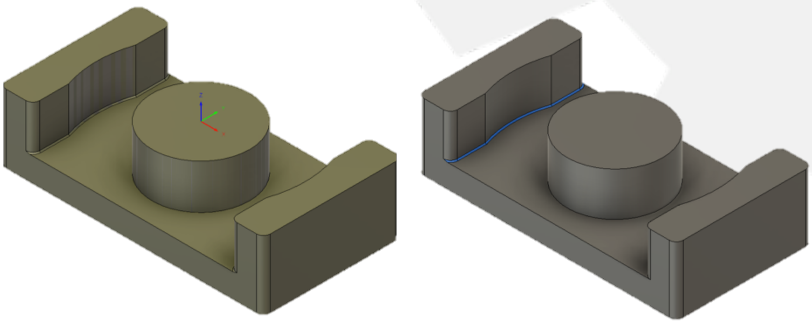
DESIGNING FOR MACHINED FERRITE – THE MACHINE SHOP

The Machine Shops cutting edge machining techniques allows engineers to design, test and verify new ferrite shapes without the need for costly pressing tools. Furthermore, it allows engineers to verify designs in different material grades from the biggest names in Ferrite, Ferroxcube, TDK, Fair-Rite and Magnetics Inc.

The Machine Shops industry leading tolerances surpass those that are available from typical pressing tools. This document is aimed at guiding design engineers through their design phase to ensure they aren't adding any unnecessary costs to the design and that they balance and understand the tolerances required within key features to ensure the part is ready for mass production.

Internal Radii – sharp corners

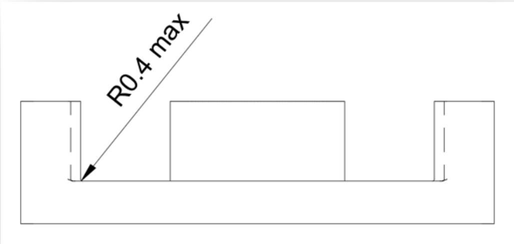


The internal corners of the core cannot be 90 degrees within the Z-axis plane, corners must have an internal radius for both machining and pressing. In pressing this is related to how the core is pressed and ensuring a consistent pressing density throughout the core. In Machining, this is related to how the cutting tools are manufactured, the tools need to provide sufficient surface area to hold the abrasive cutting compound, this means that tools cannot be made with a 90-degree corner.

Our standard process allows us to machine internal radii of 0.4mm MAX. The tools hit a nominal radius of 0.3mm, as the tool wears this increases.

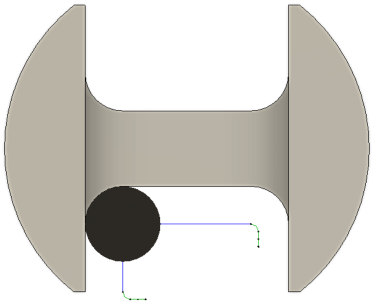
Through continuous improvement, Gateway has perfected a finishing technique that allows us to create internal radii of 0.2mm MAX. This requires extra tooling and so increases the price by around 20%.

Takeaway – Design all corners in the Z plane to incorporate a radius of 0.4mm MAX.

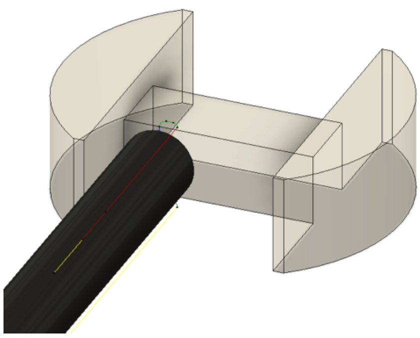


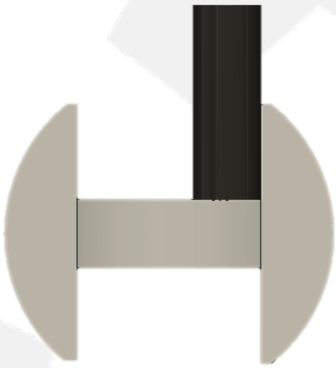
Internal Radii – smallest natural rad

When machining, the team focus on machining all features in one operation, this keeps costs and cycle times down. The smallest standard tool that Gateway stocks is 1mm in diameter, this means that radii of 0.5mm are achievable within one operation.



