Fan Controller Technologies and Power Consumption

It is generally understood that adding speed control to a fan will save energy when the fan is operating at less than full speed. With the wide range of control technologies available (TRIAC/phase control, variable frequency control, and AC to DC inverter control), determining the most energy efficient solution can be complicated. The test results discussed here attempt to normalize some of the inherent differences and make an equal comparison for using different types of motor controllers. This comparison assumes that only single-phase AC power is available.

AC-DC Inverter TRIAC/Phase Controller Variable Frequency Drive

The test setup:

The fan under test was loaded in a wind tunnel while its speed was monitored with a strobe. For each speed setting, the pressure was held constant and the input power was monitored using a true RMS voltage meter and ampere meter. This setup, shown in Figure 1, was used to test the systems described in Table 1 below.

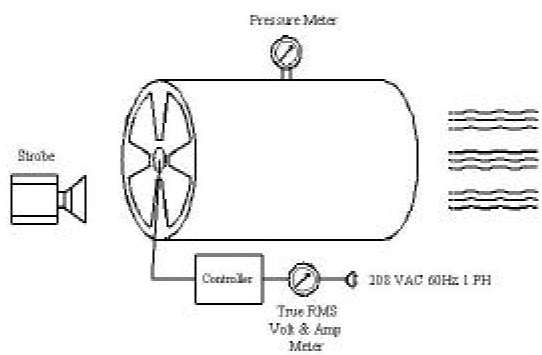


Figure 1.

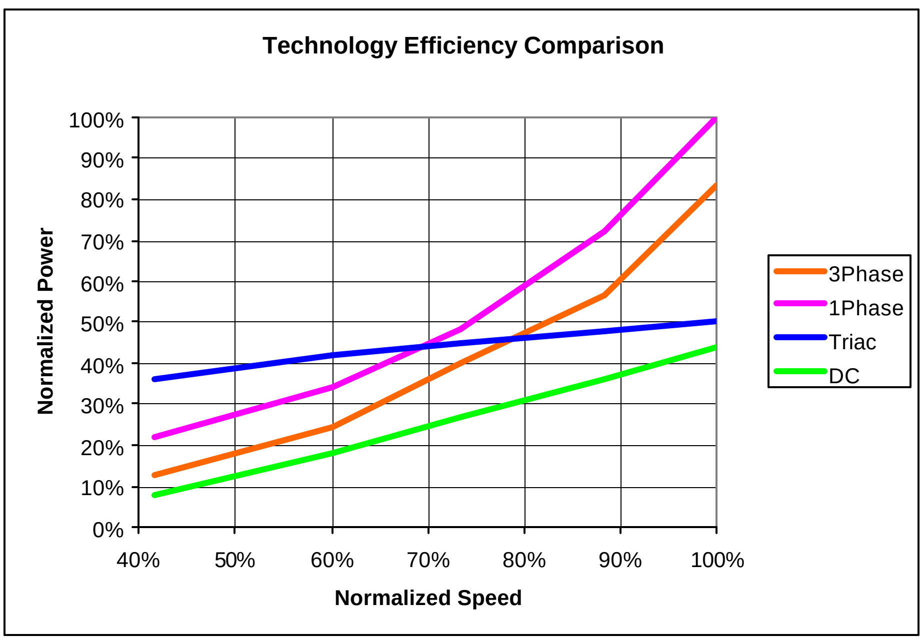
Table 1					
Controller Technology	Three- Phase Variable Frequency	Single -Phase Variable Frequency	Single -Phase TRIAC	Single -Phase TRIAC	AC to DC Inverter
Controller	Control Resources Stratus	Control Resources Stratus	Control Resources Nimbus	Control Resources Nimbus	Control Resources Inversion
Fan Model #	Continental Fan TMK355-4-34	Continental Fan TMK355-4-14	Continental Fan TMK355-4-14	EBM W2E143-AB03-01	Papst 6224 NH

The test method:

First, two fans with equivalent performance (flow & pressure) were selected in single phase and three phase 208VAC. These two fans were controlled from 100% speed to 40% using a variable frequency drive. The pressure was monitored through a wind tunnel and held constant for each speed setting during the testing to ensure that the load on the fan was constant and the flow rate was equivalent. The power consumption was calculated by taking the true RMS voltage reading on the input line and the true RMS current on the input line and multiplying them to give the power input to both the controller and the fan. This way the efficiency of the drive is also accounted for in the power consumption. The single-phase motor was driven with a TRIAC/Phase controller under the same test conditions as above.

To compare AC control to DC inverter control, two different fans were chosen - an AC single phase and a DC - which had the equivalent performance, but not the same as the previous two fans. The single-phase motor was run at the same speed points as the previous test on both a variable frequency drive and a TRIAC/Phase controller. The DC fan was then tested to the same conditions using an AC to DC inverter. The variance of TRIAC/Phase to variable frequency efficiency was consistent so this was normalized to allow the AC to DC inverter to be compared to the variable frequency drive. The normalized data is shown in the graph of figure 2.

Figure 2



Conclusions:

It can be easily seen that the DC fan driven by an AC to DC inverter yields the highest efficiency as the normalized power is lower than any other method at all points. This is mainly due to two factors: first, the DC fan motor itself is generally more efficient than its

AC counterpart, and second, the decrease in speed decreases the output voltage and output current by the same amount, resulting in a large reduction of power at lower speeds. Generally, if the speed of a DC fan is reduced to 50%, then the output voltage and output current are both reduced by 50%, resulting in the output power dropping to 25% of the full speed power.

Using figure 2 we can also conclude that a three-phase motor is consistently more efficient than an equivalent single-phase motor. The greater efficiency was also present when the fan was connected directly to the AC line, indicating the gain in efficiency was mainly due to the motor design.

If the system is restrained to using a single-phase AC fan, then the expected operating conditions must be considered to find the optimal solution. If the system will regularly require the fans to run near full speed, a TRIAC/Phase controller will yield greater efficiency than a variable frequency drive. If the system will generally require only low speed operation, then the variable frequency drive will yield better results. Also, the performance between a variable frequency drive and a TRIAC/Phase controller varies according to the motor design. While the basic trends shown above are fairly consistent, the precise crossover points will vary.

Other Considerations:

Just as one car is not suited to all individuals, one fan controller technology is not the best for all applications. Other considerations when choosing fan controller technology include controller accuracy, low speed capability (<50%), fan availability, fan compatibility, number of fans in system, induced bearing noise, size and of course total system cost. Generalities to consider for each technology are listed below:

Controller Technology Generalities			
Controller Technology	TRIAC/Phase	Variable Frequency	AC to DC Inverter
Energy Use	Good	Good	Best
Controller Accuracy	Good	Better	Best
Low Speed Capability (<50%)	Good	Best	Good
Fan Availability (large fans)	Better	Best	Good
Fan Compatibility	Good	Better	Best
Multiple Fan Capacity	Better	Good	Best
Induced Bearing Noise	Better	Good	Best
Size	Best	Good	Good
Controller Cost	Best	Good	Good

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