

# Some principles of synchronous motors

## Why choose a synchronous motor ?

To produce a certain number of movements within a well defined time period - in this case, the motor is used as a time base.

To produce a rotation movement requiring relatively low torque at reasonable cost.

## How to select from the Crouzet range

The Crouzet synchronous range consists of the following motor types :

### → 1 Single direction

Either :

- clockwise (CW or SA)
- or anti-clockwise (ACL or SI)

(We will see below how to ensure the correct direction of rotation). In special applications it is possible to dispense with the anti-return totally (SAR version). In this case, the motor may rotate in a clockwise direction.

### → 2 Reversible

The motor rotates in either a clockwise or an anti-clockwise direction. The direction of rotation is controlled by a capacitor.

## Definition of a synchronous motor

This motor is characterised by a constant speed of rotation which is independent of the load but linked to the supply frequency.

A synchronous motor maintains its speed of rotation until an overload occurs.

When overload occurs, the motor loses synchronisation, ie. it stops and develops an oscillation (vibration).

### → Speed of rotation

This basic characteristic can be calculated as below :

$$\text{Speed (in rpm)} = \frac{60 \times f \text{ (en Hz)}}{P}$$

f Hz : The frequency of the AC voltage through the coil.

P : The number of pole pairs in the motor  
(1 pair = 1 North Pole + 1 South Pole).

**Therefore the speed of rotation of a synchronous motor is defined by its construction.**

### Example :

A motor equipped with 5 pole pairs would give :

$$V = \frac{60 \times 50}{5} = 600 \text{ rpm using a 50 Hz supply}$$

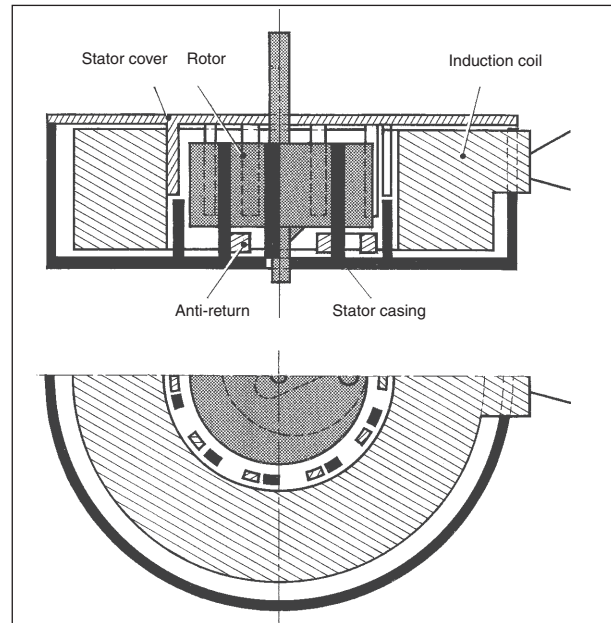
and

$$V = \frac{60 \times 60}{5} = 720 \text{ rpm using US supply (60 Hz)}$$

## → Construction of a permanent magnet synchronous motor

### Single direction

### Technology



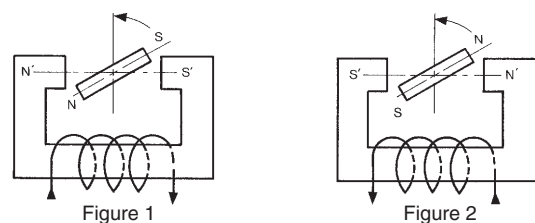
- Casing poles S.N.S.N.S.N
- ▨ Cover poles N.S.N.S.N.S

Our single direction motors are only available with a mechanical anti-return. This assembly offers the double advantage of being a relatively simple technical design while offering good performance.

The permanent magnet rotor has at its periphery a number of alternating NORTH and SOUTH poles equal to the number of poles on the stator. The latter, energised by a single coil connected to an AC supply, produces a magnetic asymmetry which positions the rotor when stopped in such a way that it is attracted by an oscillating torque when the current is switched on.

