Electronic versus Magnetic Clutch Capping Heads in Rotary Capping

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With rotary capping equipment, the use of magnetic clutch capping heads has now become routine, relegating the old friction or disc clutch rotary cappers (if anyone remembers these) to the list of obsolete packaging machinery. Magnetic clutch heads have proven, over a twenty-five year history of use in thousands of applications, to be a reliable means for applying screw-on closures with consistent torque over many hours of operation in some quite severe packaging environments and have become the standard offering with all major rotary capping machine vendors. Two principal innovations to the magnetic clutch capping heads over the last several years have been the introduction of tool-less torque adjustment and quick release chucks, features which provide both reduced downtime while requiring no tools or training to perform a cap change-over. With these innovations, it is expected that magnetic clutch capping heads will remain the industry standard for as long as packaging needs include the use of screw-on caps.

As good as this technology is however, there are occasions where the use of magnetic clutch heads fall short of an application's requirements. Cap orientation, application torque monitoring and reporting, screw cap profiling, expanded torque range, delicate cap handling, and aseptic packaging are all examples where magnetic clutch technology is either limited or simply incapable of performing satisfactorily. Given the very real need to address one or more of these requirements, electronic head technology has been developed and has proven to be the best possible solution to these high requirement applications.

Two opposing electronic head technologies have been developed, the first of which was introduced by Andre Zalkin & CIE, Paris France, initially in 1996. This technology relies on a motion controlled, brushless DC motor, fitted in a IP65 grade stainless steel housing, which is mounted at the end of the head slide where the magnetic clutch head would normally be mounted. The motor is custom built with a hollow shaft to allow a cam actuated push rod to extend through the motor to actuate the articulating chuck jaw segments for cap pick up and release. The alternate technology came into use circa 2003 and has been to be adopted by various other capping machine vendors. The majority of these companies use an off-the shelf servomotor supplied by Elau AG, headquarter in Marktheidenfeld, Germany to drive either by a gear/pinion or timing belt arrangement, a secondary shaft on which the cap chuck is mounted. As off-the-shelf servomotors are designed with a solid motor shaft however, the cap chuck used to hold the cap during application must either be a solid chuck, mounted directly on the servomotor shaft, or be mounted on the gear/belt driven secondary shaft with a hollow core to allow a cam actuated push rod to open and close articulating chucks jaws.

Electronic capping machines when properly configured provide excellent performance for all capping applications. The following examples make clear the superior advantage electronic capping holds over magnetic clutch capping for high requirement applications.

Cap Orientation

Magnetic clutch capping heads, being gear driven, spin constantly during the capping cycle. As a result, the ability to provide orientation of a cap with a feature requiring a fixed relative position once applied on its bottle is dependent on some creative mechanical means to cause the magnetic clutch to slip when the correct orientation within the 360° rotation of the capping head is reached. The use of a mechanical solution for orientation carries with it the condition of all mechanical devices, being wear and maintenance. Alternately, through the use of electronic heads, causing the rotation of the head to stop at a desired position within its rotation is simply a matter of signaling the motion controller to hold position.

Application Torque Monitoring

The ultimate goal of screw capping is to deliver an application torque to a closure that results in a properly sealed container but at a force that also yields an acceptable removal torque. Of these two attributes, a capping machine can only control the element of application torque. A number of variables contribute to removal torques which are outside the ability of any capping machine to control. These include tolerances of the cap/bottle combination, seal design, liner construction, cap temperature, and cap color among others. Consistent and repeatable application torque however, is within the capability of properly designed rotary capping machines whether employing magnetic clutch or electronic heads. A magnetic clutch, set to slip at an application torque and measured statically in the morning, will provide the same static measurement at the end of the day. While there are factors which admittedly contribute to the torque applied during actual run conditions, such as the mass of the head, the rotational speed or bottle holding, a properly designed and functioning machine should overcome or minimize the contribution to the applied torque these conditions can generate. Unfortunately, with the use of the magnetic clutch heads, there is no practical means by which to measure the torque being applied while the capper is in operation. It takes confidence in the mechanical design of a magnetic capping head to accept that the desired application torque is consistently being applied to every cap being released to the consumer. For the most part, magnetic clutch heads have not disappointed. But, even the most accurate magnetic clutch, cannot overcome the torque deficiencies caused by caps slipping in a chuck, bottles turning in a pocket, stripped caps or unengaged caps. When package integrity cannot be taken on faith, a means to monitor the applied torque must be considered.

Electronic capping heads serve this purpose well. By regulating the amount of current (amperes) supplied to each capping head motor, the subsequent torque generated by the motor shaft can be directly controlled. A static measurement of each motor is performed using a calibrated load cell which allows assignment of a coefficient unique to that motor that directly correlates the applied current to the resulting torque. Once set, the repeated measurement of the torque applied is consistently within fractions of one inch pound; a nearly indistinguishable deviation. As the current draw of each head is monitored, the resulting torque value can be captured for reporting purposes, and provide data which can be used in statistical analysis of the process. In addition, by monitoring the application torque of every single cap applied to each and every bottle, detection and subsequent rejection of out-of-spec packages becomes routine. A further benefit of application torque monitoring is the ability to detect a (round) bottle that is not properly restrained during cap application and spins as the cap is tightened or to detect a cap not properly gripped by the chuck during application - both scenarios which result in an under-torqued pacakage.

