Title: SOLVENT CASTING SYSTEM AND CONTROL SYSTEM THEREFOR

Abstract: A solvent band casting system is disclosed in which a tank is to mix and/or agitate and/or store a polymer solution for a band casting machine having at least a first and a second rotating drums about which a continuous metal band is tensioned to travel with the rotation of the drums. A sheeting die applies the polymer solution from the tank to the metal band where a drying chamber enclosing a least a portion of the metal band downstream of the sheeting die, is used to remove solvent from the polymer solution as it travels in a thin sheet on the metal band. The drying chamber may include at least one heater with a plenum for directing a flow of heated air counter-current to the travel of the metal band for more effective drying. Additionally, a surfactant applicator in communication with a supply of surfactant and a portion of the metal band may be used to attain a substantially bubble-free film. A buffer configured to pivotally abut the metal band is usable on-line to lessen system downtime. Finally, a system controller is connected such that the operation of at least one of the band casting machine, the sheeting die, the drying chamber, the surfactant applicator, and the buffer is monitored and/or controlled by the system controller.
SOLVENT CASTING SYSTEM AND CONTROL SYSTEM THEREFORE

CROSS REFERENCE TO RELATED APPLICATIONS


BACKGROUND

Technical Field

The disclosure relates generally to a solution casting system. Particularly, the disclosure relates to a control system for operating a band casting system to produce a substantially bubble-free, thin, water-soluble film. As to the water-soluble film, the present control system specifically allows parameters of the casting system to be carefully monitored and/or controlled to attain a film with specific desired properties.

Brief Description of Related Technology

Though the general technology for producing plastic materials has been used for decades, solvent-film casting is attracting increasing interest. One of the reasons is that specific requirements in the fields of water-soluble packaging and other related applications can only be met by this technology.

The development of a continuous process to manufacture thin plastic films was closely linked to the emerging photographic industry starting from the end of the 19th Century. In those times, no other technology was available for industrial film forming, and polymer science was also still in its infancy. Two different technologies were soon developed: (1) casting on wheels or large drums; and, (2) casting onto endless flexible metal belts. Surprisingly, both are still in use today, together with a third technology, casting onto moving plastic films. However, since the development of extrusion technologies for the production of thermoplastic polymer films, the importance of solvent casting methods has declined. Today, solvent casting is a specific manufacturing method which is used for niche markets and films with specific and high quality requirements.

Typical solvent casting systems utilize an organic solvent such as acetone, aniline, dimethyl sulfoxide (DMSO), benzene, dimethyl formamide (DMF), methyl ethyl ketone (MEK), ethyl acetate, ethylene dichloride, toluene, tetrahydrofuran, and the like. Such solvents usually necessitate a complex solvent vapor recovery and rehabilitation system. Further, human and environmental exposure to these solvents is most undesirable.
The system described herein can overcome these disadvantages by using water as the solvent. No recovery and rehabilitation system is therefore necessary, and environmental and human exposure is not an issue.

There are many other processes for the formation of films, including calendering, extrusion, plastisol cast systems, and organosol cast systems. Extrusion and calendering are processes which melt the polymer and shape the plastic prior to freezing. Plastisol and organosol casting processes involve the melting of the polymer in a plasticizer matrix, after which the solvent action of the plasticizer forms a film.

**SUMMARY**

One aspect of the invention is a solvent band casting system, including a band casting machine having at least first and second rotating drums about which a continuous band is tensioned and travels with the rotation of the drums and a polymer applicator for applying a polymer solution to the band. The system can include a drying chamber enclosing a least a portion of the band downline of the polymer applicator, wherein the drying chamber includes at least one heater for directing a flow of heated air counter-current to the travel of the band. The system can also include surfactant applicator in communication with a supply of surfactant and at least a portion of the band and a buffer configured to pivotably abut the band. The system can include a system controller adapted to monitor and/or control the operation of (such as with sensors, actuators, and the like) one or more components of the band casting system.

Another aspect of the invention is a method of making a polyvinyl alcohol film by solvent casting a polymer solution with the apparatus described herein, optionally including steps of monitoring and controlling the operation of one or more components of the band casting system with a system controller.

Further aspects and advantages will be apparent to those of ordinary skill in the art from a review of the following detailed description, taken in conjunction with the drawings. While the solvent casting system and control system therefor are susceptible of embodiments in various forms, the description hereafter includes specific embodiments with the understanding that the disclosure is illustrative, and is not intended to limit the invention to the specific embodiments described herein.