This start-up condition would cause the motor to turn in either direction if a mechanical device called an «anti-return» did not define and impose the direction of rotation.

### → Principle of operation



The principle assumes an electro-magnet : a permanent NS magnet rotates around axis O in the air-gap of the electro-magnet, perpendicular to the lines of magnetic force.

Let us suppose that this moving permanent magnet reaches the position marked in figure 1. If the relative positions of the electro-magnet poles are as shown in this figure, the magnet will be repelled and tend to oscillate around an equilibrium position at 180° to direction SN'.

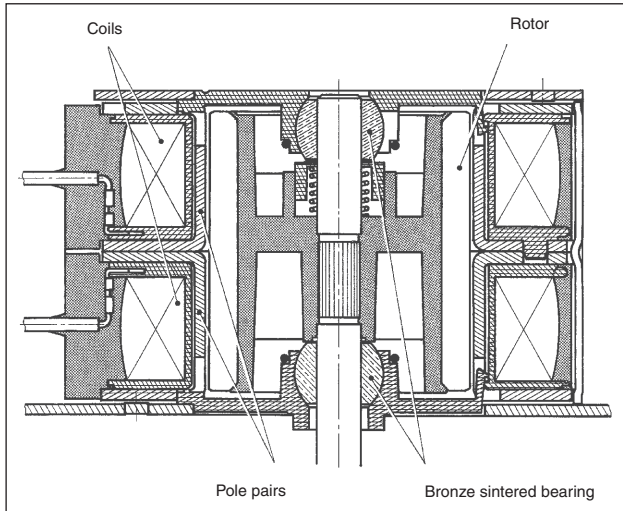
When the permanent magnet is just past this position (figure 2) and the polarity of the electro-magnet is reversed, the magnet will be repelled and return to its previous position, and so on.

By energising the electro-magnet with an AC current of frequency  $f$ , the magnet will turn at a speed of  $f$  revolutions per second.

In these circumstances, a motor can start up in either direction. To determine a particular direction, a mechanical device (anti-return) is placed on the rotor to ensure that the motor operates only in the direction required. There are several types of anti-return device which are differentiated by the degree of the reverse rotation angle within which the rotor can move.

**Reversible**  
**(Also called reversible synchronous motor)**

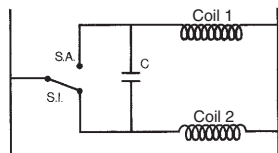
**Technology**



Synchronous motors with a single-phase AC voltage and a permanent magnet must have, for reverse operation, at least 2 stators and 2 coils. Reverse operation can be achieved electrically using a single-pole switch.

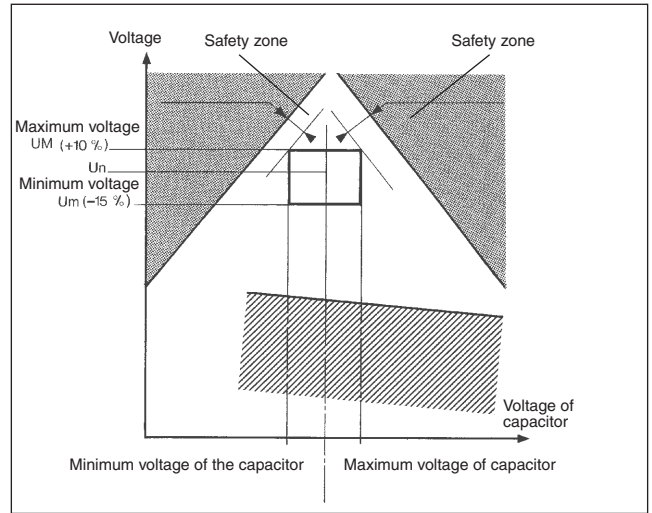
A capacitor is used on reversible synchronous motors with 2 coils to produce an electrical dephasing of  $90^\circ$  between the 2 coils. This creates a circular revolving magnetic field. Component precision assures a perfectly circular field and ensures silent motor operation.

