YASKAWA

All Servos are NOT Created Equal

Important Features that you Cannot Afford to Ignore when Comparing Servos

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There is a common belief that two servos of the same power range from different manufacturers are roughly equivalent and the only other significant comparison point is price. Let's debunk that myth right here and now. Here are some important features that you cannot afford to ignore when comparing servos:

- Rated Torque and Rated Speed
- Overload Time
- Torque to Inertia Ratio
- Resolution
- Frequency Response
- Network Based Solutions
- Physical Size
- Quality and Reliability

Torque, Speed, and Power

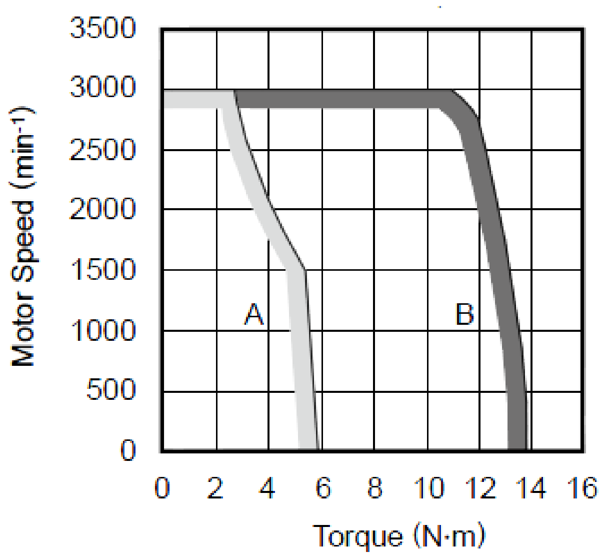

Figure 1 - Typical Torque-Speed Curve with continuous (A) & intermittent (B) duty zones shown

A servo's torque range is divided into 2 categories: continuous and intermittent duty. The continuous duty range represents the torque that the servo can deliver 24 hours a day, 7 days a week without overheating or otherwise damaging the motor. The intermittent range refers to the set of torque values that the servo can deliver for only short bursts of time. These bursts are typically used for acceleration, deceleration and dealing with brief load disturbances. Unfortunately, torque and speed ratings are not consistent throughout the motion control market. The amount of time that a servo can continue to deliver torque in the intermittent range (sometimes referred to as the overload time) varies widely amongst servo manufacturers and is not always clearly specified.   This feature alone can make a significant difference in the types of tasks that a servo system can perform. When sizing a servo one must always remember that the RMS (Root Mean Square, or roughly speaking the "average") torque requirements must be in the continuous duty range for the servo to operate without overheating. The duty cycle of a motor is limited by the heat that it can dissipate.

I once conducted a test on a customer's machine between two different brands of servos having roughly the same outer dimensions (one was 6 mm longer). Although their physical sizes were almost identical, their power ratings differed; one was rated at 750 Watts and the other at 860 Watts. After multiple tests of the machine's operation it was concluded that the 750 Watt motor was the clear performance leader for this application. This result seems counter intuitive until you understand that rated torque values are not measured at the same speeds for all servos. The equation for the power of a motor is expressed in terms of both torque and speed and neither have standard rated values for servos in the motion control industry. It is therefore critical to select a motor that has the required torque at the machine's operating speed and to not fixate on the power rating. A motor's internal stator windings can be wound to provide more speed and less torque or more torque and less speed at the same wattage.

Inertia

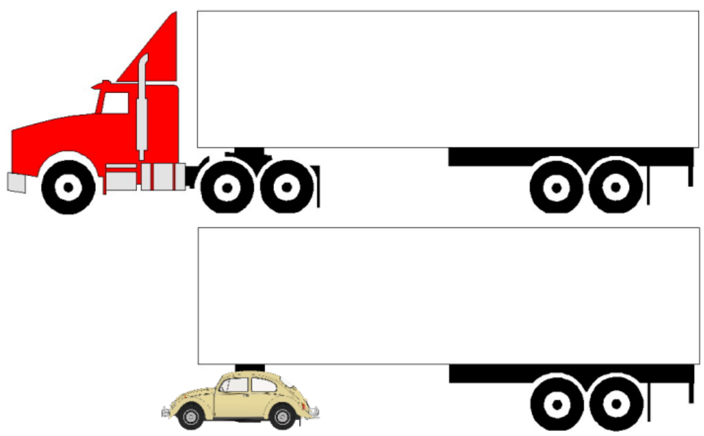

Figure 2 - Inertia Mismatch
Top = Good Inertia Match, Bottom = Poor Inertia Match

