Manufacturing Soft Ferrites: Pros and Cons of Pressing vs. Machining

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Sintering and Casting Ferrites

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
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<tbody>
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<td>Allows for complex geometries to be made</td>
<td>Can cause surface defects</td>
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<td>Very repeatable, fast, and cost effective in high volume</td>
<td>Can be costly in low volume</td>
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<td>Shrinkage of up to 20%</td>
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<td>Size restrictions of sintering furnace and parts</td>
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<td>Improperly compressed ferrite powder can lead to porosity issues</td>
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Machining Ferrites

- Because ferrites are very brittle, machining operations are limited
- Machining can be used to clean up surface defects
- Machining of ferrites can be used for the gapping of ferrite cores
- Machining can be used to obtain tighter tolerances on ferrite blocks
- Machining cores is ideal for prototyping in low-volume

Gapping of Cores

- Gapping is the most common machining operation performed on ferrite cores.
- Gapping involves removing material from a core (typically the center leg) to a specific dimensional or electrical tolerance.
- Designers use gapped cores for a variety of reasons, including preventing core saturation, increasing reluctance, and controlling inductance.
- The gapping calculator on Dexter's website can be used to determine gap length from desired $A_L$ value.
Gapping of Cores

- Gapping is done by one of two methods, either traverse (sided to side) gapping or plunge (up to down) gapping.

- The diagrams to the right show the applications of traverse gapping and plunge gapping in the case of a pot core and e-cores.
Grinding

• Grinding is one of the most common and important machining operation performed on customized ferrites

• It is best to use a super abrasive grinding wheel like diamond

• Correct determination of grinding parameters is crucial and can prevent substantial damage to the structural integrity of the ferrites

• To the right are diagrams demonstrating Ductile, Fracture, and Partial Ductile modes of grinding. These grinding parameters are critical and can affect surface and sub-surface integrity

2. (“Diamond Grinding Wheel, Steel Core 6”x1” – Jade Carver”, n.d.)
Other Operations

• In addition to grinding, CNC mills and centerless grinders may be used as well

• It is important to use coolant in order to remove significant differential thermal expansion which causes spalling/fracturing

• A goniometric head may be utilized to achieve non straight cuts on ferrites

• Lapping, can be used to obtain a better surface finish at the mating surfaces, yielding better magnetic performance of ferrite cores

Special Core Shapes

• Special or customized cores are usually implemented in the case in which standard core shapes cannot achieve mechanical, magnetic, or aesthetic specifications.

• Special core shapes can be manufactured to accommodate special air gaps or the insertion of steps, pitches, slants, caps, slots etc. to influence the modulation or allow space for mechanical/electrical components.
Special Core Shapes: EXAMPLE 1

• Ferrite assembled, glued and cut in half to be used as a snubber on a power cable

• Machined ferrites for use in a PLANAR application

• Prior to Dexter's addition of the HAAS, this design would need to have been made from 3 pieces, causing an unwanted gap at the joint lines
Special Core Shapes: EXAMPLE 2

• Photos of machined ferrites from blocks and windings used in a deflection assembly

• Machined ferrites being for use in unique power supply designs – one showing turning single phase core into three phase cores, the other displaying further use of CNC
Special Core Shapes: EXAMPLE 3

- Ferrite for Hall Effect current sensor where a standard ferrite toroid has a cut taken out so fringing lines of magnetic flux can be measured

- Machined ferrites developed for a high current, low profile inductor

- This design could not have been made by Dexter prior to the addition of the HAAS
Special Core Shapes: EXAMPLE 4

• This is an example of a core machined completely from a ferrite block

• Because of their relatively simple geometry and tight tolerancing, they were best manufactured using machining operations

• Project for 3-D scanners to give TSA agents a clearer view of potential problems in bags, including explosives, and designed to go twice as fast checking carry-on bags
Special Core Shapes: EXAMPLE 5

• To the right, a prototype for a polygonal ferrite toroid can be seen

• This custom toroid had to be machined and assembled due to the size limitations of a sintering furnace. Calculations and analysis were performed in order obtain the feasibility of machining different sizes of toroids

• 12 3C95 grade trapezoidal ferrite blocks were machined using a diamond wheel to grind them to size. They were then assembled using structural adhesive
Special Core Shapes: EXAMPLE 6

• Firstly, we see a pot core with a custom gap. It is step-gapped, as can be seen in the pictures.

• The next pictures show custom machined arc ferrites glued to the ID and OD of a housing. When assembled, these parts create a down-hole rotational transformer.

• Lastly, a picture of a custom ferrite winding used in a rechii rotor is shown.
Conclusion

KEY TAKEAWAY: Depending upon application and quantity there are trade-offs when determining whether to use a sintered core or a machined core. It is important to consider critical aspects of end use in this determination.

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