SPECIFIC FAN POWER – a tool for better performance of air handling systems

Jorma Railio[1], and Pekka Mäkinen[2]

[1]FAMBSI, Finland
[2]Fläkt Woods Oy, Finland

Corresponding email: jorma.railio@teknologiateollisuus.fi

SUMMARY

The electrical energy needed for ventilation fans and air handling units (AHU) plays an increasing role in the energy demand for buildings. Recent studies show that the electrical energy consumption can rather easily be reduced from the "traditional" level (between 5 and 10 kW/m^{3}s) into a modern level (2 to 2,5 kW/m^{3}s) with proper design and installation. Even lower levels are technically possible, but not yet widely economically feasible.

Several countries have already set, either as requirements or as recommendations, maximum target values for SFP. This has been the first important step towards energy efficient air handling systems. However, in real practice other measures are needed, including simple but reliable tools for designers for SFP calculation, and measuring guidance for installers. To check and assess the SFP should be easy and clear also for the building owner, the end user, the inspectors etc. The need for measurements should be taken into account in the AHU construction to enable easy but reliable measuring, and guidance is needed for system design as well as for those who perform the measurements.

INTRODUCTION

The electrical energy needed for ventilation fans and air handling units (AHU) plays an increasing role in the energy demand for buildings. Recent studies show that the electrical energy consumption can rather easily be reduced from the traditional level with proper design and installation.

The "Specific Fan Power" (SFP) value, expressed in kW/m^{3}s, indicates the demand on power efficiency of all supply air and extract air fans in a building. Several countries have already set, either as requirements or as recommendations, maximum target values for SFP. This has been the first important step towards energy efficient air handling systems. However, in real practice other measures are needed, including simple but reliable tools for designers for SFP calculation, and measuring guidance for installers. To check and assess the SFP should be easy and clear also for the building owner, the end user, the inspectors etc.

The present regulatory values vary typically between 2 and 3 kW/m^{3}s. The newly revised European Standard EN 13779 [1] gives a classification of SFP values, which also takes into account the fact that in some special cases (requiring e.g. HEPA filters, humidification or high-efficiency heat recovery) a higher electrical energy consumption is unavoidable. In the new EN 13779, the whole range is from 1 up to 9 kW/m^{3}s, and the recommended maximum excesses of the classified SFP values (e.g. due to high-efficiency filtration) are also defined.

WHAT IS SPECIFIC FAN POWER?

The new EN 13779 [1] includes an Annex which gives more detailed guidance about how to express, specify and also validate the SFP value in practice.

Target value for the **Specific Fan Power, SFP**, indicates the demand on power efficiency of all supply air and extract air fans in a building. This value should be defined during the early design stage for determining the useful power demand and so the energy consumption required for transporting air throughout an entire building.

A supplementary factor SFP_E makes it possible to assess how efficiently **individual** air handling units or fans utilize electric power. The definition of the SFP_E is different for heat recovery air handling units with supply air and extract air, and for separate supply air or extract air handling units and individual fans.

During the design process the SFP value for the entire building, defined as the weighted average of the SFP_E values of individual units and fans (see item "Example"), shall be compared to the target value and checked in case any changes in the individual SFP_E values appear.

Another useful specific fan power is SFP_V for validation. The intention with this value is to have a factor which is simple to specify and check. The difference between SFP_E and SFP_V is the load condition, **design for SFP_E and validation for SFP_V**. It is recommended that both SFP_E and SFP_V values are calculated (using manufacturer's software, for example).

The SFP value for the whole building is defined as follows: "The combined amount of electric power consumed by all the fans in the air distribution system divided by the total airflow rate through the building under design load conditions:

$$SFP = \frac{P_{sf} + P_{ef}}{q_{max}} \qquad (1)$$

where

SFP is specific fan power demand in kW x m^{-3} x s

P_{sf} is the total fan power of the supply air fans at the design air flow rate in kW

P_{ef} is the total fan power of the extract air fans at the design air flow rate in kW

q_{max} is the design airflow rate through the building, generally the extract air flow in m^3 x s^{-1}

In terms of SFP **for the whole building**, any fan powered terminals shall be included when they are connected to the main air supply system.

For individual air handling units or fans, to enable the designers of building projects to quickly determine whether a given air handling unit will positively or negatively meet the overall demands on power efficiency, a SFP_E for the individual fan or AHU has been defined. In a constant air volume flow system, the demands shall be met at the design air flow and design external pressure drop (pressure drop in the ducting). In a variable air volume flow system, the demands made on the SFP_E shall be met at the partial air flow and the related external pressure drop, specified for each air handling unit specification or at another point in the reference documents of the project. Therefore data at design maximum air flow and design maximum external pressure drop shall be specified, as well as the partial flow and the related external pressure drop. If the data concerning partial air flow and related external pressure drop is not specified, the following figures can be used as default values for determining the SFP_E (background and more details are presented in EUROVENT 6/8 [2]):

Partial air flow (default value): 65 % of the design maximum air flow
Partial external pressure drop (default value): 65 % of the design maximum external pressure drop.

