

## **Drives de AC vs. DC para aplicaciones de velocidad variable.**

### **Una guía practica de evaluación para decidir la mejor solución.**

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Los recientes desarrollos tecnológicos disponibles para drives de AC han traído muchas ventajas en costo para numerosas aplicaciones de velocidad variable que anteriormente solo podían resolverse con motores de DC. Esto es especialmente cierto en numerosas aplicaciones de la industria siderúrgica. Pero ningún cambio viene solo, ni es gratis: el proceso de decisión técnica se complicó enormemente. Decidir entre AC y DC para un caso en particular no es un asunto trivial y muchas veces el análisis superficial no conduce a una solución clara.

Se han escrito numerosos artículos que pretenden ayudar en este proceso de decisión, pero que adolecen de varias lagunas: se concentran solamente en el aspecto de desempeño y son terriblemente complejas de entender y traducir a situaciones prácticas. El presente artículo ofrece un enfoque más integral en que se toman en cuenta, además del factor desempeño, elementos tales como complejidad de la instalación, mantenibilidad, costo de mantenimiento y costo total del proyecto.

Adicionalmente se analizan desde un punto de vista práctico los diversos factores mas comúnmente usados para evaluar el desempeño de una aplicación en AC y DC con el propósito hacerlos mas fácilmente entendibles.



# Análisis de AC Vs DC

## DESEMPEÑO

- AC tiene mejores tiempos de respuesta
- AC requiere tacómetro para alto desempeño.

## MANTENIMIENTO

- AC requiere menos mantenimiento.
- AC proporciona mejor PF Y THD.
- DC es más fácil de solucionar fallas.
- DC es más fácil cambiar de motor y afinarlo.

## INSTALACION

- Transformador en AC es 20 % menor.
- AC puede requerir cable especial.
- AC proporciona mejor enclosure con un sistema de enfriamiento menos complicado.



***Motors***

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***Drives***

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***Installation***

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***Initial Investment***

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## ***AC***

- Lower maintenance requirements
- Conventional, low cost, 3-phase AC induction motor for Variable Torque operation only. All the Constant Torque Operations required a special motor design.
- Smaller, lighter and less expensive for most of the applications. Wide speed range operation will required a more special and expensive motor.
- Very low Base RPM motor may result in a much larger Frame compare to DC

## ***DC***

- Brush maintenance required
- No audible noise produced by switching
- Lower cost machines for a wide speed range applications.
- Higher efficiencies at rated load.
- High starting torque with no speed feedback device.
- Potential for rapid acceleration to destructive velocities upon loss of the stationary field.

## *AC*

- Can work @ hi speeds > 6000RPMs
- Safe speed control above base speed without speed feedback device.
- Much Better enclosure for hazardous environments at lower prices.
- 100% continuous torque at zero speed. This condition normally required a speed feedback device.
- Special bearing consideration at certain frames to prevent pitting. This will also require isolating the speed feedback device.

## *DC*

- Maximum safe operation restricted at 2400 RPMs
- More reliable machine for long-term operation.
- Most of the applications require external ventilation.
- Zero Speed operation normally required a very expensive motor. However this operation can be achieved without speed feedback device.
- Bearing pitting problem is very unusual in metals application.

## *AC*

•Application with multi-motor operation (Roller Tables) required a much easier individual motor protection system. No load balancing is possible by external devices. Special hi sleep AC motors are normally required for this application.

•Motor failure causes by Hi-Voltage reflective waves are not easily detected by conventional instruments like Meggers.

## *DC*

•Application with multi-motor operation (Roller Tables) required a much-complicated individual motor protection system with individual motor protection and excitation system. The individual excitation of the motors allows adjustments for better load balancing.

## ***AC***

- More components since AC to DC to AC conversions required
- Extensive use of Electrolytic Capacitor within few years expected life reduces drive overall reliability.
- The IGBT and Electrolytic Capacitor are very susceptible devices to temperature variations.
- Power device Failure not rarely result in capacitors plus some electronic boards failures as well.
- Complex control algorithms

## ***DC***

- Single power conversion from AC to DC Less expensive for most HP ratings
- Slightly better efficiency
- Drive Based on Highly reliable Power Semiconductors (SCR)
- Power device failure normally produces to replace the device only plus some power fuses.
- Easier understanding of operation (Ia proportional to Torque)

## *AC*

- No Electromagnetic contactor is required for drive and motor protection. However an AC contactor is recommended for motor maintenance.
- Regeneration normally requires additional controller plus sophisticated algorithms.
- Higher power factor operation near to unity. The use of SCR sources for regeneration will not provide this benefit plus more likely will blow fuses in the case of commutation problem.

## *DC*

- DC Regenerative drives require DC bus fuses or Hi Speed DC Circuit breaker to protect the drive in case of commutation problems. AC or DC contactor is required in general to protect the motor and drive.
- Regeneration can easily be achieved with the same control. However this option will cause to increase the required KVA feeding the drive.
- Normally low power factor operation speed dependable the best case is 0.8

## *AC*

- Total Harmonic Distortion (THD) at alternator will be approximately the same than for a DC drive if diode or thyristor source is used. For a PWM source harmonics represent a higher potential for noise problems
- For accurate torque regulation and hi overload operations, motor speed feedback is required.
- Wide speed range operation will required a higher drive rating. Sometimes 80% higher

## *DC*

- Hi THD filtering solutions are normally expensive. The only drive design possibility is using a higher pulses transformers. This solution is not economically viable below 2000 HP
- Capable of Torque regulation without speed feedback device.
- No Drive over sizing required for wide speed operation

## AC

- Tight, predictable dynamic response ( $> 30$  rad/s on speed loop), current loop response is not restricted by line frequency, since commutating from DC link. Most of mechanical system limit the speed response to 15 rad/s
- E-Stop Restricted to Class 1 operation at the most. Class 0 will required the use on expensive mechanical brakes.

## DC

- Dynamic response ( $< 30$  rad/s on speed loop), current loop response lowered at 50 Hz operations. Much better speed regulation with no speed feedback device specially at low speed.
- Dynamic braking can be achieved by using passive elements. This permits Class 0 E-Stop operation.
- High initial responses for start moving since the motor is already Preflux. In AC sometimes this required even few seconds.



- Distance between Motor & Drive limitations due to reflected wave.
- Very special considerations need to be taken for multi-motor application. The distance between the drive and individual Motor Protection Panel needs to be carefully analyze and located. If space constrains exist and output filter will need to be added to the system for proper performance.
- Special 3 conductors, symmetrical ground, armored power cable required. High frequency harmonics generate common mode currents that may damage motor bearings. This cabling method will require regular inspection of cabling terminators.
- Some application with isolated bearing will required the use of a shaft grounding brush with will need to be also maintained in good order.
- Up to 20% Lower KVA required on Transformer.



- **Bigger motors for same HP compared to AC. With the exception of wide speed range machines.**
- **Brush maintenance required, access must be provided.**
- **Higher KVA required because the lower PF operation.**
- **Complex filtering if Power Factor Correction is required.**



- AC drives will displace DC eventually, but DC it is still a viable technology.
- The installed base of DC drives and motors and the accumulated experience with this technology are important factors to consider, but the improvements in performance and maintenance requirements of AC are very important when considering new installations or revamps.
- Newer and more reliable power components will eventually match the SCR reliability and low voltage oil-filled capacitor will overcome the life issue that those devices represent.



**The other important factor is the initial investment for an AC system compare to a DC system.**

**There is not a really black and white rules to define for a coordinated drive system to define which one is less expensive, almost in every case a detail design will need to be done in AC, DC or a combination of both to find the most competitive solution for every case.**

