

# **AUTOMATIC SERVO POSITIONED AIR KNIFE SYSTEMS FOR OPTIMAL CAST FILM QUENCHING**

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## **Abstract**

It could very well be that the days of cast film manufacturers running the same product day after day without changeover are fast becoming a thing of the past. With demands increasing for more custom blends, bringing new products to market and shorter runs, the film industry has seen a need for quicker changeover between products, less down time, less set up time and the ability to obtain spec on a product in less time from start up. One response to this demand is an innovative new servo positioned air knife system with enhanced manual features as well, that has been developed to help address these issues by providing multiple axis position repeatability, stable air pressure and velocity, consistent air temperature control and more user friendly set up. These features have all been combined into one system that provides optimal cast film quenching as well as gentle pressure to lay the film smoothly on the chill roll and minimize the entrapped air layer between the film and the chill roll with superior repeatability over traditional air knives. This paper will examine these and other features and list expected benefits.

## **Discussion**

### **SET UP AND ADJUSTMENT FEATURES**

Air knife designs used for cast film applications have several specific features not required on air knives used in other industrial applications. Cast film air knives traditionally run at markedly less manifold pressures than their uses in the coating, cleaning or drying industries. Also the cast film air knife beak has to have the ability to fit into a space constricted by an extrusion die, a chill roll and be able to be adjusted within these confines. This has been accomplished for some time by angling the beak with respect to the manifold body. Usually in doing this the gap adjustment screws have remained within the air stream. The traditional approaches to this have resulted in the gap adjusters being moved too close to the beak exit just where the air is beginning to accelerate. The result is increased air turbulence around the adjusters and thus exiting the beak with a potential to create defects in some films. Also traditional adjusters usually employ a set screw for increasing the gap and an individual nut to close it. This can be quite time consuming. In an effort to address these issues, the new system employs an angularly fixed top lip with an adjustable lower lip and incorporating all of the gap movement in the lower lip. This is accomplished by utilizing a system similar to a flex lip extrusion die and by locating the gap adjusters externally below the lower lip and out of the way for both the process and the operator. In addition the unit may be located closer to the die so that the internal air flow path is unobstructed across the entire length of the air knife. The external adjusters are also single turn, minimal backlash push/pull units which allow adjusting and gap measurement at the same time by one individual. Another feature which aids in gap set up is that the entire unit can rotate completely around the manifold centerline so as to allow set up personnel to aim the lips vertically up for ease of viewing and inspection during adjustment. The gap overhang adjustment

remains the same by allowing the top lip to slide to the proper overhang by means of inline setscrews.

To address air knife position with relation to the die and chill roll this system allows three modes of mobility. They are vertical (orbital around the chill roll axis), radial (linear position from the chill roll surface) and angle of the air knife lips or beak with respect to the manifold centerline. Each one of these axes of movement is controlled with it's own servo positioning system using multi-turn absolute encoders for position feedback. In addition to recording each mode of movement, the three modes are mathematically related so as to give the operator freedom to adjust the unit for optimizing the process variables without the fear of making inadvertent contact with the die or the chill roll. Once a product is on line the operator can make a multitude of positioning revisions while running and observe the effects in real time. A good example may be neck-in of the film which can be observed and recorded for optimization as well as determining where the limits of this variable lie. Another example may be rate of cooling which can be attributed to air velocity, air temperature and also how the air knife impacts the drawdown height as well as contact line of the web to the chill roll. The mentioned variables can affect the crystallinity of the product which is important to film qualities. Different resins crystallize at different rates, necessitating multiple air knife positions as well as other process variables for different products. Clarity and haze of some films are another variable which may be enhanced by on line adjustment of these parameters.

In order to have the air knife system assist in producing consistent high quality film time after time, it is important to accurately position the air knife for each product and be able to maintain it. This system is accurate and repeatable in the vertical (or orbital) direction and the radial direction to within +/- 0.003" and in the angular beak or lip position of +/- 0.20 degrees. The benefits of this are a high degree of accuracy, repeatability, ease of set up and reduced time to making in-spec product. Also if your air knife system variables have been repeated in a new start up on the same product and the product quality is still not in spec. the operator may eliminate the air knife from the equation and look for influences outside of the air knife system as a possible cause.

Accuracy and repeatability of any system are definite positives to any process but one also has to have the ability to record and recall the set variables. This system utilizes a PLC for control and monitoring and an Allen Bradley Panelview for displaying operator interaction, position readout, maintenance, auto/manual mode, recipe and alarms. When the position is optimized for a specific running condition, it can be saved and called up each time the product is run. This saves set up time with no on machine manual adjustment needed for positioning and a record of optimal running settings. The system is operated remotely with on line running adjustment with the critical components all in clear view. In addition to being a quicker adjustment, it also allows the operator to observe the effects of the adjustment without having to be in close proximity to the die or the chill roll. The benefit of this feature is that the operators can focus on the casting process without having to manually adjust components of the air knife at the same time. If an instance occurs that a film is running with the air knife system in a specific recipe and an operator has the desire to deviate to what he or she believes may be more beneficial, the change can be made and the new settings can just be created as an additional recipe by saving the running condition as is. A touch screen button is provided to do this and the new parameters are saved and are retrievable.

