November, 2014

Paralleling Transformers

The decision to parallel transformers in the industrial market is made for a variety of reasons including:

- Load growth exceeding the capacity of an existing transformer
- Lack of physical space for one large transformer
- To add a measure of security since the probability of multiple transformers failing at the same time is very small
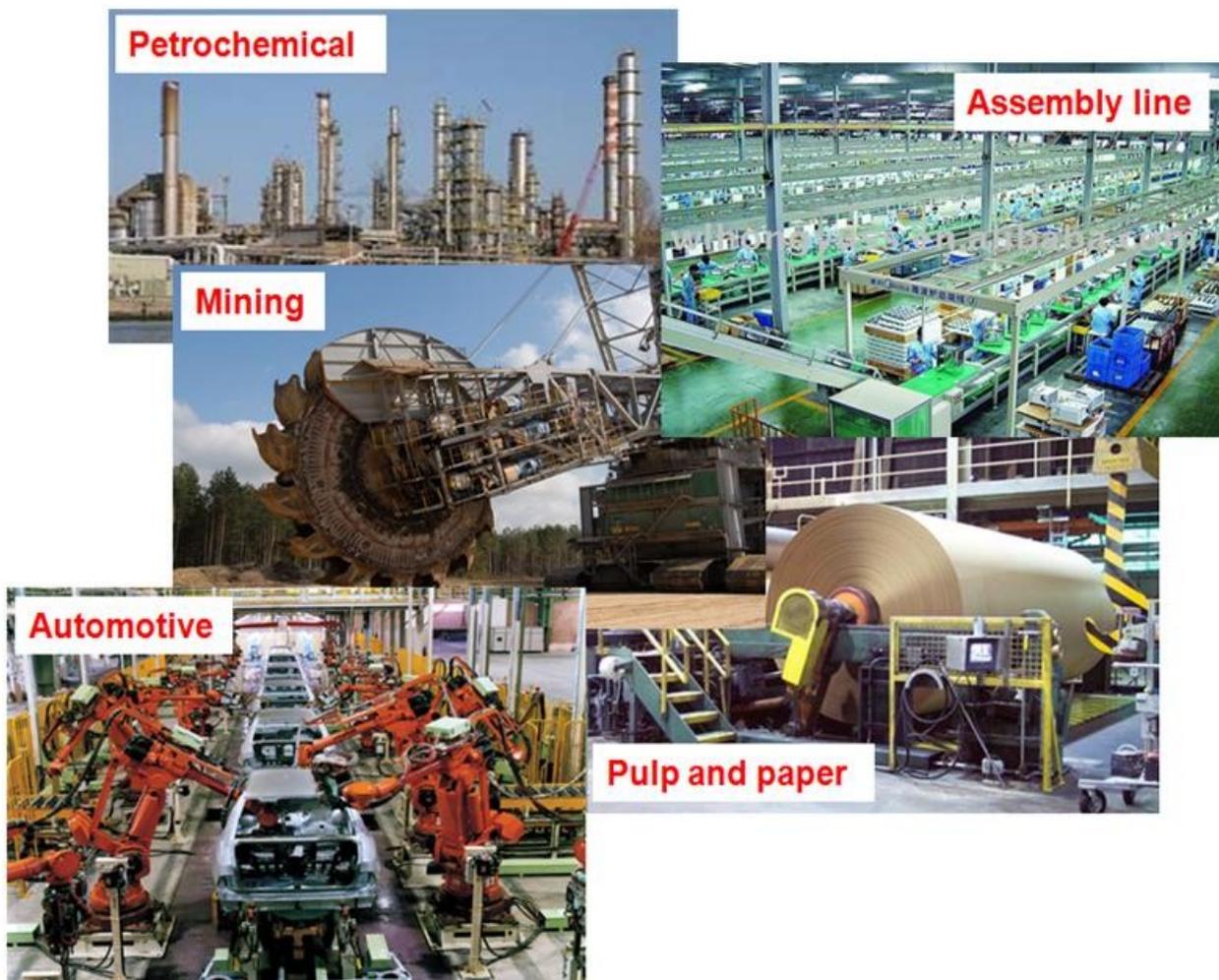
Industrial Market Examples

In facilities where load requirements are reduced during swing or graveyard shifts, a portion of the capacity can be reduced during off peak hours by de-energizing one of the paralleled transformers thereby cutting operational costs while extending transformer life cycles.

Various conditions that must be matched to successfully operate transformers in parallel include the following:

- ✓ primary and secondary voltage ratings.
- ✓ tap ratios
- ✓ taps of each unit set to same position
- ✓ phase angle shift (vector group)
- ✓ frequency rating
- ✓ polarity
- ✓ phase sequence

Of prime concern however, is the transformer impedance. The impedance of a transformer is the total opposition to current flow comprised of the conductor resistance and the transformer's inductive reactance. The impedance determines the amount of fault current flowing in the windings in the event of a short circuit occurrence during the operation of the transformer. The magnitude of short circuit current flowing through the transformer, assuming no system impedance and an infinite supply, would be the rated current times the reciprocal of the per unit impedance. An impedance percentage of 5% therefore would cause a potential short circuit current of 20 times the rated current. The lower the impedance, the higher the potential short circuit current.

