



Fan Efficiency

Guidance from the Fan Manufacturers Association

Electric motors are responsible for 40% of the UK's total electricity consumption and fans account for 22% of industrial motor energy consumption. The legislation and regulations being implemented following European and UK Government commitment to reducing Carbon emissions together with rising energy prices is leading to demands for greater fan efficiency. Fan efficiency is often misunderstood due to the variety of definitions of a fan and what contributes to the losses in a fan system. This guidance note from the Fan Manufacturers Association sets out to clarify fan efficiency.

A Fan System

When asking for fan efficiency or acting on fan efficiency data it is very important to define what constitutes the fan.

- The word fan is often used to as an alternative to the word impeller. The impeller is at the heart of the fan moving and imparting energy into the air flow. The efficiency is calculated based on the mechanical power input to the impeller and the power output from the impeller. There will be additional losses as additional items must be employed for the impeller to function, e.g. mechanical drive, electric motor, etc, that will all add losses and reduce the stated efficiency figure.
- The fan could be an impeller in a housing. The additional losses described above will need to be added resulting in a reduction in the quoted efficiency figure.
- The fan could be an assembly incorporating mechanical drive and electric motor in which case the efficiency must be calculated from the electrical power input to the motor and the power output from the impeller. If there are additional controls to be added to the fan in service, e.g. variable speed drives (VSD), then these will add losses to the fan system and will reduce the quoted efficiency figure.
- The fan could be an integrated assembly including mechanical drive, electric motor and VSD in which case the efficiency must be calculated from the electrical power input into the VSD and the power output from the impeller.

The following diagrams show the various parts of a fan system and the losses within the fan system. The overall efficiency, the efficiency calculated from electrical power input and the power output from the impeller, will include the losses from the various parts of the fan system.

$$\eta_e = \frac{P_u}{P_e}$$

Where,

η_e is the overall fan efficiency

P_u is the power output from the fan calculated from volume flow (m³/s) and pressure development (Pa). Note the pressure could be total or static



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pressure and there can be a significant difference. It is normal to use total pressure and this should be confirmed with the fan supplier.

P_e is the electrical power input to the motor (W) (or VSD drive if included in the fan system)

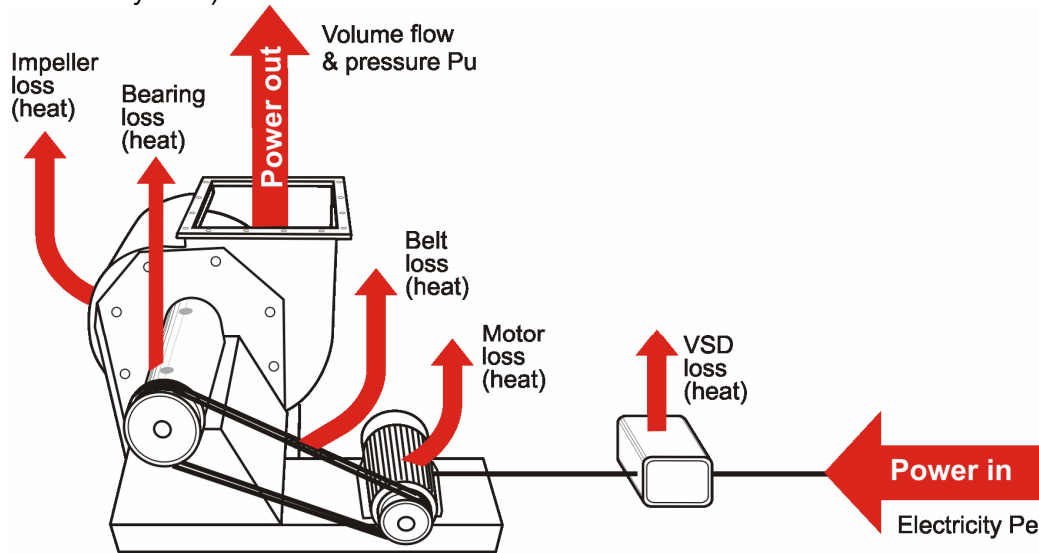


Diagram showing the losses from a fan system including VSD, motor and belt drive.

