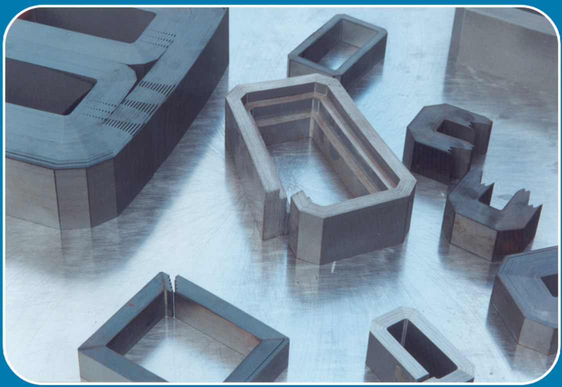
Laminated Transformer Cores - The Next Generation



SINCE THE INTRODUCTION OF LAMINATED 'C' CORES IN THE LATE 1930's, THE ONLY APPRECIABLE ADVANCEMENT HAS BEEN IN THE DEVELOPMENT OF RAW MATERIALS.

THE METHOD OF MANUFACTURE AND APPLICATION HAS REMAINED ESSENTIALLY UNCHANGED.

THIS ARTICLE DISCUSSES THE ADVANTAGES OF A REVOLUTIONARY NEW CONCEPT IN 'C' AND 'E' CORE PRODUCTION THAT AFFORDS THE TRANSFORMER DESIGNER, AND MANUFACTURER, MORE FLEXIBILITY AND BETTER PERFORMANCE THAN EVER BEFORE.

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PAST & PRESENT

Strip wound cores, such as 'C' cores, were first produced in the late 1930's to exploit the properties of Grain Oriented Silicon Steel (GOSS), developed a few years earlier.

GOSS has the beneficial attributes of high maximum flux density, low core losses and high permeability, compared to the previously established NOSS. The phenomenon of grain orientation is a result of special chemical composition, heavy cold rolling and high temperature annealing – all of which contribute to the development of the material anisotropy.

Strip – wound cores are manufactured by winding the material, in the form of a continuous strip, on a suitably shaped mandrel. This method of construction allows full advantage to be taken of the superior magnetic characteristics of the material by ensuring that the direction of winding, magnetic flux path and preferred orientation all coincide.

After forming, the cores are annealed in a protective atmosphere to relieve the material from the adverse mechanical stresses caused by the winding and forming operations. So far, so good, but there is a down side; if a complete magnetic circuit cannot be employed, some sacrifice of performance must be accepted since the provision of two coagulated halves cannot be accomplished without the existence of internal compressive stress caused by the bonding agent.

Strains due to bonding of the core can be relieved somewhat during and after the cutting operation, but complete recovery is never fully achieved. The characteristic most affected by the presence of the gap is, of course, the magnetising current but this can be improved slightly by grinding or lapping of the cut faces. Etching the cut faces can also improve the losses a little, particularly at higher frequencies.

In summary, although strip wound 'C' cores give a good magnetic performance and ease of assembly, there are a number of manufacturing difficulties which degrade the performance capabilities of the raw material.

FUTURE

UNICORE technology is a revolutionary method of producing transformer cores as an alternative to the traditional concentrated gap 'C' and 'E' cores or, indeed, stamped laminations.

The concept employs a specialised computer controlled machine to produce the UNICORES (sometimes known as 'JENcores' after Bill Jenkinson, an Australian engineer, who developed the concept).

UNICORE is a range of core styles which are fully shaped but not bonded – they can be made from various magnetic strip materials but the primary material used is GOSS of gauge between 0.2 and 0.35mm. Nife is also commonly used, either on it's own or to form a composite with GOSS.

The finished UNICORE is ready to insert into the winding, or be wound upon.

Some face styles currently available

BUTT - This is a single cut core with a flat face that simply butts together.

STEP BUTT - (Fig 1) Similar to the BUTT face but there are a number of steps in the face which angle toward the outside corner for easier insertion into the winding. This is the preferred construction to replace traditional concentrated gap 'C' cores.

ZIP TYPE - (Fig 2) Similar to the STEP BUTT except the steps are replaced with a 'Z' type face. Assembly is the same as for the STEP BUTT but the magnetic performance is enhanced.