So far we have only talked about torque, speed and power. Inertia is another very important specification to consider when selecting a servo. The ratio between the motor's rotor inertia and the inertia of the load (that which is coupled to the motor's shaft) is critical. A servo by definition is a closed loop system and its control algorithms are constantly changing the current in the motor. The current sent to the motor is based on complex calculations involving the differences between its feedback and its commanded values for the position, speed, and torque. The inertia ratio between the motor and the load will significantly affect the servo system's ability to accurately control the motor. If the ratio is too high then the motor will overshoot its target and cause oscillations. These oscillations can be as minor as a little wiggle when the motor stops or as major as violent and loud vibrations that can damage the machine. The high performance servos available on the market today have low inertia permanent magnet rotors and can provide a large amount of torque in a small package size. It is important to select the proper mechanical transmission (i.e. gearbox, ball-screw or belt and pulley) to achieve a load to rotor inertia ratio within an acceptable range (10:1 average performance, 5:1 high performance, 1:1 highest performance).

Encoder Resolution

Another important factor is the resolution of the feedback device. The resolution of encoders is constantly rising and it is not uncommon for them to be 20 bits or greater. A 20 bit encoder has more than one million pulses per revolution (2^{20}=1,048,576). You might think this is overkill but remember that the purpose of a servo is to look at the difference between the commanded and actual positions and to drive that error value to zero. The higher the resolution, the faster the servo system can detect the movement and make a correction, resulting in more stiffness and tighter control of the load.

Frequency Response

The servo system's ability to calculate and deliver current, and therefore torque, in real time can be another area where servos vary greatly. The frequency response of a servo is a measure of its ability to follow changes in the command signal. A servo's bandwidth is defined when a sinusoidal signal is commanded into its speed loop and the frequency of the sine wave is raised until the servo cannot change the shaft speed to match the commanded signal. Once the actual speed falls to 70.7% (-3dB) of the command signal then that frequency is measured as the bandwidth. Over the last 24 years we have watched the speed loop bandwidths of high performance servos increase tenfold from levels below 100 Hz to those now exceeding 1 kHz.

Network Connectivity

Along with advancements on the power side there have also been many improvements on the control side of servo systems. Most modern servo systems are network based architectures which lower implementation costs and improve diagnostic capabilities. The reduction in wiring also increases the speed at which OEMs can commission multi-axis systems resulting in higher profits and greater throughput. Network connectivity for both the control of the servos and for handling information between the factory MES and SCADA systems is an absolute must in this age of increased communication. The added diagnostic capabilities can reduce downtime and also allow for remote resources to quickly troubleshoot problems.

Physical Size

As the performance of servos has increased the size of the electronics in the amplifier and controller has decreased. More thermally efficient designs also require less space between amplifiers. These advancements help shrink the footprint of the electronics which results in a significant cost savings for the overall system. Smaller control cabinets and the resulting real estate savings can be used to create a more efficient use of the factory floor.

Quality and Reliability

Of course all of these features are of little benefit if the system suffers from inferior quality. It is important to choose a manufacturer that has a track record of great quality and the data to support those claims. Mean Time Between Failures (MTBF) is a statistical measurement of the quality and reliability of a product. Asking for this information before you purchase can help you choose a motion control partner whose product offering provides a lower Total Cost of Ownership.

Conclusion

As you can see there are many factors to consider before purchasing a servo system. The next time you are comparing servos please remember that the criterion for determining the true value goes far beyond the wattage and the price.