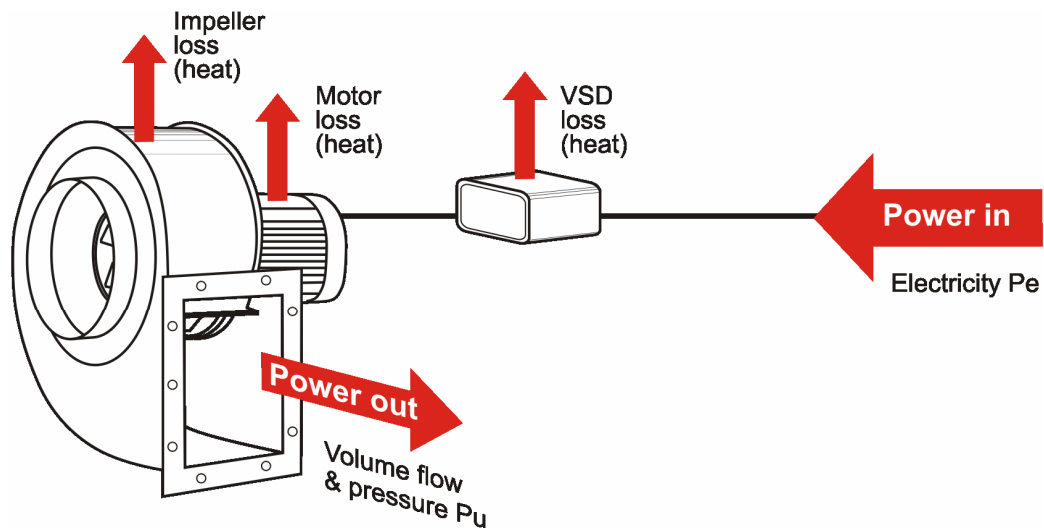


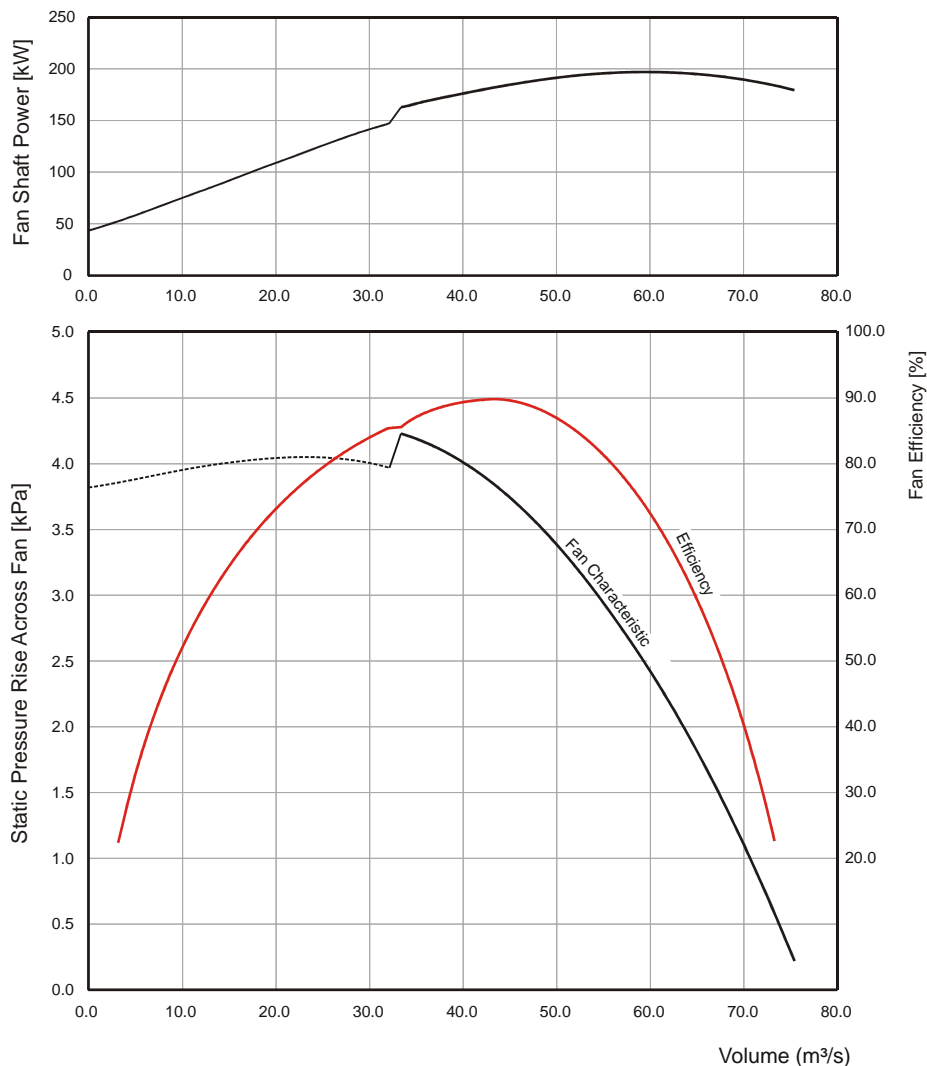
Diagram showing losses from a fan system with a direct drive electric motor and VSD

