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BOW-SHAPED TOROIDAL MAGNET COILS

BY

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BOW-SHAPED TOROIDAL MAGNET COILS

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ABSTRACT

A constant tension coil in which the structural pathway is of the form of an archer's bow is described. This shape suggests that demountable high field toroidal magnets can be constructed with the joint at the small major radius where it is most useful. The coil tension can be used to maintain the joint in compression and ensure reliable performance.

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Fig. 1. Bow Coil Arrangement.

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Fig. 2. Shape of Bow Coil for $r_1 = 1$, $r_2 = 5$, $\theta = \pi/4$.

OBJECTIVE

The objective is a toroidal coil in pure tension (see Fig. 1) with $F < T_2$. F can be made zero or negative (compression); a coil joint can be placed at A and experiences either no separating force or compression. Demountable, high field toroidal coils are thus feasible. This technique can also be utilized to simply reduce the tension in the restrictive, central region, ($r = r_1$) of a tokamak toroidal coil.

DESIGN

A tension link is attached to each coil at B in Fig. 1. The links are attached to a central disc D. A compression member C then transmits force directed towards the midplane. These structures may be integrated. Alternatively, the coil may be girdled with a tension band which loads a compression block.

EXAMPLE

Consider the case when the compression force in C equals the tension T_1 . Then

$$(T_2 - T_1) \sin \theta = T_1 \quad (1)$$

and

$$T_2 = \frac{IB_0 r_0}{2} \ln \frac{r_2}{r_1} . \quad (2)$$

The net force F in the straight portion of the coil at r_1 is then zero. A coil joint placed here sees no separating force.

An example appears in Fig. 2 using $r_1 = 1$, $r_2 = 5$ and $\theta = \pi/4$.

The example was generated using a thin shell approximation for the magnetic field $B = B_0 r_0 / r$. The tension is then

$$T = \frac{IB_0 r_0}{2r} \times \frac{ds}{d\alpha} . \quad (3)$$

The constant tension path for the outer leg was obtained by numerically integrating the equation

$$\frac{d\alpha}{ds} = \frac{1}{r \ln (r_2/r_1)} . \quad (4)$$

The constant tension path for the inner portion is given by

$$\frac{d\alpha}{ds} = \frac{1 + \sqrt{2}}{r \ln (r_2/r_1)} . \quad (5)$$

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