**BRIEF DESCRIPTION OF THE DRAWINGS**

For further facilitating the understanding of the invention, 24 drawing figures are appended hereto, wherein:

Figure 1 is a schematic showing one possible embodiment of the solvent band
casting system;

Figure 2 is a perspective view illustrating the band casting components of one embodiment of the system;

Figure 3 is a cut-away view showing the cooling coils of one possible embodiment of the end drum of the system;

Figure 4 is a side view of the end drum and an embodiment of a band tensioning mechanism;

Figure 5 is a schematic illustrating an embodiment of a band side travel control system to direct the tensioning mechanism of Figure 4;

Figure 6 is a perspective view of an embodiment of a tilt roller device used for band tensioning and guiding band tracking;

Figure 7 is a front view of an embodiment of a sheeting die;

Figure 8 is a side view of an embodiment of a vacuum box blower;

Figure 9 is a perspective view of an embodiment of a drying chamber;

Figure 10 is a perspective drawing illustrating embodiments of a scanning system and a camera system;

Figure 11 is a rear view of embodiments of a take-up winder and a trim winder;

Figure 12 is a perspective view of an embodiment of a surfactant applicator;

Figure 13 is a perspective view of an embodiment of a buffer roller;

Figure 14 is a schematic of an embodiment of a polymer solution mixing system;

Figure 15 is a schematic depicting locations of various sensors and controls of a solution casting system according to one embodiment;

Figure 16 is a table listing descriptive information of the sensors shown in Figure 15;

Figure 17 is a continuation of the table of Figure 16;

Figure 18 is a screen shot of an embodiment of a controller of a solution casting system showing the controls of the solution valves;

Figure 19 is a screen shot of an embodiment of a controller of a solution casting system showing a trend chart of film tension over time; and

Figures 20-24 are screen shots of an embodiment of a controller of a solution casting system showing setup, run mode, alarm, maintenance, and recipe management screens.

**Detailed Description**

It is desirable to provide a means for automatically controlling different devices
in a solvent band casting system. Described herein is a system controller that can be connected to any of several devices in a band casting system, and that can control and/or monitor the operation of such devices. A preferred embodiment of such a band casting system includes a mixing system, a band casting machine comprising at least first and second rotating drums about which a continuous metal band is tensioned and travels with the rotation of the drums, a polymer applicator such as an adjustable sheeting die or other device used for applying the polymer solution from the tank to the metal band, a drying chamber enclosing at least a portion of the metal band downline of the sheeting die, wherein the drying chamber comprises at least one heater for directing a flow of heated air counter-current to the travel of the metal band, a surfactant applicator in communication with a supply of surfactant and a portion of the metal band, and a buffer configured to pivotally abut the metal band. The system controller can be connected to the mixing system, the band casting machine, the sheeting die, the drying chamber, the surfactant applicator, and/or the buffer, to control and/or monitor each device.

The solution cast process offers several unique features which conventional fusion processes lack. In solvent casting, film formation depends upon solubility, not melting. Thus, a wide range of polymeric alloys can be produced by solvent casting. Because the flowability to form a film is provided by the solvent, a pure resin film can be manufactured without adulteration by heat, stabilizers, plasticizers or lubricants. Only additives which are beneficial to the finished product need to be incorporated with the polymer.

Solvent casting can provide a film which has excellent dimensional stability as well as reduction in or freedom from pinholes, gels and other imperfections. Due to the very low heat history which is inherent in a film produced by solvent casting processing, the process can also provide an extended service life to the film.

Additional advantages of the present method, apparatus and system relate to film quality. Film bubbles and pinholes can be detrimental to many film uses. Various aspects of the system disclosed herein not only allows for the reduction in the frequency and dimensions of such blemishes, but also can sense and index any such occurrences.

Referring generally to the appended figures 1 to 24, a process of and system for manufacturing a film using the system described herein can be more readily understood. The disclosed solvent casting system is generally referenced by the number "10" in the following disclosure and drawings. Other components are similarly and consistently numbered throughout the specification and drawings. While the embodiments disclosed herein are described for use with a particular continuous band casting machine, such as, for example,
those designed and manufactured by Berndorf Belt Systems, Inc. of Carpentersville, Illinois, other such band casting machines are be capable of adaptation for implementation of the described system.

The general components of the system can be described with reference to Figure 1. The embodiment of a solvent band casting system 10 begins with a mixing system 12 for mixing and storing a polymer solution. The mixing system 12 can be a single tank, or in a preferred embodiment may comprise a plurality of tanks and attendant piping, pumps and valves to control the flow of the polymer solution among the tanks. Proximate the mixing system 12, a band casting machine 14 is shown including first and second rotating drums 16 and 18, respectively, about which a continuous loop of metal band 20 is tensioned and travels with the rotation of the drums 16, 18. Operation of the mixing system 12 can be monitored and controlled by a control system 36.