The mechanical forces acting within the transformer are directly related to the square of the magnitude of current flowing through the windings. During the design of the transformer, adjustments are made as required to insure that it can withstand these mechanical forces thereby insuring that the transformer meets ANSI Standards criteria.

The measured impedance also determines suitability for paralleling with existing transformers of known impedance. A transformer whose tested impedance is higher

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than the other will cause the other transformer to carry more than its equal share of the load.

As an example consider the following: In the schematic to the right, let's assume that transformers "A" and "B" have the same kVA rating. Transformer "A" has an impedance of 5% and transformer "B"s is at 4%. To calculate the distribution of the load for transformer "A", simply divide the IZ of transformer "B" by the sum of the two. Therefore:

Transformer "A" % of total load = 4%/(5%+4%) = 44.4%
&
Transformer "B" % of total load = 5%/(5%+4%) = 55.6%

Thus the transformer with the lower IZ carries the larger percentage of the total load. In this example therefore, if the total load is in excess of the sum of the 2 transformers kVA rating, transformer "B" is overloaded due to its lower IZ level.
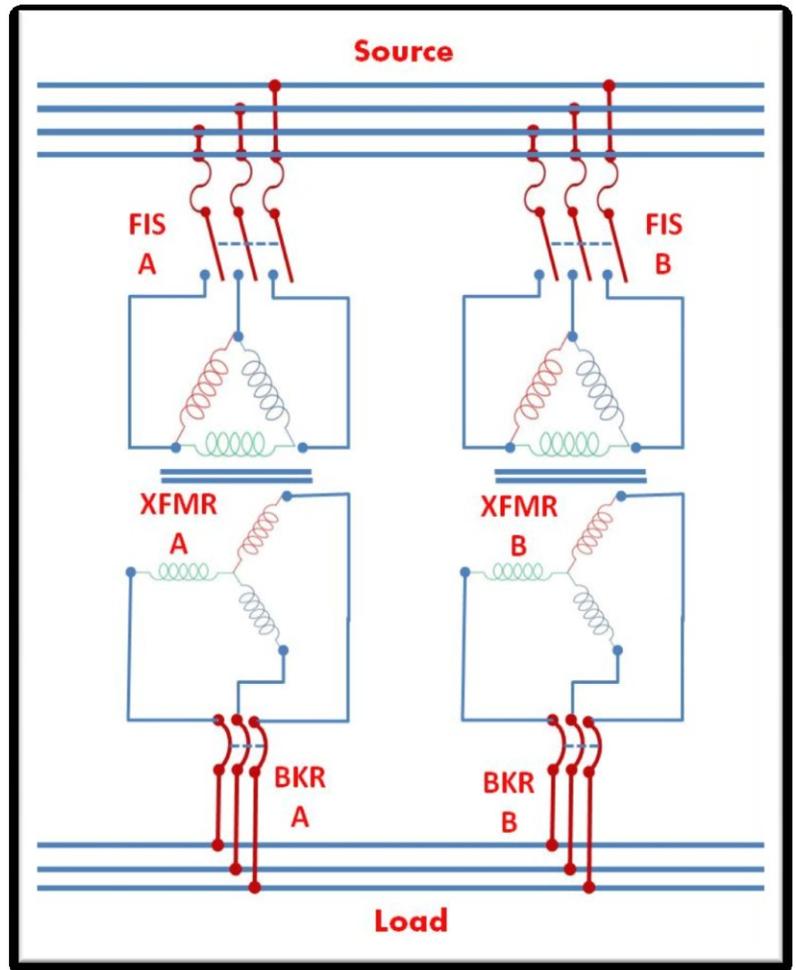
Understanding the relationship of impedance levels and parallel transformer operation can be beneficial when deciding on the design parameters for transformers purchased for providing additional load capacity.

As an example, suppose you have a business in which your load requirements are about to grow due to the addition of a new production line. In doing so, the additional load will exceed the 500 kVA capacity of the present transformer by 250 kVA. The obvious solution is to replace the existing transformer with a new 750 kVA

to accommodate the additional load. In addition to the new transformer, the load side conductors and breakers may also need to be upgraded/replaced. Problem solved…..

An alternate approach would be to add an additional transformer in parallel. Assuming the existing transformer is in good condition, one could add a new 500 kVA transformer at an impedance matching that of the existing unit. Upon installation, you would now have 1000 kVA of total capacity to handle the 750 kVA load requirement. Since the 2 transformers would now be sharing the load equally, they would each be operating at a load level of only 375 kVA. In addition, you would now have 250 kVA in reserve for additional future growth.

Example of Paralleled Transformer Installation

As touched on earlier, paralleling transformers provides protection against a total power failure since it is highly unlikely that multiple transformers with proper protection would fail simultaneously. If a paralleled transformer *does* fail, it can easily be isolated from the other by means of its LV breaker and HV switch (see earlier schematic). Once isolated, power can be restored via the other transformer albeit at a possible reduced capacity level.

Paralleled transformers also provide for the ability to service the transformers without a complete power outage. This may include oil filtering, bushing and/accessory replacements, protection upgrades, and of course transformer replacement.

Regardless of the transformer size, style, or configuration, Pacific Crest Transformers is uniquely equipped to provide both peace of mind and the best possible solution for reliable energy load requirements.

Pacific Crest Transformers: Providing innovative solutions for today's complex challenges