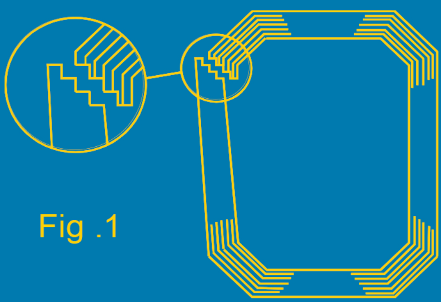


Fig .1

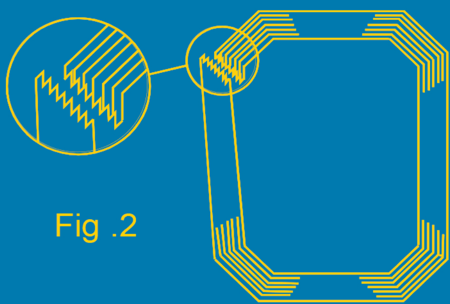


Fig .2

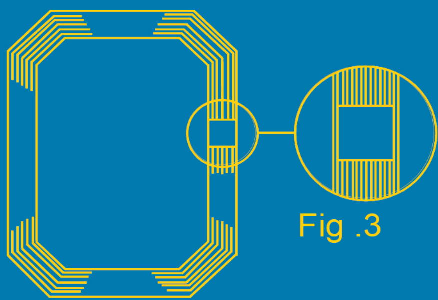


Fig .3

DGAP - This is similar in construction to the proven Telmag Temcore. A distributed gap core with each lamination overlapping the previous by a set amount. This construction has a magnetic performance almost equal to a toroidal core.

GAPPED - (Fig 3) The BUTT face can be supplied with a parallel or tapered gap to produce a swinging choke.

The styles detailed above are by no means exhaustive, but have been designed to cover the majority of applications. The unique UNICORE manufacturing method facilitates an almost infinite variety of gap styles simply by keying in the appropriate numbers.

ADVANTAGES

- Core Loss is the same as for the raw material – there are no additional losses due to core manufacture since the cores are not bonded and therefore not stressed.
- Low acoustic noise.
- Cores can be manufactured to much tighter dimensional tolerances and with shape consistency – strip cores look like engineered parts.
- Higher operating temperatures - core operating temperature is no longer limited to the continuous operating temperature of the resin. Normally class 'F' - 155 degrees.
- No tooling such as mandrels, clamps and cutting jigs required. Dimensional changes and changes to the gap style can easily, and quickly, be made. literally at the press of a button. Costs of modifying or purchasing tooling are a thing of the past.
- Since each lamination is clearly separated from the adjacent one there are no interlaminar short circuits and eddy current losses therefore kept to raw material proportions – thicker gauge materials could be used for some higher frequency applications (see Fig. 4 on reverse page).
- Better regulation.
- The manufacturing process does not affect the material permeability so the magnetising current is simply a function of the face style (see Fig. 5 on reverse page). Since tight mechanical tolerances can be respected in the manufacturing then product consistency can be achieved.

All the above points afford the transformer designer many technical and commercial advantages never before available.

The ability to obtain prototypes and prove design changes can be realised in days rather than weeks and generally with a resultant reduction in transformer size or greater VA rating for the same size.

For example – a typical 2KVA transformer with NOSS 'E' & 'I' laminations would weigh approx. 24Kg, the same rated transformer with a traditional concentrated gap 'C' core would 16.2Kg. Using UNICORE the transformer would only weigh 14Kg.

Although GOSS material is generally more expensive than NOSS because of the weight reduction the core cost is about the same but there are appreciable savings due to the reduction in copper, insulating materials and, in some cases, chassis work.

Last but by no means least there is energy savings. I have resisted using the term 'green core' but in these days of environmental awareness the UNICORE does play an appreciable role. Not only is there the obvious advantage of lower standby losses, and therefore energy consumption, there are a number of issues in the actual core production.

Since it is no longer necessary to use resins the whole manufacturing environment is more desirable from an H & S point of view – the need for solvents and other chemicals is minimised and there is no energy needed to cure the resins.

The UNICORE really does appear to hold all the aces.