A sheeting or casting die 22 (or other coating device) is used to apply the polymer solution from the mixing system 12 to the metal band 20 of the casting machine 14. A feed line 13 connects the mixing system 12 to the die 22 and is used to feed the polymer solution from the mixing system 12 to the die 22. The die 22 (see Figure 7) comprises an internal chamber (not shown) and a slot-shaped orifice 11 extending across the width of the die 22. The gap (e.g., determined by an adjustable vertical dimension) of the orifice 11 is variable across the width of the die 22 and is used to assist in controlling the thickness of the film produced by the casting system 10. The gap can be monitored and/or adjusted by the control system 36 as indicated schematically in Figure 7.

A drying chamber 24 (see Figures 1 and 9) is shown enclosing a portion of the loop of metal band 20 downline of the sheeting die 22. The drying chamber 24 of the present embodiment comprises an upline zone 26 and a downline zone 28. Each zone 26, 28 includes a heater (burner) 30 located near an air inlet 32 and an exhaust blower 34 located near an air outlet 38. The portion of the metal band 20 within the drying chamber 24 at any given time, travels over and is supported by a series of support rollers or idlers 40. The embodiment shown in Figure 1 includes a series of idlers 40 representing the combination of idlers and associated sensors for monitoring rotation of the idlers.

A take-up winder 60 (see Figure 10) is used to gather the film as it is removed at the end drum (tail drum) 18. Before reaching the take-up winder 60, however, the film is checked for gauge at a scanner 42. A trim winder 64 (see Figure 11) is also shown and is used to recover edge film 68 cut from the take-up roll.

Referring to Figures 1 and 2, at the underside 23 (also called the return side) of
the loop of metal band 20, a surfactant applicator 90 is positioned to apply surfactant to the outer surface of the metal band 20. Also at the underside 23 of the loop of metal band 20, a buffer 34 is configured to pivotably abut the metal band 20. Finally, the system controller 36 is shown, wherein the operation of at least one of the mixing system 12, the band casting machine 14, the sheeting die 22, the drying chamber 24, the take up winder 60, the trim winder 64, the surfactant applicator 90, and the buffer 34 is monitored and/or controlled by the system controller 36. The system controller 36 is described in further detail below.

"Bubble-free" is a term applied to a film product having a bubble count (e.g., air bubbles) less than a given threshold based on an optical (e.g., visual) inspection of a one square yard sample of the film. For the system described herein, in a bubble-free film the number of bubbles of less than 25 microns in diameter will not exceed 50 in the one square yard sample film. Optionally, the number of bubbles within the range of 25 to 40 microns will not exceed 10. Further optionally, there will be no bubbles of greater than 40 microns in the sample film. When a manual inspection method is used to determine when a film is bubble-free (e.g., inspection of one square inch samples under magnification), then a method employing statistical sampling from a one square yard sample (e.g., 14 different one square inch locations) can give an approximation of the total number of bubbles in the full sample.

"Upline" refers to the chronological operating position of a component on the film production line which is prior to a reference point.

"Downline" refers to the chronological operating position of a component on the film production line which is after a reference point.

"Line" is the collective sequence of production components utilized by an embodiment of the system.

"On-line" is an operating condition of the casting system where film, though not necessarily a marketable product, is being produced.

"Polymer solution" refers to any substantially homogeneous mixture of a polymer dissolved in a suitable solvent. The disclosed system is ideally suited for a polyvinyl alcohol (PVOH) dissolved in water. The water content of the PVOH solution is preferably within the range of from about 60% by weight to about 85% by weight. While other polymer solutions are suitable for use with the disclosed system, the description of the embodiments herein is made with specific reference to the manufacture of PVOH film for packaging.

Because there are so many chemically different types of products to be packaged, packaging films are formulated in different ways. That is, a PVOH resin, plasticizer system and other ingredients can vary and can provide a range of films with different product
compatibility characteristics. One or more different films may be suited to a particular application, with a suitable film grade easily predictable based upon compatibility testing.

“Water soluble” refers to a film which, when exposed to water, begins to dissolve or disintegrate to its smallest components. Polyvinyl alcohol (PVOH) is a hydrophilic polymer and the plasticizers typically used in its manufacture also have an affinity for water. PVOH will absorb moisture from a wet atmosphere and give up moisture to a dry atmosphere. As moisture content increases (even with humidity), a PVOH film will tend to quickly become softer and more elastic, losing tensile properties and increasing in ultimate elongation. Also, the coefficient of friction of a PVOH film will increase with increased moisture content.

The components and operation of a preferred solvent band casting system and controller system 36 are further described below.

