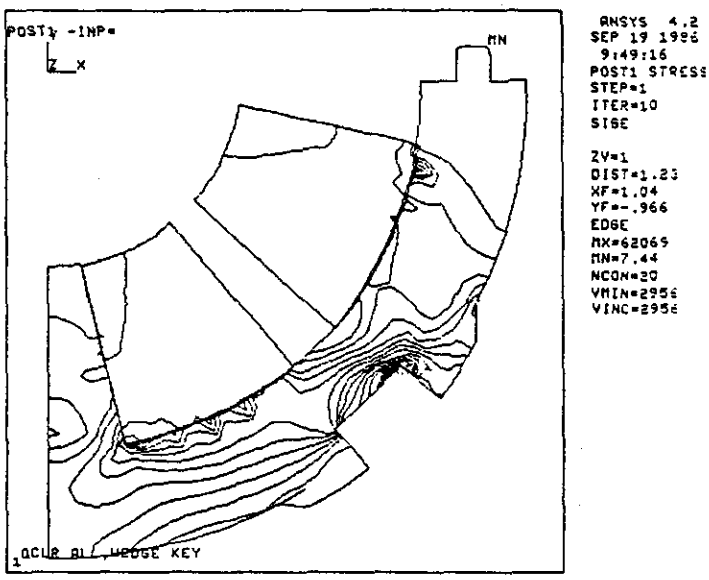


Fig. 3. 12 mm Quadrupole Collar Stresses

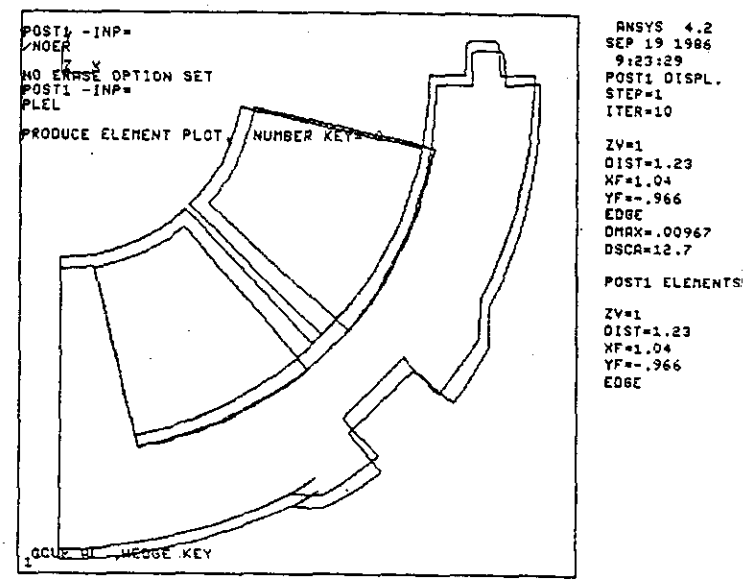


Fig. 4. 12 mm Arc Quadrupole Collar Deflections