Extended Abstract

Practical Technology Needs for Coating Faster
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INTRODUCTION

A faster coating speed can improve the economic viability of a coating line by increasing productivity and reducing costs. In order to be effective the rate increase program requires improved and additional technologies in all of the coater elements. It must also insure that quality, safety and environmental requirements are not compromised.

Successful implementation requires several practical process technologies. In addition to the major process elements of coating, drying and web handling the coater peripheral technologies and hardware must be evaluated and improved if deficient. The importance of these peripheral technologies is often not appreciated and as a result they are often ignored and the desired productivity increases are not obtained. Rate increases impact on all process elements and they must all must be considered. Every process element must function at the higher speed for the program to be effective. Also technologies that are effective at a lower speed many not be adequate at higher speeds.

This presentation will discuss several of these technologies and their importance in a rate increase program. These technologies are important for both increasing the rate of an existing coater or building a new coating line.

IDENTIFYING TECHNOLOGY NEEDS

In determining rate increase technology requirements, the desired speed increase needs to be established. The higher the rate increases over the existing speed the more critical the need for technology improvement. Once the goal speed increases are identified, the next step is to analyze the entire process to determine if the existing technology will be adequate for the increased line speeds. The basic evaluation parameters that should be used are the cycle time for all of the operations, production rate and the effectiveness of the technology at the new speed. In addition time dependent steps in the process must be identified.

The cycle time is the time required for a process element to start run and complete a function. For example the cycle time of the mixing process is the time required to prepare a batch of coating solution. It starts with a clean kettle, includes weighing mixing holding for coating and cleaning equipment. The cycle time for testing starts with obtaining samples and ends when

results are available for use in the coater. The cycle times of the peripheral equipment must support the desired coating speed. If they do not then improved technology is needed. Similarly the process elements must function at the goal speed. Some processes will not function effectively at higher speeds. The coating method is a good example of this. A Mayer rod will function at a few hundred feet per minute but not at twice the speed. There are also steps in the process, which are time limited in that they require a fixed time for a function.

The following are some of the areas where new or improved technology is needed for an effective rate increase program:

- using the correct coating method
- solution preparation and handling
- quality control
- process control systems and on line-instrumentation
- substrate
- safety and environmental

USING THE CORRECT COATING METHOD

It is desirable to use the same coating method at higher speeds as is used at the lower speed. However, the coating method may not give optimum results at increased line speeds and a new coating method may be required. Often the coating speed is increased and the quality and process operability deteriorate, resulting in no net gain in performance. This can occur because all coating methods have a coatability window, the region of process conditions in which the optimum results are achieved and good quality product is produced. When process conditions, such as line speed, coating thickness, start to move out of the optimum region the applicator will continue to coat however there will be a reduction in quality, reproducibility and yield.

A contributing factor to this effect is that often as line speed is increased the concentration of the solution is increased to maintain the same drying load to the dryer. This concentration will increase viscosity and reduce wet thickness both of which affect the coatability of the applicator.

To determine if a new method is needed, process experiments should be run to determine the coatability window for specific formulations at the desired line speed. Quality can be evaluated at the coating head and the film does not need to be dry. If no test equipment is available, coater hardware vendors have pilot equipment that can be used. If coatability window is not adequate then a new method needs to be found. There are many sources of information on the capabilities of methods in the literature and from vendors. These can be used to select a method, which has a wide coatability window at the required process conditions. Laboratory tests can be run using vendor pilot coaters or contract coaters to evaluate the appropriate methods and select the best one.

SOLUTION PREPARATION AND HANDLING:

Technology improvements in the solution preparation process may be needed to provide the increased quantity of coating solution needed to sustain the coating process. Often the mixing

process is time dependent because a fixed time is required to dissolve a polymer into solution or to prepare a solid liquid dispersion. At low coating speeds, the increased time for these steps are usually not important, but they will need to be reduced at higher production rates. The addition of high shear mixing process, improved mixing kettles and temperature can be used to provide rapid well mixed solutions.