MIXING SYSTEM

The polymer solution that is eventually cast onto the band 20 must first be mixed. The mixing takes place in the mixing system 12 (see Figure 1). In the embodiment shown, the mixing system 12 includes a bulk handling station 44, a mixer 46 having a mix tank 72 (see Figure 14), a hold tank 48 and a run tank 50. The bulk handling station 44 (shown schematically in Figure 1) is used for holding the raw ingredients for the desired solutions. These ingredients can include various resins, polymers, plasticizers, and other additives. Accordingly, the bulk handling station 44 can include a number of vessels or tanks, each corresponding to one or more different ingredients. Each of the tanks or vessels is in flow communication with the mixer 46 for transporting the desired ingredients into the mix tank 72. Additionally, the various ingredients may be manually fed into the mix tank 72. The selection and metering of each ingredient preferably is controlled by the control system 36.

The mixer 46 (see Figures 1 and 14) includes a mix tank 72 having an outer inner wall 88 and an outer wall 86 defining a steam jacket 89, through which steam or hot water is circulated for purposes of controlling the temperature within the mix tank 72. The inner wall 88 further defines a chamber 87 wherein the mixing takes place. The mixer 46 also includes a mix motor 78, a mixer shaft 74 and a plurality of mixing blades 76. The various mixing blades 76 on the mix shaft 74 provide a combination of high shear mixing and vertical movement of the solution to promote mixing. The mix shaft 74 and blades 76 are centrally located within the housing and are operably connected to the mix motor 78. For the solutions in this embodiment, the motor 78 must be a powerful one of at least about 150 horsepower. A suitable motor can be obtained from Morehouse-Cowles of Fullerton, California. The means of delivering the ingredients to the mix tank 72 and means of delivery of the solution can
include piping 80 and 13, respectively, between source and destination in combination with various pumps, as is well known in the art.

The overall process and desired parameters preferably are monitored and/or adjusted by the controller 36. The process begins by filling or charging the mix tank 72 with water and a variety of components that can include plasticizers, flattening agents, surfactants, and the like. These ingredients may need to be added at different moments of the mixing process due to their potential affect on viscosity, interactions, and targeted characteristic of the product desired. The quantity of water can impact both the mixing process as well as the quality of the product produced. Temperature of the solution or suspension is maintained within a controlled range to promote efficient dispersion of the resin. The polymer resin is then added under rapid agitation effected by the mixing blades 76. Varying amounts of water may be added throughout the resin addition to assist in the mixing process.

After the resin has been added, the tank temperature set point is adjusted to accelerate dissolution of the resin. As the resin dissolves, viscosity will increase making it necessary for a controller 84 to adjust the speed of the mix motor 78 to maintain adequate solution movement without causing damage to the solution or mix tank 72. In one embodiment, a programmable inverter drive is used to automatically adjust mixer speed in response to changes in the solution viscosity. While the controller 84 is shown as an independent controller in this embodiment, the system controller 36 can optionally monitor viscosity (or some proxy thereof) and adjust the speed of the mix motor 78.

In another embodiment, a programmable temperature controller is also used in conjunction with the controller 36 to control heat transfer into and out of the mixing tank 72. Temperature control is useful for accelerating resin dissolution while preventing damage to resin, which could be caused by overheating.

The amount of time required to produce a batch of finished solution depends on the size of the batch and the type of resin. The finished batch is then pumped out of the mix tank 72 to a hold tank 48 or a run tank 50, but typically to a hold tank 48. The transfer of ingredients into mix tank 72 as well as the transfer of solution among the mixing tank 72, the hold tank 48, run tank 50 and die 22 preferably are monitored and controlled by the control system 36.

The hold tank 48 is typically used to hold the solution to allow bubbles (e.g., air bubbles) and other imperfections (such as gels or affects due to temperature variation) to rise to the top and be separated from the solution. This preferably occurs while the solution is undergoing mild agitation to maintain the solution. Typically, the hold tank 48 is maintained
at a temperature of 185 °F (85 °C) through use of a water or steam jacket to prevent coagulation. Other heating methods are acceptable. An agitator or stirrer (not shown) may also help minimize coagulation of the solution and maintain uniform temperature throughout the tank. Both the temperature and the agitation preferably are monitored and controlled by the controller 36. A feed line 13 runs from the hold tank 48 to the run tank 50, from where it is pumped to the extrusion die 22 for casting onto the band 20. A filter 47 may be placed between the hold tank 48 and the run tank 50, or between the run tank 50 and the die 22, or both places.

**BAND CASTING MACHINE**

The band casting machine 14 is further understood with reference to Figure 2. The casting machine 14 is comprised of a first or lead drum 16 and a second or end drum 18 around both of which is wrapped a continuous metal band 20. The drums 16 and 18 travel in the direction indicated by the arrows, imposing a similar revolution of the band 20. In a preferred embodiment, the drums are approximately 65 inches wide and 48 inches in diameter, and the band 20 is approximately 61 inches wide with a circumference of approximately 325 feet. A suitable band casting machine is manufactured by Berndorf Belt Systems, Inc. of Carpentersville, Illinois.