Fig. 4: Power Loss against Frequency (@ B=1.0 T)

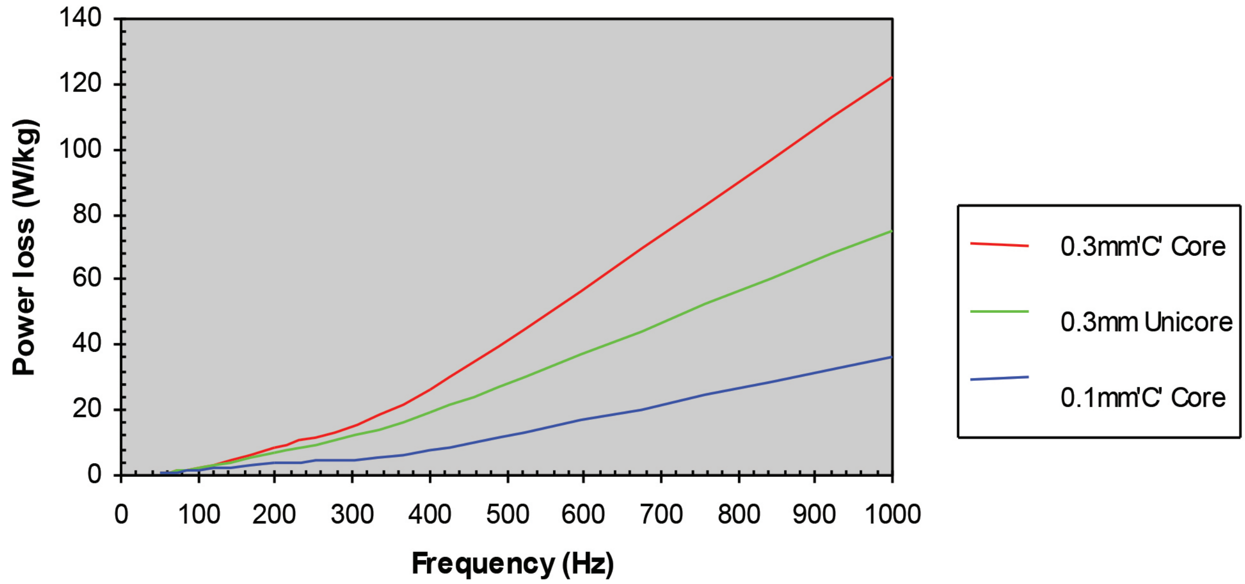
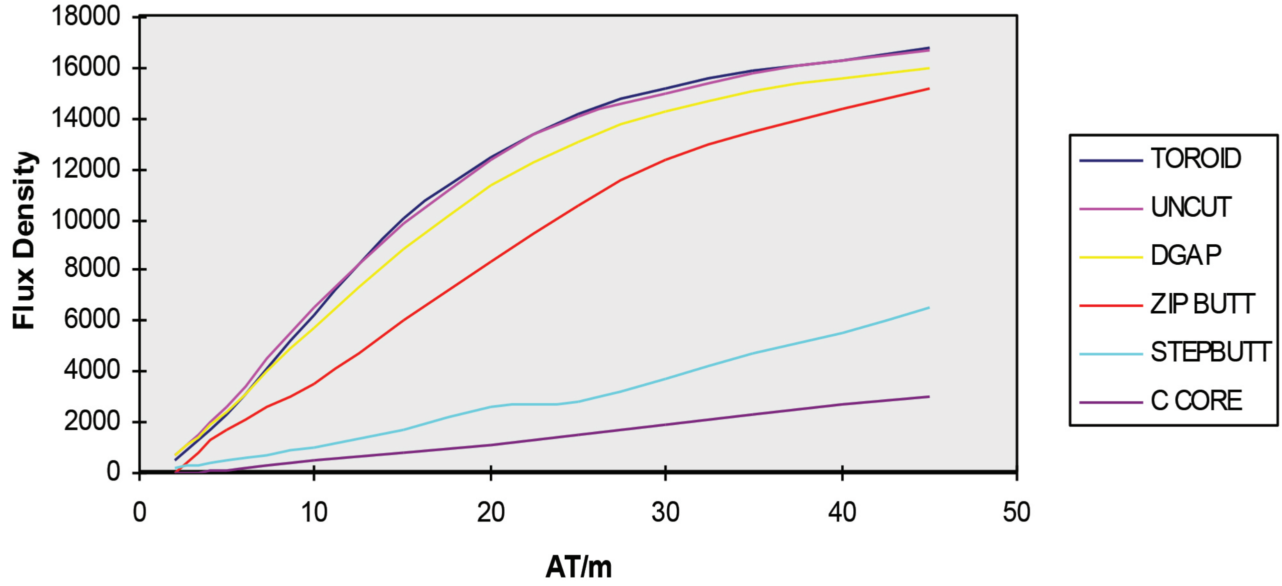


Fig. 5: Flux Density (in gauss) against AT/m



WILTAN magnetic components

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