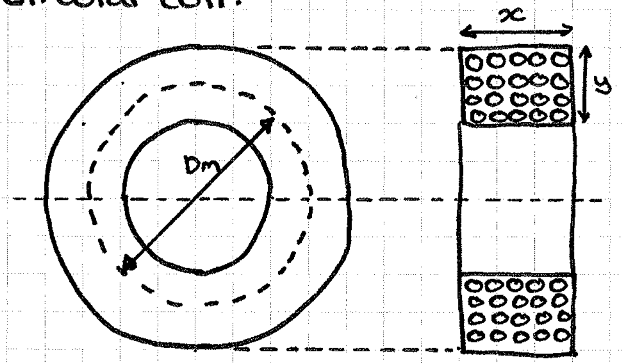
12R017 - PACKING FACTOR AND RESISTANCE OF SIMPLE COILS

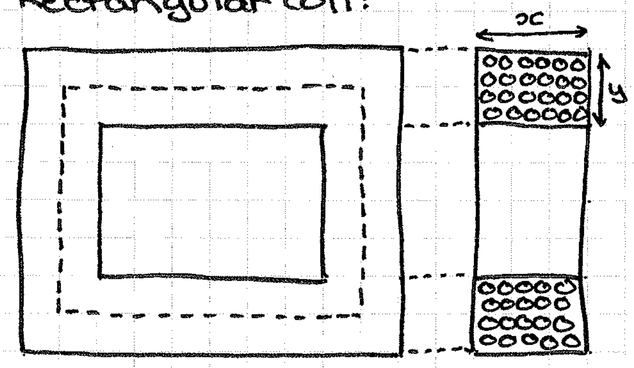
Aim - calculation procedure of packing factor and resistance for simple rectangular and circular coils

1. GEOMETRY DEFINITION

Circular coil:



Rectangular coil:



It is assumed that both coils have a rectangular cross-section, with dimensions x, y.

2. KEY PARAMETERS

- mean length per turn (MLT) - in the geometries shown, the turns on the inside of the coils have a shorter length than those on the outside of the coil. The average turn length is shown as a dashed line. This dashed line is the average of the coil's inner and outer dimensions.

- length of wire in coil (ℓ) = MLT × number of turns (N)
  i.e. $\ell = MLT \times N$

- wire diameter D_{cu}

- wire cross-sectional area (A_{cu})
  $A_{cu} = \pi D_{cu}^2 / 4$

- resistance of coil (R)
  $R = \frac{\ell}{A_{cu}} \times \rho_{cu}$
  where ρ_{cu} = resistivity of copper

- copper packing factor: this is the fraction of the coil cross-sectional area which is copper
  $pf = \frac{N \times A_{cu}}{x \times y}$ ← COIL CROSS-SECTIONAL AREA

  The packing factor is < 1 due to airgaps between the round wires and the layer of insulation around each wire. Typical values of packing factor are between 0.3 and 0.5.

3. ANALYSIS EXAMPLES

3.1. Find Number of Turns - given coil dimensions and wire diameter, and coil resistance (measured).

- find wire cross-sectional area A_{cu}
- find wire length ℓ
- determine MLT from geometry

hence find number of turns
$N = \ell / MLT$

3.2. Choose Wire Diameter - given coil dimensions and coil cross-sectional area, and the number of turns

- choose a value for copper packing factor. A value of 0.3 is a good starting point. You can generally do better with careful winding.
- calculate the wire cross-sectional area A_{cu} using
  $A_{cu} = \frac{x \times y \times pf}{N}$
- find wire diameter D_{cu}
- find resistance of coil R_{cu}

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