The first or lead drum 16 is preferably hollow to allow for pre-heating the band 20 prior to coating with or casting the polymer solution. The second or end drum 18 is preferably cooled to assist removal of the final film product (see Figure 3).

Extending about lead drum 16 and end drum 18 is a continuous loop of metal band 20. As configured in the figure, the loop has a production or upper portion 21 and a return or under portion 23. The outer surface 25 of the band is used to support the applied polymer solution during drying. A plurality of idlers 40 (see Figures 1 and 9) may be spaced along the underside of upper portion of the band 20 to provide support of the band 20. The idlers 40 may also be monitored by the control system (e.g., by position sensor for monitoring rotation), to determine movement of the band 20. As the band 20 can be a very expensive piece of equipment, any complications of production which might tend to damage the band 20, such as an idler that stops rotating (e.g., resulting in the band being dragged across the idler or guiding the band off the edge of the drums 16, 18) can be avoided by monitoring and taking appropriate control action.

The band 20 will travel from a temperature of about 125 °F at the lead drum 16 to a temperature of about 215 °F at the end drum 18. These temperature changes can have an effect on the tracking of the band 20 on drums 16 and 18. As the dimensions of the band 20
change -- even incrementally due to heating or cooling -- the band 20 can begin to run off one end of a drum. Accordingly, the band preferably is made of stainless steel to address the varying thermal gradient of the system existing between the lead drum 16 and the end drum 18. Other metals, alloys, plastics, or rubbers, having desired thermal expansion parameters may also be suitable for construction of a casting band 20.

In further addressing the fluctuation of the band size due to thermal expansion, a feature of one embodiment of the present solvent band casting system is the incorporation of a band tensioning mechanism. The tensioning mechanism is used to maintain a substantially constant tension across the width of the band 20 to control tracking around the drums 16 and 18. In one embodiment, shown in Figure 4, the end drum 18 is attached to a movable skid or sled 19. The skid 19 is responsive to a mechanism (e.g., a gear, cylinder, or the like) to move in the direction of the arrows shown in Figure 4. Only one side of the skid 19 need move to control the band 20 tracking; however, both sides may be made capable of movement, if desired.

In a preferred embodiment, the movement of skid 19 is directed by a pair of sensors 17a and 17b and a comparator 15, as illustrated in Figure 5. A first sensor 17a continually detects an edge of the band 20, while a second sensor 17b continually detects a stationary reference. The comparator 15 compares the two signals generated by the sensors. When the band 20 begins to drift the signals are unequal and the comparator 15 sends a correcting command to the mechanism to reposition the skid 19 until the signals are brought back into equality or alignment. The sensors 17a and 17b preferably are monitored by the control system 36. In such an embodiment the control system 36 includes a comparator routine, and the control system 36 sends a correcting signal to the mechanism to reposition the skid 19. In one embodiment, the edge of the band will be monitored from the side, to detect sag of the band in the vertical direction. In another embodiment, the edge of the band will be monitored from a plan viewpoint above or below, to monitor lateral drift of the band.

A second tensioning mechanism may be used to supplement or replace the above-described mechanism. In the embodiment of Figure 6, a tilt roller 31 (see also Figure 1) is used to engage the band 20 along the return side. This mechanism allows the band tracking on the lead drum 16 to be monitored as well. The lead drum 16 typically cannot be easily moved like end drum 18 due to the additional components of the system 10 which might be negatively affected by such movement. In any event, the tilt roller 31 is capable of independent vertical movement on either or both sides (see arrows of Figure 6), preferably to vary the tensioning of the band 20 and prevent edge runoff at lead drum 16. The vertical
movement of the tilt roller 31 preferably is monitored and controlled by the control system 36. Any number and combination of such tensioning mechanisms may be used to assist tracking the band 20.

