Specifications for new JGG Coils

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Abstract

The old coils of the Jolly Green Giant Magnet need to be replaced. A new coil geometry has been selected to improve magnetic field uniformity, cf. MIPP note 134. Due to cost considerations the new coils will be made from aluminum whereas the old coils were made from copper. This note lists the specifications and parameters for the new coil in one document to double check the expected performance of the coils with existing power supplies.

I. JGG COIL PARAMETERS

The size of the coil packs of the JGG is largely determined by the shape of the magnet yoke and pole pieces. The new coils will have (close to) the same cross section area as the old coils. However, there are several important differences. The old coils were made from water-cooled copper. The new coils will be made from aluminum. The old coil system consists of 4 coils with 256 turns each (2 coils with 512 coil turns above the magnet aperture and 2 below). The new system will have only 180 coil turns per coil and only two coils. The conductor in the new coils will be 1×0.92 inches in diameter with a 0.5 inch hole for the water. This is larger than the copper conductor, resulting in the smaller number of turns. The table compares old and new specifications side by side.

II. MAGNETIC FIELD, CURRENT, AND POWER

The field was modeled by Bob Wands for different coil extensions using the old coil specifications with a total of 1024 coil turns. The models were run at a current of 687 A. This provides the magnetic field strength desired by the experiment. The number of coil turns in Ang Lee's computation is 16% higher than that in Bob Wand's field model. The last column in the table lists voltage and current for the new coil to produce the desired field strength. I consider this a safety margin in the model.

Thus the power supply needs to provide $2276A$ at $344.1V$ (assuming the two coils are connected in series) or $4552A$ at $172V$ (coils parallel). According to Walt Jaskierny the supply can provide a maximum current of $2500A$ at up to $400V$. Thus the coils can be connected in series to the supply.

The JGG power supply actually consists of two suppies operating together, just the same as it has been in the past. The supplies are connected to the magnet through a reversing switch rated at $2500A$ and a water cooled bus between buildings rated for $5000A$. The voltage drop on the bus is not taken into account in detail here, but the margins are sufficient.

Some of the short cable runs between supplies and reversing switch and bus and magnet may have to be improved. Also, the new coils will need a modified cooling water manifold.

parameter	old coils	new coils (Ang's calculation)	new coils, operating point
material	Copper	Aluminum 1350	Aluminum 1350
number of coils	4	2	2
turns per coil	256 (8×32)	180 (10×18)	180 (10×18)
coil size	nominal	extended 9 inch	extended 9 inch
conductor length		$4303.51 ft$/coil	$4303.51 ft$/coil
coil turns (total) N	1024	360	360
coil current I	$687 A$	$2275.55 A$	$1954.13 A$
power supply current	$1374 A$	$2275.55 A$	$1954.13 A$
voltage drop		$194.5 V$/coil	$167.0 V$/coil
power supply voltage		$389.0 V$	$334.0 V$
NI	703,488	819,200	703,488
$B_y(0,0,0)$	$0.646 T$	$0.797 T$	$0.684 T$
Coil resistance		0.085462Ω per coil	0.085462Ω per coil

TABLE I: Parameters of old and new JGG coils. New coil parameters are taken from Ang Lee's coil heating calculation and Bob Wand's magnetic field model. Numbers for the new coil were computed at 819,200 A-turns and are scaled to 703488 A-turns for comparison with the old coils.

These are relatively minor tasks with no impact on the coil design.

III. CONCLUSION

The new JGG coil design can be operated with the existing JGG power supply to provide a field of ~ 0.7 Tesla strength and better uniformity than the old coils could provide.