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"FAN ENGINEERING"

AIRTICLE® 1

THE EFFECTS OF TEMPERATURE AND ALTITUDE ON FAN PERFORMANCE

INTRODUCTION

Fan performance tests are carried out according to different fan connection types to the test set up. According to AMCA (Air Movement and Control Association) standards 210 -a, fans are tested and classified according to 4 different mounting types. These standard types are shown in Figure 1.

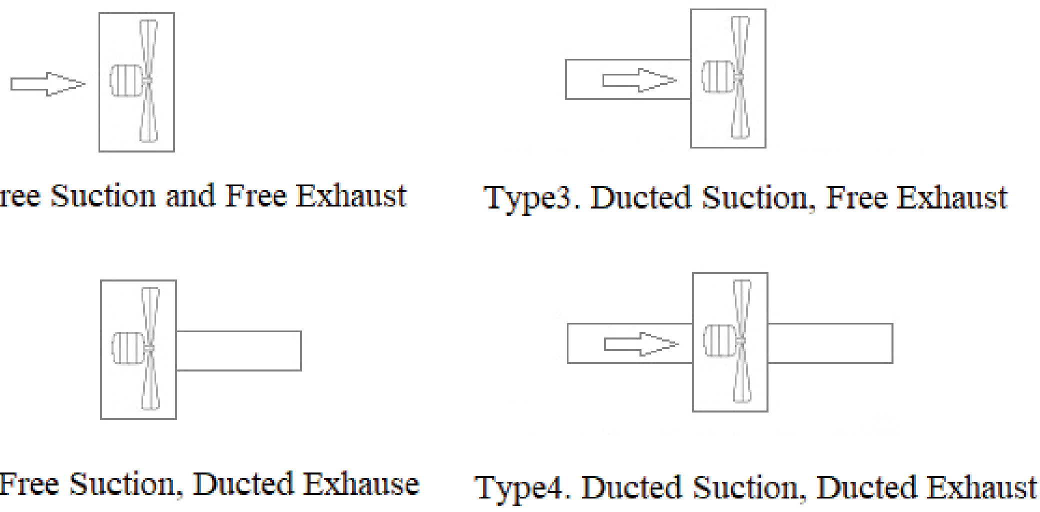

Figure 1: Standard Fan Mounting Types

In addition, tests should be done by providing standard air density at the entrance of the fan. The standard air density in ventilation sector is 1 atm (at sea level) pressure and 20 ^{0}C temperature is accepted as 1.2 kg/m^3. Fan performance tests and fan classifications are performed according to this standard. The fans will work under different weather conditions when they are installed in the system at the site. Therefore, the necessary calculations should be done to obtain the correct results. However, calculating the fan performance according to the intensity is not enough. The effects of air density on the structural components of the fan should also be considered. Because as the temperature changes, the flexibility and fragility properties of the alloy used in fan construction may also change. For these reasons, the air density at the entrance of the fan should be considered.

The effect of temperature on Fan performance.

The density of the air is affected by the ambient temperature. When the air density in the working environment of the fan is different from the density in the environment in which it is tested, the pressure of the fan and the required fan power are directly affecte. On the other hand, the flow rate of the fan is not affected by this difference in density. So how does it calculate the density of air at different temperatures? By using the table given below, the desired values can be found in a simple operation.

Table 1: 1 temperature verification factor at atm pressure

Temperature (°C)	Factor	Temperature (°C)	Factor
-150	0.43	120	1.34
-100	0.61	140	1.41
-50	0.78	160	1.47
0	0.93	180	1.54
20	1.00	200	1.61
40	1.06	250	1.78
60	1.12	300	1.95
80	1.20	350	2.12
100	1.27	400	2.29

$$factor = \frac{\rho_{standard}}{\rho_{real}}$$

In fact, by using these values, the fan performance can be corrected directly. This factor equals the ratio of the standard air temperature to the input temperature in the area where the fan is used. In addition, there are other factors which affect the density of the air. Humidity and external gas are among the elements which affect air density. Accordingly, the factor given above should be calculated by making actual measurements as described. Let us summarize what we have described with an example.

