A Novel Approach to Electrical Machines based on Coated Conductors

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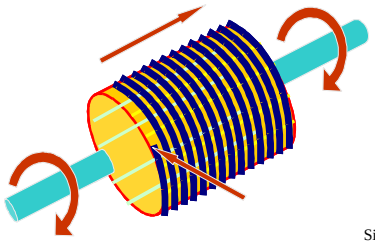
Abstract— A radically new approach to the fabrication of electrical machines based on coated conductor has been developed. Instead of long lengths of coated conductor tape being wound into coils in a conventional manner, we propose to use a combination of thin film deposition and patterning techniques with an essentially coaxial cylindrical geometry to produce multilayer coils. These patterned coated conductor cylinders can subsequently be configured in different ways to form a variety of superconducting electrical machines all based on highly manufacturable "standard" cylindrical modules with high engineering current density. The cost benefits of such standardized manufacturing may be very significant in future applications of coated conductor. Initial feasibility studies [(1)] support the basic concepts [(2), (3)].

(1) J.S. Abell, R.I Chakalova, Y.L.Cheung, T.W. Button and E.F. Maher : "Growth of Multi-layer Coated Conductors on curved surfaces", CCA2003 Workshop, Milan.

(2) Interrnational Patent Application PCT/GB02/03898 "Novel Coil Fabrication Techniques", E F Maher, filed 24th August 2002.

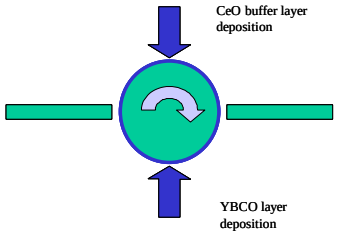
(3) E.F. Maher : "Coated Conductor Cylinders – an alternative approach", CCA2003 Workshop, Milan.

In-situ coil fabrication
- Example 1.



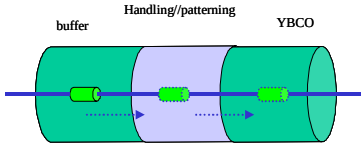
Buffer and YBCO layer deposition on an IBAD textured former followed by laser scribing to "pattern" a coil – similar to a thread cutting operation on a lathe. A similar structure could be achieved by an IBAD beam writing process followed by buffer and YBCO layer depositions.

In-situ coil fabrication
- Example 2.



Simultaneous buffer and YBCO layer deposition on rotating former to form a "Swiss Roll" pancake coil.

In-situ coil fabrication
- Example 3.



"Shuttling" of cylindrical former between different chambers for different process steps during fabrication.

What is 3-C's novel thin film coil fabrication technology?

In a nutshell
– joined-up manufacturing technology

- Multilayer coated conductor films deposited directly on rotating cylindrical formers, patterned for in-situ coil fabrication.
- Higher engineering current densities and lower AC losses – no unwanted substrate.
- Slow texture step if required – once only. Thereafter texture copied layer by layer.

Benefits :

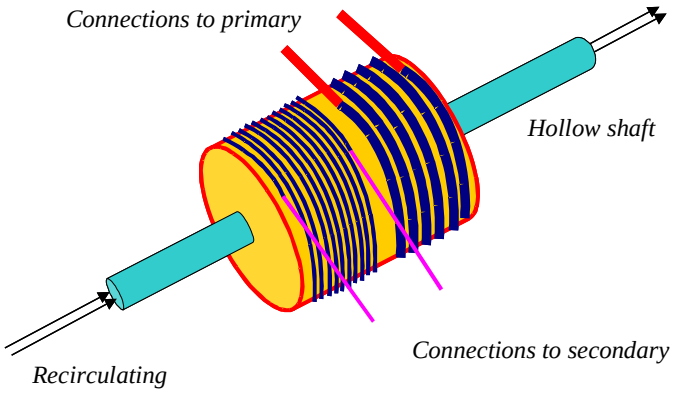
- New degrees of freedom for designers via film patterning.
- Co-axial symmetry simplifies film deposition.
- Substrate rotation increases film uniformity.
- Elimination of tape handling problems.
- Process step verifications facilitated.
- Greater structural integrity.

SUBSTANTIAL SIZE AND WEIGHT REDUCTION LEADING TO LOWER SYSTEMS COSTS.

Proposed 3-C's Demonstrator

- several functions within one construction

- Single layer YBCO coated conductor film deposited directly on rotating cylindrical former, patterned into two coils for different demonstrations. Cooled by circulating coolant within former, or by simple immersion in LN2.
- **Demonstrate :**
  - Step-up and step-down transformers
  - Resistive FCL (two different coils)
  - Inductive FCL
  - SMES module
  - Linear motor module



Proposed single layer test structure – for step-up transformer.

System implications of "Modular Approach"

- Volume manufacturing of standard parts will give significant cost benefits
- Lower systems development costs using "standardised modules"
- Highly reproducible performance from standard "building blocks"
- Built-in protection devices will operate within each module- easy replacement
- Integrated refrigeration and easily modelled thermal characteristics

Examples :

- Multi-module SMES unit– options for connecting a SMES "array"
- Multi-module motors and generators– with easily replaced elements
- Linear array of modules to form linear motors for traction systems
- Modular FCL systems with variable load level and recovery options depending on connection scheme

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