Transform efficiency

If energy losses could be cut by an amount equivalent to 1% of all electricity consumed, surely we'd all jump at the chance? Apparently not, says Stuart Harvey

The good news is that transformers – both the plant used throughout the network operating companies' infrastructure and those at large energy users, such as factories and hospitals – are relatively efficient. In fact, modern power transformers typically offer efficiencies in excess of 97%. The even better news is that transformers built using amorphous cores can do even better and save an amount equivalent to 1% of all electricity consumed. The bad news is that almost nobody in Europe or the US is using them.

Why? Conventional transformers have cores assembled from stacks of laminations made from silicon steel with an almost uniform crystalline structure. In transformers with amorphous cores, a ribbon of steel is wound, usually in a toroid, to form the core. Although the material is still silicon steel, the manufacturing process leaves it with an irregular crystalline structure, which results in lower hysteresis losses – meaning less energy wasted in magnetising and demagnetising it during each cycle of the supply current. And there's another difference: amorphous cores have higher electrical resistance, so losses due to eddy currents are also reduced.

Loaded question

However, these effects, known collectively as iron losses, are most significant in transformers that are lightly loaded, so how important are they in practice? The answer is 'very', because most transformers rarely operate at full load. In fact, because they are sized to handle maximum load, most spend many hours ever day very lightly loaded. For example, a unit supplying a factory may be 70% loaded during working hours, but only 10% during evenings and at weekends. Such figures suggest that plant used to supply factories typically has load factors around 40%, while those at offices and hospitals are as low as 20%.

Real loss data for a conventional modern 500kVA transformer supplying an industrial installation with a load factor of 40% shows no-load losses of 665W, and on-load losses of 4,400W. Corresponding figures for an amorphous core unit are 220W, 3,500W and annual losses of 6,883kWh. That's a massive 5,159kWh reduction which, at £0.08 per unit, corresponds to a cash saving in excess of £400. During a typical 30-year transformer life, that's £12,000 at today's prices. Even more impressive is the reduction in CO_2 emissions, which equates to almost 3 tonnes per year. In commercial and residential applications, where the load factor is invariably lower, the savings would be even greater.

But if power transformers with amorphous cores have so much to offer, why are they only seeing uptake in countries such as Japan, China and India? Is it just that Europe and the US are too conservative? Well 'yes and no'.

Would-be users argue that amorphous core transformers are expensive. And they were, except that the silicon steel used in ordinary transformers has increased in price much faster than the amorphous materials – so the price differential is now very small. So small, in fact, that current estimates show a payback period on amorphous core transformers in the region of three to five years – and significantly shorter as energy prices continue to increase.

Another objection trotted out has been that amorphous core transformers are physically larger and generate more noise. Which, once again, used to be true – but, with the latest materials, differences are becoming smaller and indeed the noise issue is almost completely solved.

Regrettably, it seems that contracts are still being placed on lowest price, with scant regard to lifetime costs. In a world where global warming is starting to have severe consequences, no one can afford to be complacent about energy losses – least of all organisations that generate, distribute and use large amounts of electrical energy. For these organisations, amorphous core transformers open a cost-effective route to achieving serious savings in terms of kWh of energy and tonnes of CO_2.

10 Pointers

- Modern power transformers offer efficiencies around 97%
- Amorphous core units can improve that by some 1%, although that's on lightly-loaded units
- However, factories, offices and hospitals have load factors as low as 40%
- Over a 30-year unit life, changing up to amorphous core units saves £12,000 per transformer, equating to 3 tonnes of CO_2 emissions
- That far outweighs any slight additional cost

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