Accurate physical orientation of the air knife is not the only parameter that this system is able to record and repeat. Two additional features that are not always addressed but are important are air temperature and air knife manifold pressure (i.e. air velocity). This system provides automatic thermal control of the air via an in stream temperature sensor located just prior to the air entering

the manifold. Air temperature can be held to within +/- 1.0 degrees F using thermocouple feedback to a controller which operates a modulating valve on a cooling water loop to a water/air heat exchanger. The system also provides automatic manifold pressure control of the air via a magnehelic transducer output to a controller which operates a variable speed drive on the pressure fan. Static pressure in the manifold can be held to within +/- 1/4" water. Static manifold pressure in conjunction with lip geometry determines air exit velocity. The blower is provided with a variable frequency drive. Most traditional systems have little to no control of either of these variables. These automatically controlled parameters again allow an operator to make product within spec much more quickly.

The internal design of this air knife allows for an option for internal deckles since there is no internal adjustment mechanisms in the air stream. The air knife can be deckled to minimize sheet lifting on the edges and allow for a wide variety of resins for the machine. Although the shape of the deckle may have to be empirically adjusted in the field to minimize edge lifting, the provision is available and the deckles can be adjusted from the manifold end caps. This allows the operator keep away from the close proximity of the die, air knife lips and the chill roll.

## MAINTENANCE AND DESIGN FEATURES

It is easy to see how this design can save time setting the machine up for a new product and being able to get in spec as soon as possible but how easy is this system to maintain?

Some cast film products need different chill rolls for process and also need minimum downtime when changing chill rolls. An integral part of this design is that the air knife assembly is able to stay within the machine when the chill roll is removed. Due to an orbital system that is not connected to the chill roll journal or it's bearing housings, and also that the air knife moves far enough away from the chill roll, the roll can be removed without any air knife disassembly. It should also be mentioned that this system lends itself well to being retrofitted within an existing casting section.

Maintenance time can also be saved with the use of the home position which rotates the air knife and positions the lip so that it is easy to work on as mentioned above in the adjustment section pertaining to gapping. While in this position maintenance personnel can remove the end caps exposing the machine wide internal gap created by the two lips. Since there is no internal adjustment mechanisms a clean and dry cloth can be run the entire length of the lips with a narrow section of the cloth actually going between the lips. The air knife does not need to be disassembled for cleaning other than the end caps. This not only saves time for disassembly but also means that the air knife lip gap doesn't need to be re gapped and set again before running.

## SAFETY FEATURES

Safety is also important in the consideration of saving time, running good product and is an integral part of this air knife system.

The primary machine safety feature is an anti-crash logic protection within the PLC. The anti-crash protection is based on complex algorithms developed to consider chill roll size, die size, die shape, die position and air knife size and position. In addition should the anti-crash logic fail, mechanical safety stops are provided that will not damage the chill roll. These stops are made of

bronze, follow the shape of the lip periphery and are integral to the end caps. The stops contact the chill roll at the ends before the steel components of the air knife have a chance of getting near what is one of the most expensive parts of the machine (the chill roll). These stops should never be needed but they are provided as an integral design of the end cap.

The three servomotors are positioned on the assembly so as to avoid operator and process interference during normal operation.

This machine has the option of password protection on the operation of the air knife. Thus non-designated personnel cannot accidentally move the air knife or erase a product setting or recipe minimizing the chance of producing out of spec product.

An interlock is provided for safe casting section retraction also. This ensures that the air knife will not inadvertently hit the die while the casting section is retracting. Damaging the die or the air knife by not lowering the air knife could be costly in terms of downtime and repair of these components.

A few other safety features are fail safe brakes for the servos that are instantaneous if power is lost. They are not used for the held positions. Also, the blower is provided with inlet filtration and a muffler to minimize ambient noise.

## **Conclusion**

With the need for quicker changeover between products, less down time, less set up time and obtaining spec on a product in less time from start up, the benefits of a servo positioned air knife are numerous. Repeatable positioning, stable pressure and temperature all aid in the pursuit of producing the highest quality film for the converter. The automatic and manual features listed above are all combined into one system to provide the converter an effective tool towards the goal of optimum film quality.

## **Acknowledgements**

The authors would like to thank Adnan Bdour and Alex Smart for their assistance in the controls and safety discussions within this paper.