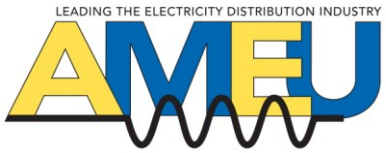
Transformer re-designs in modern economic times.



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Abstract:
Transformers are a critical part of any Power supply system and although inherently reliable and long lived, they can represent a significant cost when circumstances dictate their replacement. Re-design and refurbishment can offer a cost effective alternative to simple replacement.

1. Introduction
Transformers form an essential part of any electrical supply system, and although inherently reliable and long lived, they can represent a significant cost when circumstances dictate their replacement.

The longevity of transformers lies in the fact that unlike other equipment such as circuit breakers, transformers essentially contain very few moving parts, which may be subject to wear and tear.
The basic materials of construction, namely steel, copper and porcelain are also not subject to significant aging.
Typically the one element of transformers than can degrade as a function of time is the oil /paper insulation systems within the transformer.

Of these two elements the most significant is the condition of the paper since, unlike the insulating oil, paper insulation cannot readily be changed or replaced.
The condition of the insulating paper within the transformer is therefore often used as the ultimate end of life criteria when evaluating transformers.

Typically replacement of transformers is only considered for three reasons:
1. The transformers have failed prematurely.
2. The transformers have reached the end of their effective life.
3. The requirements of the electrical system have changed.

In the case of failures or units that are significantly aged the option facing the owner of the equipment is either to repair the old units or to purchase a completely new transformer or set of transformers.

2. Repair

Repairing or rebuilding the transformers can have a significant cost benefit especially when multiple units are involved.
As an illustration a transformer which is completely re-fitted with new windings and insulation can cost as little as 60 – 70% of the price of a new unit.
A transformer which has been fully refurbished in this manner may be considered to be the equivalent of a new unit in terms of its expected lifespan.
In some respects this option is also superior since it utilises a basic design which has already proven itself suitable for a particular application.

In the case of partial replacement of windings and insulation these costs can be significantly reduced. (20 – 30% of the cost of a new unit)
The degree of degradation of the insulating paper is the determining factor in deciding between complete replacement of the windings or partial re-use of some of the windings

3. Redesign

Up until now this has been the basic approach of Rotek Engineering and has involved the repair of units in strict accordance with the original design.

The drawback of this approach lies in the fact that electrical system requirements are constantly changing and the unit may be of an older design which does not quite satisfy the requirements of the present day application.
Another potential problem is the perpetuation of known design shortcomings in the original transformer.

In such cases it is possible to alter the original design of the transformer to suit the new requirements while still reaping the cost benefits of re-using the basic, non aging elements such as the core, tank and fittings.
Known shortcomings of the original design may also be addressed in a similar manner.

Redesign does not only involve the improvement of certain operational parameters but can also involve the complete change of the basic parameters of the transformer. This is in some cases in fact easier than trying to improve the operational parameters of an existing design, and allows a potentially redundant piece of equipment to be effectively re-used as an income generating item of plant.

This approach can be seen as a logical extension of Rotek's repair capability and is in the process of being implemented, with support from local and independent over-seas experts in the transformer design field.

What can be changed?

Typical elements which can be modified with a re-design are:

1. Voltage ratios and rated voltages
2. Vector group
3. Short circuit Impedance's
4. Short circuit withstand capability
5. Cooling systems
6. Losses – no load and load losses
7. Increased power ratings or lower operating temperatures.(typically 20-30%)
8. Improved built in protection and condition monitoring systems

9. Detection and elimination of potential problem areas in the design

The degree of change depends heavily on the original design, with some designs having more scope for alteration than others.
The potential for re-design will vary for each type, rating and manufacturer.

How can this be achieved?

Transformer design is basically a trade off of desired performance criteria, and can be approached in a number of ways depending on the relative importance of the various requirements.

People specifying their requirements for transformers generally provide a list of performance parameters in their specification but do not usually indicate which of the desired elements are critical and which may be open to some adjustment in order to achieve an optimal design. This may force the designer to implement certain design approaches which result in a transformer which has wide scope for alteration when the actual performance requirements are analysed.

Older designs in particular tend to be built along more conservative lines than modern day equivalents. This can often most obviously be seen in the fact that modern day transformers are physically smaller than similarly rated, older units.

This increased material uilisation is possible as a result of a number of factors:
1. Changing materials within the industry.
2. Improved quality of materials with more predictable performance.
3. Improvements in design methods and computer aided analysis.
4. Increasing emphasis on low cost, optimised designs.

The conservative approach of the older designs allows the re-designer the opportunity to utilise the existing core and basic layout in combination with modern design practices and materials to achieve greater utilisation of the materials and altered performance characteristics.

In many cases the premature failure of a new transformer is as a result of a small element of the overall design of a transformer.

Examples of this are:
1. Restricted oil flow paths
2. Thermal activity in structural elements such as core clamping
3. Core earthing arrangements
4. Jointing systems

Therefore when reviewing a transformer for repair or re-design the performance of the transformer as a whole can also be reviewed and weak elements of the design eliminated. This is an avenue of evaluation that is often not available to the original manufacturer, since these shortcomings are often more visible after several years of service.

4. Understanding the existing design and its performance to date

An essential part of any re-design is a complete evaluation of the existing design and its performance to date.
In cases where the original design information is not readily available from the manufacturer, this would involve a complete strip down of the unit in the workshop.
The strip down process is also valuable in detecting weak points in the original construction and design.

The potential application for the unit needs to be clearly identified and the basic requirements of the new unit need to be discussed and agreed upon.

5. Conclusion

Changing system requirements and age can lead to a large amount of redundant equipment that may require replacement.
Although not a universal cure-all, the re-design of old transformers can be a low cost alternative to the purchase of new units and should be considered whenever new units are being purchased or when old units are disposed of.
The benefits of re-design are not only in the lower cost but also in the possibility of elimination of potential weak points in an already proven design.