Example 1: We need a fan which will provide 20000 m^3/h flow rate and can overcome 240 Pa pressure. Our fan will work at 100 °C in the application, but let us think that we are not aware of this information. We will choose this fan from the performance curves offered by the manufacturer. These curves are curves formed under standard conditions. According to the selection outputs of Aironn ventilation company, a fan with a diameter of 800 mm providing 20000 m^3/h flow rate and 240 Pa pressure is running at 1500 rpm and needs 3.2 kW power. For selected fan, to calculate the performance at 100 °C let's use the values of Table 1 . Our verification factor value at 100 °C is 1.27. So our static pressure and fan power are calculated as follows:

$$\frac{240}{1.27} = 189\ Pa \qquad \frac{3.2}{1.27} = 2.51\ kW$$

As seen in the example, when the temperature is not taken into consideration, the fan selected could not provide the required pressure. So that we understand that fan Selection temperature is an important factor. It is clear that the return value and flow rate were not affected. To be summarized:

- If the temperature is higher than 20 °C, the density of the air will decrease, so the pressure provided by the fan and the required fan motor power will decrease.
- If the temperature is lower than 20 °C, the density of the air will increase, so the pressure provided by the fan and the required fan motor power will increase.

THE EFFECT OF ALTITUDE ON FAN PERFORMANCE

The behaviour of the fan when operating at a temperature higher than 20 °C is similar to that of the fan when operating at an altitude higher than sea level. As the altitude rises, the density of the air decreases. The altitude verification factor is given in Table 2 below.

Table 2: Altitude at 20 °C-validation factor

Altitude	Factor	Altitude	Factor
0	1.00	1750	1.23
250	1.03	2000	1.27
500	1.06	2250	1.31
750	1.09	2500	1.36
1000	1.13	2750	1.40
1250	1.16	3000	1.44
1500	1.20	3250	1.49

For a better understanding of the fan performance of altitude, let's calculate on an example.

Example 2: Consider 2000 m altitude in an area of a shopping center 40000 m^3/h and 300 Pa to select a fan. Since the temperature is not specified, let us consider the temperature to be 20 °C for the time being. If we take advantage of Table 2, in a place with an altitude of 2000 m, the verification factor appears to be 1.27. The following action should be taken before going to the manufacturer's fan performance curves.

$$300 \, x \, 1.27 = 381$$

After this process, a fan should be selected from the manufacturer's fan performance curve providing 40000 m^3/h flow rate and 381 Pa pressure. If we take advantage of the fan performance curves of Aironn Havalandırıma, we can choose a fan that needs 7.5 kW engine power with a diameter of 1000 mm running at 1500 rpm.

Effect of temperature and altitude on Fan performance

The above sections describe the effect of temperature and altitude on fan performance separately. When calculating the effect of temperature and altitude on fan performance, we can use Table 1 and Table 2 as we did in the sections above. Multiplications of the validation factors we found for temperature and altitude will give us a new validation factor. Let’s discuss on an example;

Example 3: Let’s consider a project in Ardahan carpark in which a fan with 60000 m^3/h and 500 Pa is required. First of all, we should find the altitude of Ardahan and the highest temperature in the year. The altitudes of Turkey on a provincial basis are presented the link presented at the end of thes paper. To reach the highest temperature in the year, You can find it on the Official Website of the General Directorate of Meteorology of the Ministry of Forestry and Water Affairs of Turkey. These values for Ardahan are 2200 m and 24.3 °C. When we use the above tables, the altitude and temperature verification values are 1.3 and 1.01. The following procedures should be applied before looking at the manufacturer's fan performance curves.

$$1.3 \; x \; 1.01 = 1.31$$

$$500 \; x \; 1.31 = 656 \; Pa$$

As a result of the operations of the manufacturer's fan performance curve we need to look for 60000 m^3/h and 656 Pa. When looking at the fan performance curves of Aironn Havalandırma, a fan with a diameter of 1250 mm is selected at 1500 rpm with a motor power of 20.5 kW.

Note: The Altitudes of Turkey on Provincial Basis
https://www.kgm.gov.tr/SiteCollectionDocuments/KGMdocuments/Root/Uzakliklar/ililcemesafe.pdf