Air Vision,

Start & brake of centrifugal fans

The centrifugal fan's impeller may have sometimes an important inertia, if we relate it to the power motor in charge to drive it.

N.B.: We know that the motor power is in general designed according the absorbed power of the fan,

$$Pabs = \frac{Q\ (m^3/s) * H(daPa)}{100 * \eta\ (\%)}$$

It is sufficient then to take an extra margin of 15% on this value, and we will select a motor with a standard power straight ahead above the calculated result.

If the flow is low and the static pressure important, the impeller of the fan will be tight but with a large diameter. Its inertia will be therefore important regarding the power (and the torque) available to speed-up it.

Inertie $I = MD^2/4\ (kgm^2)$, avec
$MD^2 = \Sigma Mi.Di^2$,

Mi represent the various loads of the impeller,
Di= The gyration diameter of these loads.

In such case, it is necessary to take certain precautions when starting the fan, otherwise the starting current - which is known to be 5 to 9 times the rated current - is extended for an inadequate time and may cause a heating of the motor damageable for it.

According the type and the execution of the motor, the manufacturer advise to limit the starting-up time to 8-10 seconds with direct-on-line start.

It is necessary then to calculate this time, if it is too long, we will switch to one of the following solutions:

- Start with closed damper: the resistive torque will be therefore weaker, this will allow you to increase the available motor torque, but this solution is rarely sufficient.
- Selection of a higher power level motor. Easy solution, but considering the oversizing, the motor will be operating with an efficiency which is not the best.
- Installation of a hydraulic coupler between the motor and the fan. The starting-up goes then soft, but the hydraulic coupler is an extra maintenance cost, and we should select a fan considering an extra slip of the speed around 3% at the nominal speed. The hydraulic coupler is also a power consumer.
- Installation of variable speed drive (this device operate with U/f=constant, therefore with a constant torque till 50 Hz). This solution is very common and used, thanks to the high decrease of its investment cost since 15 years, but also thanks to its flexibility allowing to adapt the speed of the fan to any modification in the system, with considerable energy saving resulting from it.

It is important to remind:

- A star-delta star is absolutely not helpful in our case. Indeed, in star, the current is divided by 3, but the torque also. The start-up time is therefore longer with the same possible heat damages to the motor.
- The electronic soft starter (in opposition to the variable speed drive, works with a reduced voltage for a constant frequency) do not offer a sufficient motor torque to start and should be excluded too.

The starting time for a direct-on-line start is calculated as following:

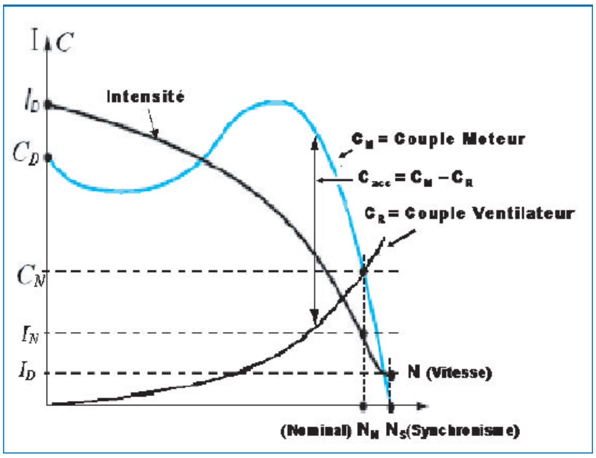
The acceleration torque is the difference between the motor torque and the resistive torque.

$$T_{acc} = T_M - T_R,$$

but might be written also as : : $T_{acc} = I \times d\omega/dt$.
with $d\omega/dt$. = the derivative of the angular speed regarding the time *(=angular acceleration)*

Therefore $dt = I / T_{acc} * d\omega$. the integral of this function may allow us to find the startup time if the torque was expressed with a basic function of ω.

To express it in an easier way, we can write:



$$T_{start} = \frac{MD^2(fan) * N^2 (fan)}{365000 * (Cd/Cn - 0.33) * P_{mot}}$$

with *N = fan target speed*
Cd /Cn = start torque / nominal motor torque. (this value is a characteristic of the motors and is given in the datasheet of it).
Pmot = nominal power motor

Reversely, it might be interesting to know the necessary time for a fan to stop after switching off the power supply:

$$t\ (sec) = 0{,}278 \cdot 10^{-5} \cdot MD^2 \cdot \frac{N0^2}{P0} \cdot \frac{N0-N}{N}$$

With N0 = rotational speed of the fan at the power supply cut *(RPM)*
P0 = Power absorbed by the fan at the power supply cut *(kW)*
N = Speed at the time t, after the power supply cut *(RPM)*

When we extend N to 0, then $\frac{N0-N}{N}$ *extend to the infinity. By experience, we observed that we need the same time to cross from N0 to N0/10 than N0/10 to 0. We calculate then N0/10 and we multiply the calculated time by 2*.