**→ Wiring diagram for capacitor**



The capacitor specification must be appropriate to each type of motor and to the supply voltage. An incorrect capacitor may distort the magnetic field and have detrimental effects on the reliability of the start-up of the motor as well as on operational quality.

The curve (motor reversing curve) below shows the limits within which the motor will always start in relation to variation in supply voltage and the capacitor values.



- Nominal voltage of capacitor
- ▨ Zone within which the direction of the motor on starting is not controllable
- ▨ Zone within which the motor will not start

The zone within which the motor operates, ie. the area around the nominal voltage of the capacitor, must be completely controlled by the manufacturer.

Operating within this zone guarantees starting and operating in the direction selected by the user.

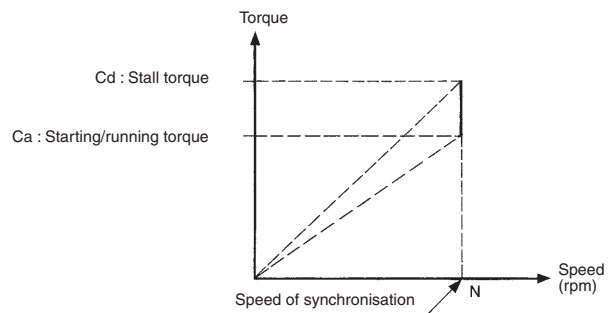
As the diagram shows, we build our motors so that the operating zone is as far as possible from the critical zones, whatever the nature of the torque.

**Boosted winding**

Our experience in this area allows us, in certain cases and depending on the precise specification, to operate outside this zone to produce a higher torque and increase performance by between 30 and 80%. Please consult us.

**→ Motor torque**

2 types of torque can be distinguished.



**Starting/running torque (or synchronisation torque)**

This is the torque that a synchronous motor can develop both at start-up and at synchronisation speed.

**N.B:**

In all technical data concerning geared motors in this catalogue, the torque/speed curves indicate the value of the starting/running torque for all the gearbox output speeds.

**Stall torque (or desynchronisation torque)**

This is the torque limit at which a synchronous motor loses its synchronisation.

## Motor and gearbox combination

The motor output shaft turns at a defined speed. This speed is generally too high for the majority of applications.

To reduce this speed we provide users with a complete range of gearboxes, each equipped with a series of ratios.

As a result, the motors can be used for numerous functions.

### → Gearbox characteristics

Each gearbox has been designed for a certain workload. We have defined its potential and its limits for optimum mechanical life.

The principal characteristic is its capacity to absorb a maximum torque in continuous operation.

The range of gearboxes in this catalogue can be used for maximum torques of between 0.5 and 6 N.m for long mechanical lives. The values given are for standard products used in the normal operating conditions specified.

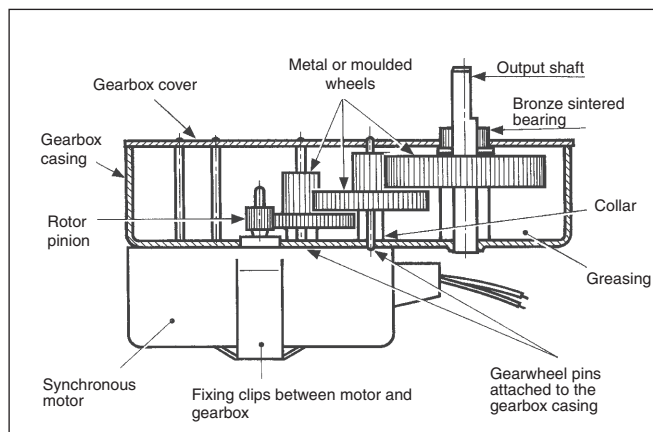
In certain cases, these values can be increased if the required life is reduced. Special cases are dealt with by our design staff.

