Energy saving utilizing sinusoidal motor controllers

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Apart from the primary power reduction in KW (P) attained by the sinusoidal controller, there are favorable indirect energy reductions associated with the primary savings. In this paper we attempt to quantify the significance of these secondary effects.

<u>Indirect influence on real power – P</u>

When considering electricity savings, one customarily focuses on the reduction of direct wattage consumption. This factor is indeed the dominant one and it can be straightforward related to capital expenditures savings according to the electricity tariff, $/kWatt-hours. Nevertheless, there are additional derivatives of electricity consumption reduction, which add to the straightforward evident effect. Parts of the secondary effects further add to the consumers' capital savings and other parts contribute to the electricity system and society benefit.

Generally speaking, the electric energy cost represents two primary components: operational cost (such as cost of fuels and equipment maintenance), and infrastructure costs (equipment and infrastructure, financing, land, etc.). Electricity consumption reduction contributes in two ways:

1) Lowering the current (throughout the entire electricity system), thus reduced conduction losses (I^2r).

2) Freeing of the transmission and distribution system, which is equivalent to increasing the installed power capacity of the power system.

Conservatively, the losses due to series voltage drops along the transmission and distribution systems may be appreciated by some 10%-15% and an additional 5%-10% of consumer internal losses (from the energy meter until the actual load). Thus, a power saving of ΔP at a particular load generates and additional power saving of approximately $0.2\Delta P$; half of which generates a respective capital saving for the customer and half for the benefit of the utility.

<u>In summary</u>, it may be said that due to indirect effects, a given real power saving of ΔP actually influences as $1.1\Delta P$ saving from the consumer’s point of view and as $1.2\Delta P$ from a rather global point of view (utility, power system, greenhouse gases emission, etc.).

Indirect influence of reactive power, Q, and its significance

Pure reactive power represents the periodic travel of energy back and forth between a generator and a load, whose average is '0'. Therefore, reactive power *supposedly* necessitates no generation, thus requires no fuel consumption and no cost. A rather careful examination reveals that reactive power involves a non-negligible cost. Herein, we attempt to quantify the economical significance of reactive power consumption savings.

Reduced losses:

The powers relation before (S_1, P_1, Q_1), and after (S_2, P_2, Q_2), a reduction in reactive power consumption, ΔQ, are illustrated in Fig. 1. Evidently the reactive power consumption reduction (while active power consumption is maintained) generates a reduction of apparent power S, from S_1 to S_2.

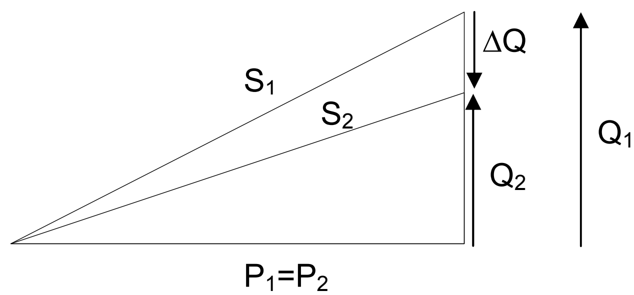

Fig. 1: The influence of reactive power savings on conduction losses

Assuming the power factor seen by the generator is 0.9 ($\Phi=26^0$), it can be shown that the saving on conduction losses, as a result of reduced reactive power consumption, are equivalent to 1/2 of the saving that would be attained by an equal reduction of the active power ΔP

Infrastructure liberation:

Reduced load demand liberates part of the infrastructure capacity which can be used to supply more loads. In this sense, the reduction of load demand has the same effect as increasing the installed capacity. The installed capacity is rated roughly in terms of apparent power, S.

Therefore, reduction of the reactive power consumption Q, enables an increase of the real power supplied, P. The increase of active power due to reduced reactive power (while utilizing the full installed power capacity, S) is illustrated in Fig. 2.

It can be shown that the increase of active power that is made possible due to the reactive power saving is 50% of the reactive power saved, $\Delta P = 0.5 \Delta Q$, where Q is measured in VAR and P in Watt.

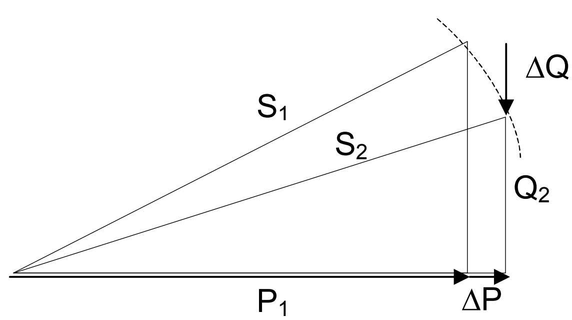

Fig. 2: Effectively increased installed capacity due to reactive power saving

It is concluded that as regards secondary effects, reactive power savings induce similar effects to those induced by active power saving but with a 50% magnitude.

A conservative approximation of power savings significance, accounting for indirect effects results in the simplified relation: $\underline{\Delta P^{*} = 1.2\Delta P + 0.1\Delta Q}$, where the reactive power saving ΔQ is taken in VAR, the direct active power saving ΔP is taken in Watt, and ΔP* represents the power saving global impact accounting for direct and indirect effects. For example, reducing a load's (such as a motor) power consumption by ΔP saves an additional 20% ($0.2 \times \Delta P$) in the power system, half of which is to the costume's benefit. In addition, reducing the load's reactive power consumption by ΔQ affects the system as if an additional 10% real power was saved. For instance, saving 1kVAR-hours is equivalent to saving 0.1kWatt-hours with respect to the electricity network.