Motor Capacitors

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Background

There are small electric motors everywhere; in every house, commercial building, industrial site, sports complex, and any other facility worldwide. These range from small fan motors in cooking rangehood extractors to large single phase motors in saw benches, and everything in between. The vast majority of these motors have at least one capacitor, either mounted on the side of the motor or in the termination box attached to the motor. Depending on the design of the motor, there may be a 'run' capacitor and/or a 'start' capacitor. As the name implies, a 'run' capacitor is a device that is integral to the running of the motor and is in service all the time that the motor is operating. Similarly, a 'start' capacitor is only in operation during a predefined starting period, typically 1 or 2 seconds.

Looking at the purpose of these capacitors, it is found that a 'run' capacitor is used to create a phase shift between the motor's two windings such that a torque is produced to encourage rotation. The size of the 'torque' is determined by the size of the capacitor and it is matched to the current (load) capacity of the motor. A 'start' capacitor is nothing more than a large 'run' capacitor in function, although there are often structural differences. It is sized to provide a very big torque that will make a motor start, even if it is against a heavy load such as in a water blaster or air compressor. This 'start' capacitor will cause the motor to draw a heavy current for a short time so that the motor attains a certain speed which concludes the start period – the motor then transfers over to the run capacitor. This means the 'start' capacitor and the 'start winding' (if applicable) are only utilised for a short period to avoid overheating.

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Motor Capacitor Requirements

Fundamentally, there are two different capacitor technologies required for these two types of motor capacitors: Metallized Polypropylene (MPP) for 'run' capacitors, and Electrolytic for 'start' capacitors. The main reason for this is that both types of capacitors must be of a physical size that will fit into the designated place that the motor manufacturer has allowed. Further requirements are thus:

Motor Run Capacitors	Motor Start Capacitors
Must be able to operate continuously without failure	Must be able to operate for 10-20 seconds without failure
Must be sized to provide the motor's field winding operating current – this will be small to moderate – meaning these capacitors are physically quite small, so MPP technology can be used	Must be sized to provide the motor's start winding operating current – this will be high to very high – meaning these capacitors are physically very large, meaning Electrolytic technology must be used to reduce the size

MPP Capacitors

These capacitors are the simplest and most reliable capacitors available, manufactured by many companies throughout the world. To design them, the capacitor designer needs to know four key points: the operating voltage; the capacitance; the temperature rating; and the physical size. The capacitance and the temperature are usually fairly easy, although the operating voltage and the physical size are much harder. The motor manufacturer will state the voltage the motor is run at (e.g.: 230V) as well as the length and diameter of the capacitor. The missing information is that the field voltage applied to the capacitor inside the motor may be significantly higher (e.g.: 375V), making the capacitor size ridiculously inadequate. Considering the capacitor design process (please see other documents written by kVArCorrect for further information):

- Take the capacitance required to determine the plate area required for the capacitor
- Choose the polypropylene film thickness that is required to handle the voltage stress. An example is to handle 230V and achieve 3,000hr life expectancy; 5 micron thick film is required. To achieve 375V and 3,000hr life expectancy; 7 micron film is required
- Once the plate area is known, choose a cell height and then calculate the number of turns of polypropylene film of the chosen height that will be required to achieve the required plate area. The finished diameter of the cell is proportional to the number of turns wound and the thickness of the film
- The designer will vary the cell height and the film thickness to fit the physical space the motor designer has allowed, and ***the compromise is almost always a reduced life of the capacitor***

The cell is usually too small physically to ensure a long life.

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Electrolytic Capacitors

Motor start capacitors are characterised by requiring a large capacitance that can deliver a large current for a short time. MPP capacitors are capable of playing this role, and sometimes are used in place of start capacitors, but are physically several times too large. What is required is a capacitance rating of 10 times the capacitance in the same physical space. This is done by the addition of nasty chemicals (the electrolytic) that allow very thin polypropylene or polyester films to withstand much higher voltages for short periods of time. This means that the capacitor delivers significantly higher microfarads in the same space when compared with MPP cells. The downside is that these chemicals are horrible and the losses in the cell are much higher, and whenever there are losses, there is heat. The heat generated is so intense that the capacitor cannot operate for more than a few minutes before failure occurs. This is generally OK because the whole motor design is such that the start circuit is only enlivened until the motor is up to speed. Generally, electrolytic motor start capacitors can quite easily be manufactured to fit into the available space.

The most common problem encountered by capacitor sales companies

Customer: “I like your capacitors but they are too large to fit into the motor space that I have.”

We have two solutions to this problem, leaving it up to the customer to choose their fate:

1) A capacitor that fits the physical space
    a. Short lived, poorly designed
    b. Will last no longer than the original
    c. May cause safety issues

2) A capacitor that may not fit the physical space
    a. Reliable, high quality, safe, solid design
    b. Will last significantly longer than the original

About the Author

The opinions expressed here are the researched views of Allan Ramson, General Manager, kVArCorrect Ltd. All claims have been substantiated by testing and observations from the Australasian market between 2007 and 2019. Having been associated with the design, manufacture and supply of many thousands of capacitors, kVArCorrect are confident that they will recommend the correct capacitor for the application.

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