Manufacturing an electronic motor stator built from thin amorphous metal

ANDRÁS BÁRDOS*, ATTILA SZABÓ*, STEFAN BÖRZEL† AND MIHAI STOIAC†,‡

* Breuckmann GmbH & Co. KG Heiligenhaus, Germany; † IFW Dresden, Germany; ‡ TU Dresden, Germany

Introduction
An asynchronous electric motor core is made from stacked laminates of 0.1 – 1 mm thick electrical steel. The laminates are typically formed by stamping the mechanically soft electrical steel into the desired shape; subsequently, they are stacked to form the motor core. Although thin metal strips or amorphous ribbons offer a higher magnetic performance compared to the presently used thicker crystalline electrical steels, they have been considered unsuitable to build the rotor and/or the stator of classical electric motors because of fabricating limitations. Both the electrical isolation and the stacking process seem to be already solved, but below 0.1 mm strip-thickness the punching process is not stable. Moreover, the strip can be easily damaged or even fractured and this has a negative impact on the quality and also increases the costs of production. The thinness of the metal strips also causes an increased number of laminates in the assembly, increasing the total cost of an amorphous metal core. The present work focuses on the construction of an electric motor core built from partially pre-laminated and subsequently punched 0.02 mm thin amorphous metal ribbons. During our work the magnetic properties were also measured and compared to the presently used motor stators.

Motivations

Why do we use amorphous materials in electronic motors?

- Good formability
- High saturation magnetization
- Low Hc
- High permeability

Experimental

The chosen material

Requirements:

<table>
<thead>
<tr>
<th>Physical quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation Induction (T) As Cast</td>
<td>1.36</td>
</tr>
<tr>
<td>Maximum D.C. Permeability</td>
<td>600000</td>
</tr>
<tr>
<td>Annealed</td>
<td></td>
</tr>
<tr>
<td>As Cast</td>
<td>40000</td>
</tr>
<tr>
<td>Saturation Magnetostriction (μm)</td>
<td>27</td>
</tr>
<tr>
<td>Electrical Resistivity (μΩ/cm)</td>
<td>130</td>
</tr>
<tr>
<td>Curie Temperature (°C)</td>
<td>399</td>
</tr>
</tbody>
</table>

Alloy type: Hitachi metals 2605SA1

The chosen geometry

An existing motor-stator-geometry has been chosen to be able to perform comparison-test

Designing the technology

Strip lamination

Problems: Brittle, even if the strip has good formability

Solution: Preparing prelaminated strips, mounting amorphous metal strip together using a bounding material with high dielectric constant

Striplamination

Solution

Tool design

Requirements:

- High precision because of thin strips
- Complete the shaping in one step
- High shaping edge hardness
- Keep the strips flat during the punching process

Punching steps

Step 1: Fixing the sample and prevent it from bending
Step 2: Cutting the inner contour
Step 3: Cutting the outer contour

Results and conclusion

The steps of amorphous stator production

1. Mounting the strips into prelaminated stacks using an adhesive glue
2. Using a pressure to force the air and unwanted adhesive glue out
3. Punching the prelaminated stacks into given shape
4. Mounting the punched prelaminated stacks together to form a stator

Conclusion

- Using the mounted strip during the punching process, the flexible adhesive layer helps to avoid the thin sheets from cracking or even from breaking.
- Using hartmetal cutting blades the life cycle of the punching tool is extended.