.The **specific fan power** ***SFP*$_E$ –** for **supply and extract air units** (normally also equipped with heat recovery), is the total amount of electric power, in kW, supplied to the fans in the AHU, divided by the largest of supply air or extract air flow rates (i.e. not the outdoor air or the exhaust air flow rates) expressed in m^3/s under design load conditions.

$$SFP_E = \frac{P_{sfm} + P_{efm}}{q_{\max}} \quad (2)$$

where
SFP_E is the specific fan power of a heat recovery air handling unit in kW x m^{-3} x s
P_{sfm} is the power supplied to the supply air fan in kW
P_{efm} is the power supplied to the extract air fan in kW
q_{max} is the largest supply air or extract air flow through the air handling unit in m³ x s^{-1}

Air handling units with liquid-coupled coil heat exchangers and separate supply air and extract air sections also belong to this category of air handling units.

For separate supply air or extract air handling units and individual fans, the **specific fan power,** ***SFP*$_E$** is the electric power, in kW, supplied to a fan divided by the air flow expressed in m^3/s under design load conditions.

$$SFP_E = \frac{P_{mains}}{q} \quad (3)$$

where
SFP_E is the specific fan power of the air handling unit/fan in kW x m^{-3} x s
P_{mains} is power supplied to the fans in the air handling unit/fan in kW
q is air flow through the air handling unit/fan in m³ x s^{-1}

The intention with the SFP_V value is to have a factor which is simple to specify during building design and straightforward to validate when commissioning and controlling the ventilation system. The ***SFP*v** is the electric power, in kW, supplied to a fan divided by the air flow expressed in m^3/s **under validation load conditions.** When defining a ventilation system specification it is convenient to specify the highest permissible SFP_V as this will help to influence the choice of air handling units or fans towards those of a desired power efficiency.

EXAMPLE

In a typical commercial or public building there are a few air handling units and also some separate supply or extract air fans to serve different purposes. There may also be a wide variety of activities in the building, some of which can be served by a simple fan (e.g. exhaust from toilets) and others requiring high-level air treatment and distribution (auditoria, exhibition facilities etc.). For this reason, the SFP values for individual units and fans can vary within a wide range especially in multi-purpose buildings. The following example presents also how to calculate the SFP for the whole building as a weighted average of all individual SFP's, as the total power consumption of all fans altogether, divided by the total supply **or** extract air flow, whichever the greater. EN 13779 [1] actually defines several ways to determine the SFP values, due to the still remaining national differences in the definitions. It is therefore important also to include in the design and commissioning documentation, which calculation procedure has been applied in each individual case.

AHU equipped with both supply and extract air units

Supply air fan	**Air flow** m^3/s	**Ductwork pressure** Pa	**Power supplied to the fan 1)** kW	**Extract air fan**	**Air flow** m^3/s	**Ductwork pressure** Pa	**Power supplied to the fan 1)** kW	**SFP_E of this AHU** $kW/(m^3/s)$
S-1	0,5	300	0,98	E-1	0,5	250	0,85	3,66
S-2	2,5	250	3,36	E-2	2,8	250	3,93	2,60
S-3	6,9	300	9,17	E-3	7,2	300	8,71	2,28
S-4	3,3	250	4,33	E-4	3,6	250	4,83	2,54
Total	13,2		17,8		14,1		18,3	

Separate supply air units or fans

Supply air Fan	**Air flow** m^3/s	**Ductwork pressure** Pa	**Power supplied to the fan 1)** kW	**SFP_E of this fan** $kW/(m^3/s)$
S-5	0,4	300	0,66	1,65
S-6	1,2	220	1,44	1,20
Total	1,6		2,1	

Separate extract air units or fans

Extract air fan	**Air flow** m^3/s	**Ductwork pressure 2)** Pa	**Power supplied to the fan 1)** kW	**SFP_E of this fan** $kW/(m^3/s)$
EF-1	0,1	160	0,06	0,60
EF-2	0,2	220	0,17	0,85
EF-3	0,5	350	0,35	0,70
EF-4	1,0	220	0,67	0,67
Total	1,8		1,25	

Total supply air flow	13,2+1,6	14,8 m^3/s
Total extract air flow	14,1+1,8	15,9 m^3/s
Total electrical power	17,8+18,3+2,1+1,25	39,4 kW
SFP =	**39,4/15,9**	**2,48 $kW/(m^3/s)$**

1) Power supplied to the fan
This means the power supplied to the fan at design air flow and given pressure loss of the ductwork. This value can be calculated for example using the manufacturer's dimensioning software. This figure is used as input data for calculation of the SFP for the entire system. This figure includes the efficiency of fan, motor, belt drive and frequency converter. This is also the power, which should be verified by measurements in the completed installation after balancing and final adjustment of air flows.
2) Ductwork pressure, in case of separate extract air fan

APPLICATIONS, AND TASKS FOR DIFFERENT TARGET GROUPS

Guidance for design, measuring and documentation has been developed during the recent years in Finland in order to support practical implementation of the relevant clauses of the National Building Code [3], which gives a maximum target value for SFP (**2,5 kW/m^{3}s for ordinary systems;** for special applications a higher value is allowed) and also requires validation by measurements in commissioning.

