METHODS TO IMPROVE THE EFFICIENCY OF ELECTRICITY USE FOR BUILDING SERVICES

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INTRODUCTION

The results from the Stockholm Project clearly show that apartment buildings with little need of purchased energy have been accomplished with high dependence upon electricity as a consequence. Electricity for the building services and domestic electricity can account for more than half of all the purchased energy. The decidedly dominating item consists of fans, which account for more than one-third of all electricity for the building services. Measurements on ten fan units in the Stockholm Project were carried out by the Project Group for Energy Conservation in Buildings (EHUB) at the Royal Institute of Technology (KTH) in Stockholm. The comprehensive measuring equipment was installed in six multi-family residential apartment buildings. Measurement data have been processed and various parameters influencing electricity use have been studied.

The total efficiency of the fan units, defined as flow multiplied by total pressure increase in proportion to the amount of electricity supplied to the fan motor has been calculated. The fans are of centrifugal type. All electric motors are three- phase squirrel-cage motors and power transmission is accomplished by belt drive. Table 1 shows the efficiencies measured for all ten fans, together with total pressure drops, flows and power factors. The total efficiency of the installations = η_t, is defined as the ratio between the measured air flow, Q_m (m^3/s) multiplied by the total pressure drop p_t (Pa) in the installation divided by the measured power to the fan motor, P_m (Nm/s).

It has not been possible to directly measure fan efficiency. All the fans embraced by the study have forward-directed blades. Nowadays this type of fan

Table 1. Results From Measurements of Ten Installations of Fans in the Stockholm Project Buildings

Fan Unit	P_m (W) Measured Power	L (%) Load	PF_m Power factor	Q_m (m^3/s) Airflow	P (Pa) Press-ure	η_t (%) Effi-ciency
Ai	1000	70	0.62	0.67	500	34
Ae	1670	57	0.54	0.65	640	29
Bi	1040	69	0.61	0.68	640	42
Be	1980	66	0.62	0.86	590	26
Ci	700	64	0.57	0.68	330	32
Ce	1560	104*	0.58	0.73	578	27
De	2130	97	0.57	0.83	1450	57
Ee	1140	38	0.42	0.50	333	15
Fi	5100	46	0.51	1.98	540	21
Fe	7110	65	0.68	1.84	1268	33

* Variable speed of Ce is controlled by a frequency converter, why the load can exceed the rated load.

is commonly used in ventilation plants on account of their compact size and the fact that they give good pressure boosts. Moreover, they are relatively inexpensive. According to data from manufacturers, efficiency may be expected to amount to between 50 and 60 per cent.

The total efficiencies, including motor and transmissions, may be expected to be between 45 and 55 per cent, whereas the measuring result gives a mean value of 32 per cent. If the motors are either overloaded or underloaded their efficiency declines. Only one of the ten motors measured was fully loaded. For other motors, the load varies between 38 per cent and 70 per cent of rated load. For motors of power range 1 - 5 kW the efficiency drops rapidly when the load decrease 50 - 60%.

The motor efficiency has not been measured in the field, since this is a complicated procedure in a plant that is actually being operated. On the other hand, the total efficiency has been compared with the load on the motor. This comparison clearly shows that it is a matter of the utmost importance to exert an optimum load on both motor and fan in order to achieve good total efficiency.

Generally speaking it may be said that the electric motors included in the investigation are overdimensioned. On average, they are subjected to a load equivalent to approximately 60 per cent of the rated output. Apart from the effect of the low load on the efficiency of the motor, the proportion of reactive power is also affected. Proper dimensioning is important not only in order to ensure that the work of the fan is done with good efficiency but also to make good use of the electricity from the power distribution network.

CONCLUSIONS

Why is electricity use high?

Unless the total service life of a system is taken into consideration there is a risk of pressure drops in ducting and air treatment units being disregarded at the design and planning stage. These pressure drops are then likely to be unnecessarily high.

It is impossible to precisely calculate the pressure conditions in a system at the planning and design stage, especially since the systems are tending to become increasingly complex. This is partly due to the fact that modifications to planning and design documents are frequently introduced during the construction stage and while the building services are being installed. Moreover, it is impossible to predict what the velocity profiles in different parts of the ducting system will look like in reality.

In consequence of this fans and motors are frequently overdimensioned in order to ensure that the flows specified in the building regulations are attainable. If the flows are excessively high, they are normally reduced by throttling the flow by means of a damper. This can cause substantial losses.

If the flow is to be variable the fan and motor must be adapted for different operating conditions and priority be given to the normal operating case. The conditions for normal operation are often adversely affected by a forcing need of short duration.

How can electricity use be reduced?

In order to make correct dimensioning possible a development work with a method that extends across both the design and the commissioning stage has been carried out. The method is based on a combination of calculations and measurements.

1. At the planning and design stage the utmost importance must be attached to endeavours to minimize the pressure drops in the system without it being necessary to make an exact calculation of the magnitude of the pressure drop. This applies to both ducting, registers and air treatment units. It is not only the investment as such that will influence the choice of components but also the overall cost, including maintenance and electricity use. Fans and motors are selected so that they can be easily replaced after commissioning or when the needs become different.
2. After installation of ducting systems and fans the pressure drops, power requirements and flows for different operating conditions are measured. The length of the measurement period chosen depends on the operating strategy. This makes it possible to determine the frequency of the operating cases. In order for such measurement to be

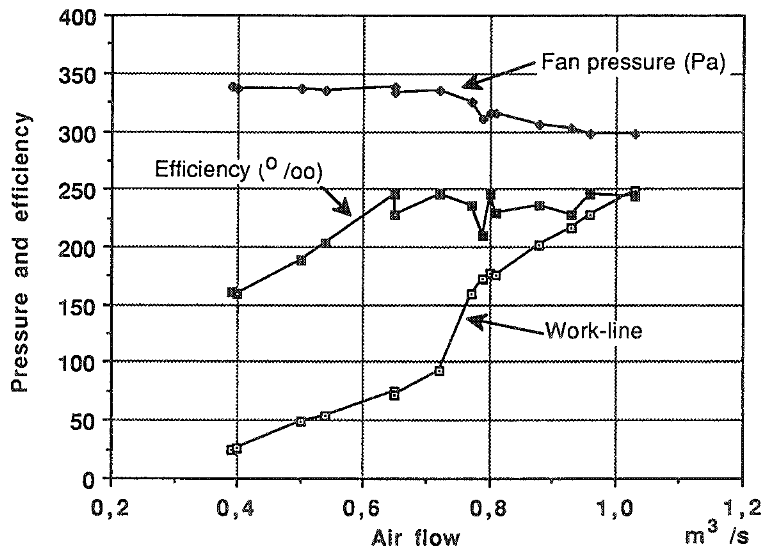

Figure 1. Measured Work-Line and Efficiency Related to Air Flow

carried out in a simple manner use is made of data loggers and a special register for flow measurement.

3. The results of the measurements are analysed and give the system's work line, fan curve, normal operating case, true power requirement, flow and efficiency.

4. Only when all this has been done is there a sufficiently good base for selecting the best components for a specific system. The fan can be selected within its best working range. The fan motor can be properly matched to the fan and the true power requirement. With the great range of fans available today it is moreover often possible to select a direct-driven fan.

Efficiencies for power transmissions, fans and motors can be optimized. This, together with low pressure drops, gives excellent prospects of reducing electricity use for fan drive regardless of which system is chosen. The method can also be used in existing systems and is particularly beneficial if the system is to be rebuilt.