To achieve less than 0.5mm would require a separate setup routine which sets the corner parallel with the Z axis, even with this separate setup, the sharp corner rule still applies which would leave a rad of 0.4mm MAX or 0.2mm Max if the finishing technique was used.

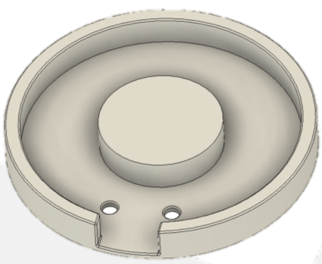




This limitation is only relevant to machining ferrite, sharp corners can be pressed in the X and Y Axis with a minimal radius.

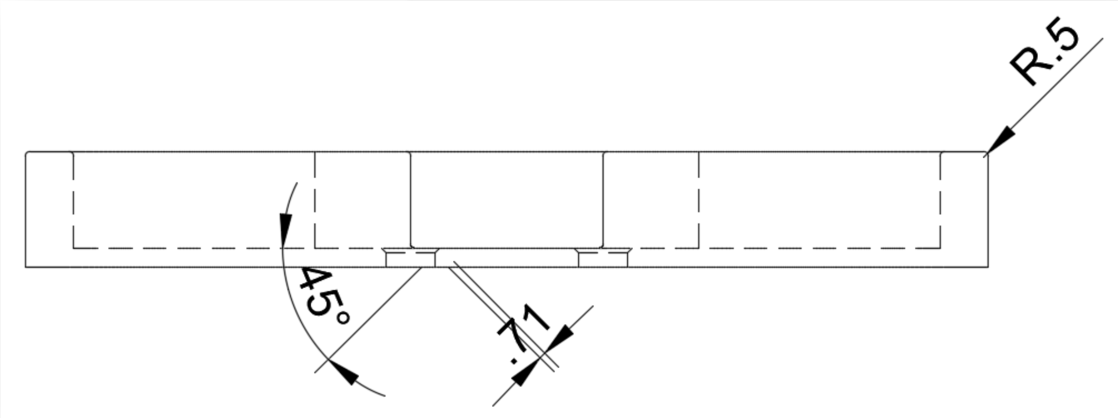
Takeaway – Design radius in the X and Y plane to incorporate a minimum radius of 0.5mm

Break Edges – Fillets, Chamfers or Break Edge

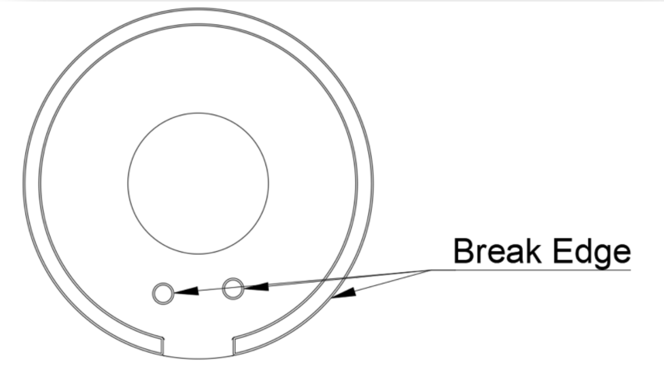


Design engineers often add break edges onto parts to remove sharp edges, sometimes this is warranted to ensure insulation breakdown doesn't occur over time or on high voltage applications it can remove arcing.

If the break edge has a positive impact on the electrical/magnetic performance of the core, then defining this as a tolerance dimension is advised. The team would always recommend a chamfered profile over a fillet profile, this is because chamfers can be achieved with one pass of a chamfer tool whereas fillets require multiple passes of a ball nose cutter, in some instances specialist tooling can be manufactured with the required radius to machine a radius in one pass, this is only viable if the order quantity is in the hundreds of pieces, otherwise the cost of the tool outweighs the benefits derived in cycle time.