POLYMER SOLUTION APPLICATOR

The process of solvent casting begins with the application of a layer of polymer solution onto the band surface 25. This is accomplished by the use of polymer solvent applicator such as an extrusion die 22 or other coating device. A suitable die 22 is commercially available from Extrusion Dies Inc. of Chippewa, Falls, Wisconsin or Cloeren Incorporated of Orange, Texas. The die 22 coats (deposits) a continuous curtain of polymer solution across the width of the band 20. The die 22 (see Figure 7) includes an internal channel (not shown) through which the solution flows. At the end of the channel is a slot-shaped orifice 11 which extends across the width of the die 22. An upper surface of the slot is formed by a lip 53 and is deformable with respect to a lower surface 55 of the slot to allow for changes to be made to the dimensions of the slot opening 11. A series of threaded bolts 52 across the width of the die are used to vary the dimensions of the slot opening depending upon the direction of rotation of the bolts. Additionally, the bolts 52 may be heated or cooled to control the thickness of the slot 11. The controlled expansion and contraction of the bolts can vary the dimensions of the slot 11. Some of the parameters which affect the film quality and thickness can be addressed at the die, including the die gap, die pressure, and angle of incidence to the band surface. Those skilled in the art are readily able to make the proper adjustments to achieve a desired film quality and thickness. An extrusion die is the preferred embodiment, however other devices may be used to apply the polymer solution to the band surface.

In one embodiment, the die 22 is controlled automatically. The die 22 is capable of adjustment in response to a downline film scanner 42. The scanner 42 measures the film thickness across the width, which is relayed to a computer screen for visual display. An operator can set maximum and minimum limits on the film thickness for quality control. If any scanner readings exceed these limits, then one or more adjustments can automatically (or manually) be made to the die 22 to return to acceptable operating conditions.

VACUUM BOX BLOWER

A vacuum box blower 54 and a vacuum box 51 are positioned adjacent to the automated die 22 (see Figure 8) to create a lateral pull of the film solution onto the band 20 to counteract the natural tendency of the rotating band to pull the solution out of or away from
the die 22. Preferably, the vacuum created by blower 50 is within the range of about 7.0 to 18.0 inches water column. More preferred is a range of about 9.0 to 15.0 inches. The blower speed is variable, but 50 Hz is a recommended starting point to assist in bubble prevention. A suitable vacuum box blower is commercially available from Cincinnati Fan Manufacturers of Cincinnati, Ohio and a suitable vacuum box is commercially available from Cloeren Incorporated of Orange, Texas.

DRYING CHAMBER

Downline from the sheeting die 22, and encasing a portion of the band 20, as shown in Figure 9, is a drying chamber 24. The drying chamber 24 includes two zones 26, 28, either of which can be represented by Figure 9. Each zone 26, 28 includes a heater 30 located near an air inlet 32 proximal to the downline end of the zone 26, 28. The heaters 30 are adapted for introducing heated air into the drying chamber 24. Each zone 26, 28 also includes an exhaust blower 34 located near an air outlet 38 proximal to the upline end of the zones 26, 28. The heater 30, air inlet 32, air outlet 38 and blower 34 all combine to produce a heated air flow within the drying chamber 24 in each zone 26, 28.

The heated air flow is directed in a counter-current flow to the band direction, as described and shown in the figures, though other arrangements may be useful in other embodiments. Preferably, the air inlets 32 in the present embodiment are configured to create and control a turbulent flow as the heated air is discharged. Baffles, either fixed or adjustable, can be installed to further control air flow. Such features can provide a more efficient drying of the film. Preferably, the heated air flows across both the upper surface 25 and the under surface of the production portion 21 of the band 20 as it moves through the drying chamber 24. Finally, infrared heating elements, either inside the drying chamber or outside, can be used to further increase the drying capacity of the system.

The drying chamber 24 preferably covers a substantial length of the band 20 between the lead and end drums, 16 and 18. The chamber 24 preferably is made of an insulated sheet metal body, and can have periodically-spaced temperature sensors (such as thermocouples 29) and moisture vapor sensors, to monitor chamber temperatures and humidity (e.g., relative humidity). The thermocouples 29 preferably are be connected to the control system 36 to allow automatic monitoring. For maintenance purposes, trap doors 39 preferably are provided on the top of the chamber 24. The idlers 40 are seen to extend from the chamber 24 to provide a visual guide regarding band movement. A suitable drying chamber is commercially available from Feco of Cleveland, Ohio.
WINDERS

At the end drum 18, the dried film material is removed (in any conventional manner) from the drum 18. The temperature of the removed film can be measured with a suitable sensor, such as an infrared sensor. A take-up winder 60 can be used to spool the finished film product, as shown in Figures 10 and 11. For quality assurance purposes, the formed film roll should be of good uniform size with flat edges and no gauge bands. As mentioned above, a film scanner 42 may be used to monitor film thickness or gauge. The scanner 42 preferably is implemented just after the point of film removal from the end drum 18. A preferred film scanner 42 is commercially available under the trade name ADVANZ from ADVANZ Measurement and Control.