Fan Efficiency

The fan efficiency, be it for just the impeller or for a complete fan system, will vary across the operating range of the fan. The following graph of a backward inclined



aerofoil section fan (impeller and housing only) clearly show that the efficiency reaches a maximum point, in this case in the middle of the graph, but significantly reduces with lower or higher pressure development. The fan efficiency is normally quoted at this 'peak efficiency' or 'best operating point'.



Graph showing characteristics of a backward inclined aerofoil section fan (impeller and housing only)

Further information regarding fan efficiency can be found in appendix 1 of the Fan Application Guide (Andrews et al, 2006).

Fan Standards

The fan standard, ISO5801:1997, fans for general purposes, part 1 – performance testing using standardised airways, explains in detail how to measure the above parameters. The revision of ISO5801 due to be published in 2007 will have an Appendix E, electrical input power consumed by a fan, and gives a good explanation of the losses within a fan system. Draft copies are currently available.



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The standard approaches the efficiency equations in a subtly different manner, making a summation of efficiencies of the various facets of a fan system, but the result is the same.

Specific Fan Power (SFP)

An alternative way describing the energy efficiency of a fan system is its specific fan power. The calculation is significantly different and there is not a 'peak' or 'best operating point'. Fan manufacturers cannot quote a SFP for a fan without reference to a particular operating point.

The SFP is a function of the volume flow of the fan and the electrical power input;

$$\text{SFP} = \frac{P_e}{V}$$

Where,

V is volume flow (l/s)

P_e is electrical power input (W) to the fan system or complete air movement installation

Annex E of ISO5801 shows that by rearranging the formula it can be derived that the SFP is a function of fan pressure divided by the efficiency of the fan system. Therefore the SFP will increase or decrease with a respective increase or decrease in the system pressure.

The term SFP is also applied to groups of fans and the complete air movement system. In such a case the sum of the power inputs of all the fan systems within the air movement installation is divided by the volume flow (the greater of supply/extract) of the installation. As with fan efficiencies it is important to determine what elements of a fan system have been considered when calculating the SFP and what additional losses need to be added when installed to other elements in the air movement installation.



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Bibliography

Andrews, I., Biggs, C., Cowell, P., Davis, I., Hopkins, D., Lockwood, G., Mulholland, R. (2006) *Fan Application Guide – TM42:2006*, CIBSE, London

Radgen, P. (2002) *Market Study for Improving Energy Efficiency for fans*, Fraunhofer Institute, Stuttgart

ISO 5801:1997, Fans for general purpose, Part 1 – Performance testing using standardized airways.

ISO FDIS 5801:2006 Industrial fans – performance testing using standardised airways (due to be published ISO 5801:2007 in 2007)



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