An unofficial guideline was published in 2004 and revised in 2005, freely available in www. A simple excel calculation tool for designers was included in the second edition. The feedback from designers and inspectors indicated that the information was not very widely known.

In order to have the SFP calculation and validation widely adopted also in practice, a short summary was added in the information package in 2006. It points out the importance of the issue to the "key players" as follows:

-the designer will make the system design, including: specifying the target value for SFP, selecting the AHU's, calculating the exact SFP value (for each unit and fan, and finally the overall SFP as the weighted average as described in the example above), and dimensioning of the air distribution and diffusion system accordingly. The designer also makes the design documentation including the SFP calculation sheet

-the installer will install the system and take care that the system is built according to the designer's specifications – not only physically, but also functionally. The installer takes also responsibility of the SFP measurements at the commissioning stage, including the relevant measurement report

-the building inspector will check the design documentation and the measurement report and confirms their conformity to the building regulations

It has to be pointed out that the use of SFP as guidance for system design and construction is a relatively new issue everywhere. There is no scientific data yet available about the SFP level and how much it has reduced during the recent years. However, the measurements done by some manufacturers and inspectors indicate that the most common regulatory values, between 2 and 2.5 kW/m^{3}s, represent the state-of-art in modern applications. Lower regulatory values do not yet seem to be very realistic, taking also into account the fact that some 15 years ago a much higher power consumption (between 5 and 10 kW/m^{3}s) was the normal practice. Levels down to 1 – 1,5 kW/m^{3}s are technically possible, but not yet widely economically feasible.

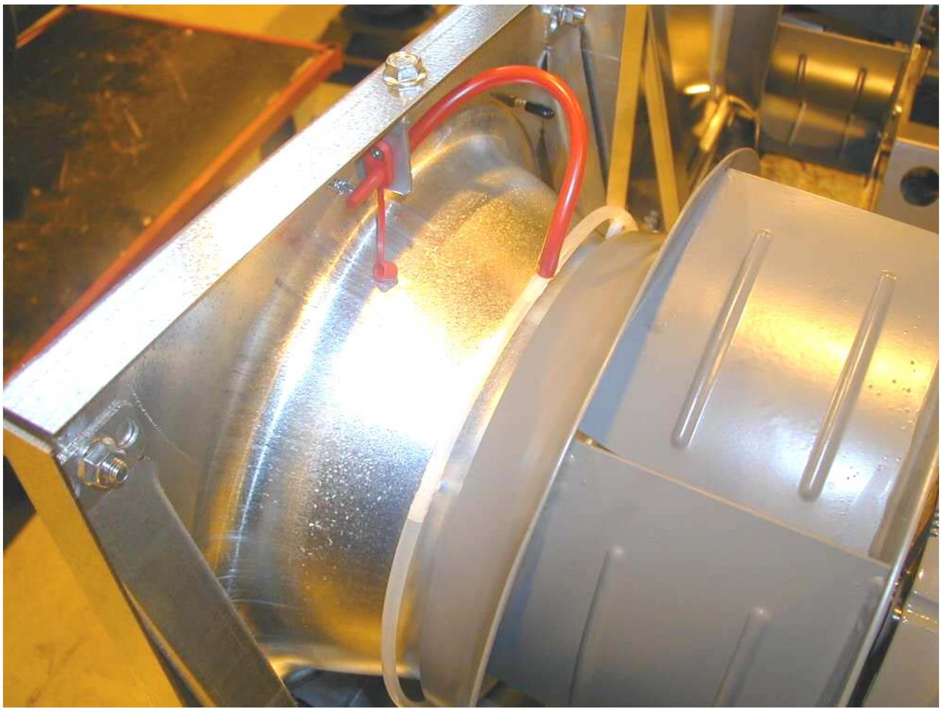
DISCUSSION

Recent studies show that the electrical energy consumption can rather easily be reduced from the "traditional" level (between 5 and 10 kW/m^{3}s) into a modern level (2 to 2,5 kW/m^{3}s) with proper design and installation. Even lower levels are technically possible, but not yet widely economically feasible.

In addition to put some target values for the SFP number, it is also important to give tools for practitioners so that the target values can really be achieved and maintained in real practice.

The SFP value can be easily measured in practice, if the measurability is taken into full consideration in design and construction of the AHU. Normally the power consumption can be easily measured in modern AHU's, see the figure on the left.

Also the air flow has to be measured to determine the SFP value. To do this in an easy but reliable way, the AHU or fan should be equipped with a built-in air flow measurement arrangement. One example is presented in the figure below.



REFERENCES

1. EN 13779 Ventilation for non-residential buildings - performance requirements for ventilation and room-conditioning systems. Revision, 2007
2. Recommendations for calculations of energy consumption for air handling units. EUROVENT 6/8, Eurovent/Cecomaf, 2005.
3. Indoor Climate and Ventilation of Buildings. National Building Code of Finland, Part D2, 2003. http://www.ymparisto.fi/default.asp?contentid=127529&lan=fi&clan=en