Another inspection component of the system is the camera system 62, shown in Figure 10, positioned in this embodiment to observe the film after it has been taken off the end roll 18. The camera system 62 is designed to alert the operator to the presence of holes or other defects (such as gels, bubbles, dark spots, slits, and “fish eyes”) in the film greater than 0.015" inch in diameter. When a hole is detected, a light (not shown) above the take-up winder 60 will illuminate and an audible alarm may sound. Other visual and audible alerts may be used. The camera 62 preferably is also monitored by the control system 36. An operator can then inspect the roll on the machine to verify the presence of a hole and its location. A film segment containing the hole can then be marked for customer notification or the segment may be removed and recycled or disposed of.

Still referring to Figure 11, the take-up winder 60 has several available options. For commercial film product approximately one inch is trimmed from each edge of the film. This trim can be taken up on a separate trim rewinder 64 to be later dissolved and recast. The trim rewinder 64 is preferably a dual winding system. That is, the trim rewinder 64 includes two trim spools 61, 63, each having its own dedicated magnetic clutch (not shown) internal to the rewinder 64. The clutches permit an identical and constant tension to be maintained in the film being trimmed and wound on the trim spool, regardless of the diameter of the trimmed film wound on each spool 61, 63 at any given moment. The control system 36 preferably monitors the tension and adjusts the clutch mechanisms accordingly to control the tension. A preferred trim re-winder is commercially available from LML Automated Systems of Burns Harbor, Indiana.

The film can also be slit by blades or slitters (not shown) while being taken up on take-up winder 60. The placements of slits are set to correspond to desired film widths, leaving as little waste film as possible. The final roll of film may be separated into smaller roll
sizes at any later time.

The final film preferably is substantially free of bubbles. If the number of bubbles is excessive (see definition above), the process can be adjusted to reduce the frequency. Adjustments to reduce or eliminate bubbles include vacuum box blower speed, line speed, drum temperature, amount of band coating applied (see section on “Surfactant Applicator” below), drying chamber temperatures, solution temperatures, and the like.

SURFACTANT APPLICATOR

Referring to Figure 12, the return portion of the band 20 is illustrated. A surfactant applicator (in one embodiment, a roll coater) 90 is positioned to apply surfactant to the outer surface 25 of the band 20. Without being bound by any particular theory, it is believed that a surfactant, or combination of surfactants, can have one or more functions including (1) acting as a release agent for more cleanly and easily releasing film product from the band and (2) acting as a wetting agent to more thoroughly wet out the polymer liquid on the band and thereby reduce or eliminate bubbles or other imperfections. It is believed that some surfactants can fill in or smooth out minor imperfections in the band surface, thus improving wet-out of the polymer liquid. In a preferred embodiment, a rubber roll 33 pivotally abuts the band 20 and applies a thick layer of surfactant prior to a pad 35 (e.g., felt), which is adapted to remove excess surfactant. The rubber roll 33 communicates with a trough 37 which runs the width of the band 20. The surfactant applicator preferably is in communication with the band at all times during operation. The surfactant applicator preferably is upline of the buffer 66.

The preferred surfactant is a solution of ZONYL FSP commercially available from E.I. du Pont de Nemours and Company. A range of from about 0.05% by weight to about 5.0% by weight of ZONYL FSP surfactant is preferred. Other surfactants and wetting agents can be used for producing a substantially bubble-free film, including non-ionic surfactants, hydrocarbon surfactants, silicone surfactants, polysiloxane surfactants, other fluoro surfactants, and surfactants compatible with aqueous systems. For some products, even using water to wet the band can have a surfactant effect, assisting in wetting out the polymer solution on the band and reducing the occurrence of bubbles. In one embodiment, the surfactant includes one or more surfactants the same as those employed in the formulation of the polymer film. The surfactant applicator 90 need not be monitored or controlled by the system controller 36, but can be if desired.
ON-LINE BUFFER

The final area of the solvent casting system 10 is an on-line buffer 66 (see Figure 13). The buffer 66 is comprised of a bristled brush of approximately the same width as the band 20. The brush is preferably a hollow-bristled, metal brush. A suitable brush is commercially available from Osborn International of Cleveland, Ohio. However, several alternative bristle designs are suitable, including those commercially available from Power Brushes, Inc. of Toledo, Ohio. Alternative bristle designs include spiral wound and stacked. Any suitable material can be used, including one or more of copper, stainless steel, and polyester.

In a preferred operating sequence, the buffer 66 is initially “off-line” as film product is being made. However, at some point in time the band 20 may become contaminated with film residue or the like which may inhibit the quality of the film. At this time, the buffer may be brought on-line where, with a continuous quenching of water, the brush will rotate in contact with the band surface to strip away any such residue. While film preferably is produced during buffing (to avoid shutdown and startup of the casting process), such film may not be suitable for commercial use. Because buffing the band 20 on-line avoids all required procedures which must be followed for a line shut-down and start-up, the time savings can be as much as half the time otherwise necessary to buff the band off-line.