Screw Cap Profiling

One major advantage of electronic capping technology is the use of motion control to allow functions impossible to achieve through the use of conventional magnetic clutch capping heads. To support this claim, the following case study is presented. A well know pharmaceutical company, experiencing a high level of miss-applied caps. It was determined that the root cause for the miss-application resided in the cap / bottle thread design. As the thread design included a blunted (squared-off) lead in, interference was created when the cap and bottle finish engaged at just the right (or wrong) point, resulting in a miss-applied cap rate of two to three percent; unacceptable by anyone's standards. Unable to change the bottle/cap design, a solution was sought through technology. By using the electronic motion controlled capping head, any interference experienced, in the form of resistance, could be measured during the capping process. If resistance was detected within one rotation of the motor, it could be safely assumed that interference was being experienced at the thread interface. By briefly reversing the motor while the top load spring applied downward pressure on the capping chuck, the cap thread was able to reposition itself below the bottle finish thread, avoiding the interference upon re-applicaation. The motor would then be powered in the correct rotation, successfully applying the cap. The ability to function as described in this example would not be possible with the magnetic clutch capping heads and before the advent of electronic capping technology, would have required either hand application or a re-design of the package.

Expanded Torque Range

Magnetic clutch capping heads have a low/high torque value range which is a factor of the strength of the magnets, and more importantly, the number of magnets used. The greater the number of magnets, the higher the achievable torque value will be for the clutch. Loading the clutch with more magnets, while raising the high end, also raises the low end. This is not an issue in applications where one or a few similar cap sizes or styles requiring similar torques are being applied. However, where application torque varies dramatically within the selection of caps requiring application, the only solution with magnetic clutch capping heads is to have two sets of heads with different available torque ranges. This is an expensive proposition, initially as well as in the costs incurred as the inevitable result of change-over down time and increased maintenance. Standard electronic capping heads have an capable torque range from 0.0 to 40.0 inch-pounds which gives this solution a wider comparative range to magnetic clutch heads and enough high end torque to satisfy the great majority of capping needs. For unique application requirements, the Andre Zalkin & CIE offering allows a motor to be designed for a substantially higher torque range capability up to 80.0 inch-pounds, a range well beyond the capability of a typical magnetic clutch.

Delicate Cap Handling

Another important advantage of an electronic capping head is its ability to control the rotation of the capping chuck thoughout the capping cycle. An electronic head can allow the capping chuck's rotation to be stopped when the cap is picked-up from the cap transfer mechanism (used to move the cap from the discharge of the cap chute to the proper position below the capping head). This allows for a gentler pick-up of the cap as compared to the spinning head pick-up by the magnetic clutch heads. More importantly however, is what occurs during cap release once the cap is applied to the bottle. A magnetic clutch slips upon reaching the desired application torque putting the capping chuck at a rest while the upper head, being gear driven, continues to spin. As the capping chuck opens and begins to release the cap, the magnetic clutch starts to engage, causing the chuck to begin spinning again. Once the chuck starts to spin, it must be fully clear of the cap, or damage to the cap can, and occasionally does, occur. With electronic capping heads, once application torque is reach, power is removed from the head, eliminating any possibility of cap damage caused by a spinning cap chuck during opening (cap release). A further advantage of electronic capping rotational control is that caps can be rapidly spun down until resistance begins to build at which time the rotational speed can be slowed allowing for a gentle tightening of the caps in the final stage of the process, avoiding such possibilities as liner or thread damage.

Aseptic Packaging

Due to the elimination of the gearing needed to drive the magnetic clutch heads, electronic head technology is inherently 'cleaner' than magnetic clutch technology. However, the over-riding advantage of electronic head technology is that in the event an adjustment to the applied torque is needed during production, the integrity of the Class 100 environment, required by aseptic packaging, does not need to be violated. Torque can simply be adjusted through the machine control panel (HMI), while the line continues to run, and without the need to enter the clean room.

Further Considerations

In addition to the benefits listed above, electronic capping head technology further provides improvements in change-over by allowing "menu" touch screen change for different caps, including global change of the applied torque provided by all heads, change in the rotational speed needed for single to multi-thread caps and the ability to compensate for the effects of inertia at different run (including ramp up/down) speeds.

Two additional points merit a brief mention when considering the appropriate technology for a given application. At the plant level, a sound understanding of mechanical principals is required to support magnetic clutch capping machines, whereas a solid understanding of electronic devices should also be available to properly support electronic capping head machines. Additionally, due to the increased cost incurred by the scope of the electronics supplied, these machines do carry a modest price premium.

In conclusion, there remains a continued and amply met need for the traditional magnetically clutched capping head technology. However, for those applications which require a unique solution to a very specific requirement, or for some who perhaps only wish to take advantage of the latest that technology has to offer, the electronic capping head technology is becoming firmly established.

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