Each gearbox nevertheless has a limit which is the

### Breakdown torque

This torque, applied to the gearbox, can cause its destruction when first used.

### → Gearbox construction

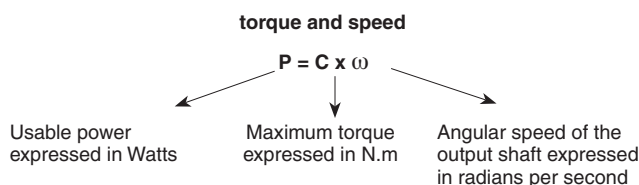


### Selecting a geared motor

Selection is made in relation to the prospective workload.

Before making a selection, it should be remembered that the motor absorbs a certain amount of power, the absorbed power and it cannot deliver more than a fraction of this power : the maximum is defined as the usable power or the mechanical power.

Usable power links 2 factors.



Analysis of this formula clearly shows the function of the gearbox.

It reduces speed and increases torque since the usable power produced by the motor is recovered by the gearbox (within the limits of normal efficiency of course).

The torque requirement thus serves to define the gearbox (characterised by its maximum torque) and the choice of motor depends on the speed at which the torque is required.

The usable power should be borne in mind in all cases, as it is the basic parameter when choosing a motor.

## Addinal information

### → Temperature rise

Permanent magnet motors generally have relatively low efficiency and some of the lost energy is converted into a rise in the temperature of the motor.

We consider that this rise in temperature reaches its maximum level after 2 hours of continuous operation.

To calculate the rise, we use the method known as resistance variation.

$$\Delta T = \frac{\Delta R}{R} (234.5 + T_a) - (T_1 - T_a)$$

**R** = Coil resistance at ambient temperature before applying voltage to the motor (expressed in Ohms -  $\Omega$ ).

**R'** = Resistance of the same coil after 2 hours of continuous motor operation.s

$\Delta R$  =  $R' - R$  = Increase in coil resistance.

**T1** = Ambient temperature at the end of the test.

**Ta** = Ambient temperature at the beginning of the test.

### → Dielectric strength

All our products are tested to current standards.

### → Insulation resistance

This is greater than or equal to 75,000 M $\Omega$  measured using a 500 VDC current in conditions of ambient temperature and humidity.

### → Safety

Crouzet synchronous motors are designed and manufactured for integration into equipment or machines meeting, for example, the requirements of the Machinery standard : EN 60335-1 (IEC 335-1) : Safety of domestic electrical appliances.

Integration of Crouzet synchronous motors into appliances or machines should, as a rule, take into account the following motor characteristics :

- no earth connection,
- so-called «principal insulation» motors (single insulation)
- protection index : IP40
- insulation class : B.

## Standards and approvals

Our motors are in general designed to conform to international recommendations (IEC), American standards (UL - CSA) and/or European standards (EN).

Proof of compliance with these standards and recommendations is demonstrated by an approval (a mark or certificate of conformity granted by an accredited body) or the manufacturer's declaration of conformity (drafted in accordance with ISO/IEC 22 guidelines).

## Rules and regulations

### → EC directives

Our motors are compatible with European Community directives (Low voltage 73/23 > 50 VAC) and in particular the aspects of electrical safety referred to in the above standard EN 60335 (domestic electrical appliances).

The «CE» mark on all our products is proof of this conformity.

Moreover, our products are particularly suited, for example, to applications concerning both office equipment and medical equipment covered by standards EN 60601 and EN 60950 respectively.

### → Environmental protection

The modern concept of protection of the environment is an integral part of our motors, from product design through to packaging.

## Electromagnetic compatibility

(EC Directive 89/336/EEC dated 03/05/89)

Both asynchronous and synchronous motors and geared motors designed for integration into more complex equipment by professionals, rather than end users, are excluded from the areas of application of this directive.

Crouzet will however be pleased to provide the EMC characteristics of its products on request.