Any other edge that is designed to incorporate a break, that doesn't have a positive impact on electrical/magnetic performance, should be labelled as a break edge, in this scenario the team would apply a small chamfer to these edges.



When the parts are pressed, it is useful to have a break edge to allow for a homogenous pressing density and to allow the core to be easily removed from the tool.

Takeaway – Define break edges as exactly that, this will save time and money

Minimum Wall thickness

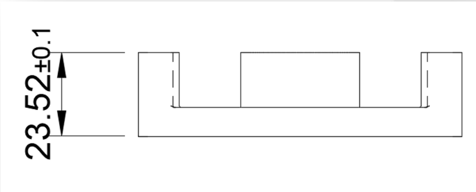
Thin walls are sometimes unavoidable in designs that contain multiple holes. The minimum wall thickness recommended for both pressing and machining is 1mm. The Machine shop have machined parts with wall thicknesses of 0.8mm, however the yield on these parts was considerably lower than our standard yield.

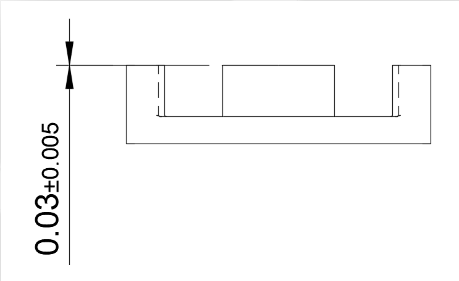
Takeaway – Design with a minimum of 1mm wall thickness.

Minimum Hole size

Designs containing holes range from EMC application through to access holes within sealed units or chambers. The Machine Shop can machine holes down to 0.75mm in diameter.

Gap Tolerances





Standard tolerances on dimensional gaps are +/ 0.02mm, this is achieved using a standard process, for AL specific requirements the standard tolerance offered is based on the IEC standards. From time-to-time customers request extremely tight tolerances on the gap dimension, the tightest tolerance the machine shop can achieve on a gap is +/-0.005mm or +/-1% on AL value, this involves pre processing of machine tools and utilising specialist tooling and increases the price by 30%.

The impact of gap tolerance is relative to the size of the gap, the table below highlights an example of a recent requirement.

Core	Gap		AL Value (nH)			
	Size	Tolerance	Min	Nom	Max	AL Tolerance
ER28/14/11	0.03mm	+/-0.005mm	1653	1791	1955	+/- 8%
ER28/14/11	0.5mm	+/-0.005mm	236	238	240	+/-0.8%

The above table highlights how as the gap becomes larger; the impact of a tightly controlled machining tolerance becomes less important.

Takeaway – Do you really need +/-0.005mm?

Maximum Block size

The main constraint on machining ferrite is the size of the raw material. The largest blocks available are 120/120/38mm, these are usually power grade materials, as the permeability increases, the block size usually decreases. Some manufacturers offer blocks that are larger in one dimension, these usually reduce another dimension to achieve this increase, for example 155/110/23mm. The size of blocks is limited by the size of press that is available at each.

factory. Most materials have several block sizes, and the team will always try to match the most economically friendly block size.

These blocks can also be glued together to achieve larger assemblies, sometimes the blocks will be glued prior to machining, other times the model will be machined in several pieces and then glued together with a finishing pass carried out over the final assembly.

Gluing – Residual air gap

The team use two types of adhesive to glue blocks or machined parts together, one is a standard adhesive and the other is a high temperature adhesive, details of these can be provided on request along with a tensile strength vs temperature graph. The typical air gap created by this adhesive is 0.1mm

Annealing Ferrite

Machining ferrite introduces stress into the material, in some materials this can create a higher Pv and sometimes shorten frequency response. This effect is particularly apparent in higher frequency application over 300KHz.

Therefore, in some cases it is advisable to anneal materials, this typically adds 1 week to the lead time of the machined parts.