The solution handling system has several process elements, which can require improved technology to provide the necessary increased flow rate to the coating applicator. Higher flow rates can require a new pumping system. The pumps and lines must be optimized to provide steady uniform flow without the introduction of bubbles, Gravity fed systems may not be adequate and new systems required. In roll coating methods the higher solution recirculating rates can lead to the build up of bubbles in the lines and holding tank, which will lead to coated films defects. Deaeration technology is needed in these situations to remove the bubbles prior to coating. New improved filtration and temperature control systems may also be needed

In addition, a new solution handling system may be required if the applicator method is changed. Converting from a roll coater to a premetered method will require new systems to convert from a recirculating system to once through feed system.

QUALITY CONTROL AND ON-LINE INSTRUMENTATION

Faster coating speeds can result in more saleable product being produced. However, if quality control procedures for raw materials and coated product are not improved it is also possible to make more scrap then at the lower speed and effectiveness of the rate increase will be lost. The quality control process is typically time limited in that a fixed time is require to sample and test solutions or finished product. This time is independent of coating speed and can result in more products at risk until testing is complete

There are several technologies that can be used to improve the testing speed. Basically the involve using technology to more the quality control testing from the laboratory to real-time testing in the coater. Coating weight is a key parameter for all coated products. On-line coating weight measurement equipment can be installed to get rapid measurement of average coating and cross web profiles. There are a variety of measurement technologies available, which can be used for most products.

Coating quality is another key property, which can be evaluated on-line in real time. There are several detection technologies from several vendors that are available to evaluate physical quality on-line and permit rapid troubleshooting. They can detect a wide range of defects, spots, chatter, streaks and are cost effective. Their use will give the to rapidly evaluate quality and reduce testing cycle time.

Viscosity of the coating solution is another key quality control parameter, which should be measured and controlled for optimum coating quality. In-line viscometers are available to measure viscosity. There are a wide variety of instruments available at reasonable prices.

Flow rate to the applicator is an important property for all high speed methods. Automated flow meters can be used for ongoing measurement and they can be tied into the on-line measurement system and pumping systems for closed loop control

Another key element quality control is obtaining, managing and analyzing all of the process, product and quality control data that is being generated. Computer based information systems can be used for this purpose. Also manual recording of all data should be replaced with computer based acquisitions systems. This will insure all data is collected and will improve the ability of the operators to monitor and control the process.

PROCESS CONTROL SYSTEMS

A high speed coating process will require improved process control instrumentation. The higher line speed requires that steady state be rapidly reached, to avoid producing scrap during this start-up period. This will require a new control strategy and equipment and may be an important factor if many product changes are made in the coater. New control functions such as measurement and control of dry point may be needed. Measurement and control systems for controlling feed systems, coater conditions, dryer conditions, web speed and tension levels may not be slow response and not sufficiently accurate for the new line speeds. Therefore, new computer controlled instrumentation and control strategy should be implemented.

SUBSTRATE

There are several substrate areas that can need improved technology. The first is substrate wetting. The substrate at higher coating speed has less contact time with the coating solution in the coating gap. The bead is typically fixed in length and as the speed increases there is less contact time between substrate and coating solution. This can lead to decreased adhesion and coating quality problems. As a result surface treatment, flame, ED, plasma, may be required in the coating line to increase wettability and adhesion. Also the increased line speeds can attract more dirt on to the substrate surface and roll cleaners may be needed

The substrate supply cycle time is the time required to locate a roll in vault, transport it to the coater, allow for temperature equilibration and load it into the coating line. If the same roll lengths are used then this process must be sped up to match consumption. Often this procedure is manual and is adequate for low speed operation. Higher speeds can require the addition of automated vaults and mechanized automated transport from vault to coater and back.

Longer rolls and fewer roll changes are essential for high speed operation. Frequent short rolls are undesirable. An optimum roll length needs to be determined and vendor informed of the new requirements. The longer roll lengths may require improved technology in the vendor process. If short rolls are a reality because of partial leftover rolls or vendor supply problems, then off-line splicing technology is needed.

SAFETY AND ENVIRONMENTAL

The higher line speed can also create new safety hazards. Operations that were done manually at low speeds may not be safe at higher speeds and may need to be improved to protect personnel. Similarly the higher speeds can create increased emissions and waste, which will require improved technology

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