Total drive train optimization of industrial fans and pumps considering VFD driven motor, transmission and load

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Introduction

Standards and mandatory legislations concerning minimum efficiencies of electric motors have entered our world of electromechanical drive trains over the last years. It was a logical step to consider these elements as they account for the largest amount of energy consumption in the European industry. The European ecodesign measures count for 40% of total estimated savings in electric motors by 2020. However, not only the driving motor has to be considered when it comes to optimizing the drive train efficiency. This paper shows the saving potential in other drive train components based on measurement campaigns during several research projects at Ghent University Campus Kortrijk.

Drive train components efficiency

Due to legislations on motor efficiency, manufacturers have pushed themselves to construct “IE4”-levelled motors which are often based on other principles than the well-known induction machine. When it comes to further raising this motor efficiency in the future, it seems that technological limits are almost being reached.

A lot of energy saving potential can be found in the other components following the motor. Gearboxes or belts and the efficiency of the load itself often carry more saving potential than the electric motor and often at lower investment costs. For a long time, it seemed legislation on drive train efficiency had forgotten these components. MEPS for transmissions such as gears for instance simply don’t exist. Catalogs sometimes give a single efficiency value, but information on the measurement methods is not available. Research during past projects at UGhent Campus Kortrijk reveals that the reliability of these catalog numbers is often very low [1]. Figure 1 shows the differences between catalog efficiency and measured efficiency at UGhent Campus Kortrijk for different kind of gearboxes. As figure 1 shows, differences up to 25% have been found during this campaign [2] [3].

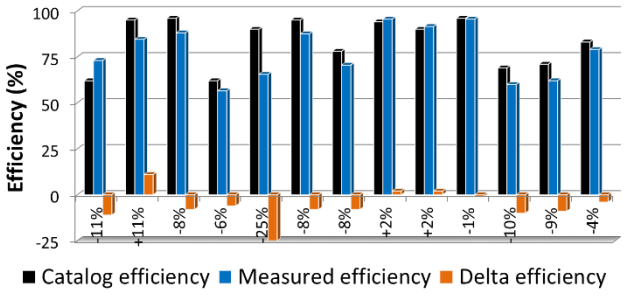

Figure 1, Catalog versus measured nominal efficiency gearboxes 0.34-5.6kW / i=11-90, UGhent Campus Kortrijk

Extended Product Approach

Recent evolutions in standardization are slowly shifting towards an Extended Product Approach. This methodology takes into account the overall efficiency and hence requires information on the efficiency of all components including transmissions. Examples of this total system approach are the latest EU

directives on circulator pumps [4] [5], air conditioning systems [6], domestic comfort fans [6] and industrial fans [7]. The European Regulation 327/2011 for industrial fans for example considers as minimum efficiency level the overall system efficiency. This is defined as the electrical input power versus output airflow/pressure. This system approach demands a thorough analysis of all the different parts of the drive system in order to make a sound technical and economical choice on which part to invest to rise the overall system efficiency.

An industrial fan case study

A case of a speed regulated, belt driven industrial fan for cooling animal food pellets during production is used to illustrate the possibilities of optimizing the different drive train components. Both the motor, transmission and the fan are considered.
The original motor is a 22kW, 4pole IM, with an efficiency level below IE1. Electrical measurements show an electric input power of 11kW which indicates the overdimensioning of the motor. Taking into account the load profile (40% full load, 40% @ 70% speed, 20% @ 50% speed), the efficiency of the original motor drive system is estimated at 87,6%. An 11kW IE3 IM alternative and (according to IM levels) IE4 SynRM are evaluated based on test bench results at UGhent. The IE3 alternative results in an efficiency rise of 3.4% (-2.9% in kWh), the SynRM alternative in a rise of 9.25% (-7.3% in kWh). This last result indicates the potential of “IE4”-alternatives coming on the market with other technology than IM. Most of these technologies have the advantage of keeping higher efficiency in partial load compared to IM (figure 2).

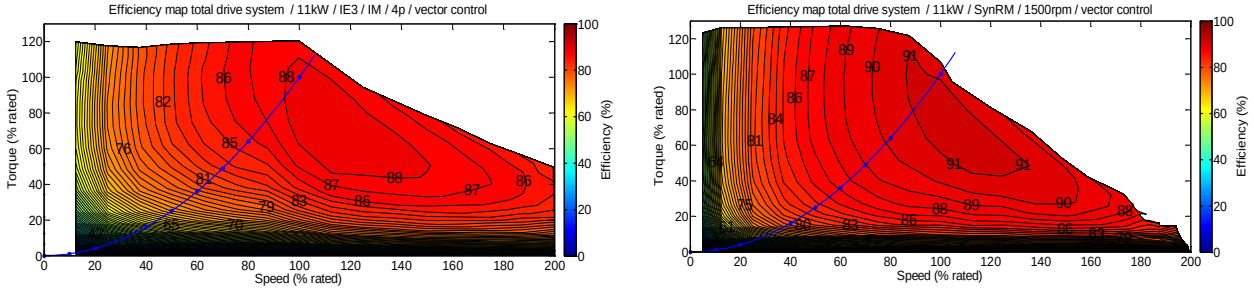

Figure 2, Evaluating speed controlled IE3 IM versus SynRM for a typical fan characteristic, UGhent Campus Kortrijk

Using the direct drive principal by eliminating the (often overdimensioned) belts in the system has proven in the past to result in a efficiency gain of 2-4%.
At last the fan itself is considered. Based on airflow and pressure measurement in the system the fan efficiency is estimated at 30% which again indicates an incorrect dimensioning of the fan in this case. By redimensioning the fan, the fan efficiency can rise up to 55% for the given load profile.

Conclusion

Due to a lack of information on efficiency of all drive train components on the market it is often difficult to find a technical and economical energy efficient optimum. Therefore not only electric motors have to be included in measurement standards. Also information on components such as gearboxes and belts need to be made available by manufacturers, both in nominal conditions and partial load conditions.

References

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