SYSTEM CONTROLLER

As a means for coordinating all the various components of the casting system, a system controller 36 may be used. From the tank mixing, drum speed, drying chamber temperatures, die gaps and temperatures and pressures, winder speed, and on-line buffing to the adjustment of the tensioning mechanisms, vacuum box blower speed, thermocouple sensors, film camera, and film gauge scanner, the system controller 36 may be employed to control each component to produce the highest quality film possible. In one embodiment, the system controller 36 is provided the initial input of operating parameters (e.g., set points or ranges for film gauge, temperatures, etc.) and then senses and acts to maintain such parameters at or within the acceptable preset ranges.

In the present embodiment, the system controller 36 uses PC-based Wonderware software and programmable logic controllers to monitor and control such process parameters as temperatures, speeds, pressures and others mentioned elsewhere in the present application. The process data preferably is stored in a database as an archive of specific running conditions for later use.
Figure 15 shows a schematic overview of the solution casting system 10. The numerals 1 to 41, all without leaders, represent various locations for sensors and controllers of the control system. Each of the sensors communicates with the PC-based software utilized by controller 36. The numbers in the left hand column of the table beginning at Figure 16 and continuing on Figure 17 correspond to the numbers of Figure 15 indicating sensor/controller locations. The second or middle column of the table of Figure 16 and 17 gives a description of each sensor/controller as relates to its position within the solution casting system 10. The third column of Figures 16 and 17 indicates whether the particular sensor/controller is a simple sensor, in that it only provides data to the controller 36, whether it is a controller, in that some parameter of the system 10 may be adjusted at said sensor/controller, or whether it some combination thereof.

Figures 18 to 24 show a series of screen shots from the preferred embodiment of the system controller 36. Figure 18 is a screen shot of the controller of a solution casting system showing the controls of the solution valves. Figure 19 is a screen shot of the controller showing a trend chart of film tension over time. Figures 20 to 24 show various other screen shots. Figure 20 is a screen shot of the controller showing the setup screen; Figure 21 shows the run mode screen; Figure 22 shows the alarm screen of the controller; Figure 23 is a screen shot of the maintenance screen; and Figure 24 depicts the recipe management screen.

The foregoing description is given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications within the scope of the invention may be apparent to those having ordinary skill in the art. Throughout the specification, where the system is described as including components or process steps, it is contemplated that they can also consist essentially of, or consist of, any combination of the recited components or steps, unless described otherwise.
What is claimed is:

1. A solvent band casting system, comprising
   a band casting machine comprising at least first and second rotating drums
   about which a continuous band is tensioned and travels with the rotation of the drums;
   a polymer applicator for applying a polymer solution to the band;
   a drying chamber enclosing a least a portion of the metal band downline of the polymer
   applicator, wherein the drying chamber comprises at least one heater adapted to direct a flow
   of heated air counter-current to the travel of the band; and
   a system controller adapted to monitor and/or control the operation of one or more
   band casting system components.

2. The solvent band casting system of claim 1, wherein the band is metal.

3. The solvent band casting system according to any one of the preceding claims, further comprising a mixing system for preparing the polymer solution.

4. The solvent band casting system according to any one of the preceding claims, further comprising a surfactant applicator in communication with a supply of surfactant and at least a portion of the band.

5. The solvent band casting system according to any one of the preceding claims, wherein the surfactant applicator is a roll coater, and further comprising an absorbent pad for removing excess surfactant.

6. The solvent band casting system according to any one of the preceding claims, further comprising a buffer configured to pivotably abut the band.

7. The solvent band casting system according to any one of the preceding claims, wherein the system controller is adapted to control the rotation of the drums.

8. The solvent band casting system according to any one of the preceding claims, wherein the polymer applicator is a sheeting die.

9. The solvent band casting system of claim 8, wherein the sheeting die is adjustable.

10. The solvent band casting system according to any one of the preceding claims, further comprising a vacuum box disposed in proximity to the polymer applicator and a
18
vacuum box blower, wherein the system controller is adapted to control the vacuum box blower.

11. The solvent band casting system according to any one of the preceding claims, further comprising a film gauge sensor, wherein the system controller is adapted to monitor the film gauge sensor and control the polymer applicator in response to the film gauge sensor.

12. The solvent band casting system according to any one of the preceding claims, wherein the system controller is adapted to control a drum temperature.

13. The solvent band casting system according to any one of the preceding claims, wherein the system controller is adapted to control a downline drum temperature in response to a film temperature sensor.

14. The solvent band casting system according to any one of the preceding claims, comprising a plurality of drying zones.

15. The solvent band casting system according to any one of the preceding claims, wherein the drying chamber comprises a plurality of thermocouples, and wherein the system controller is adapted to monitor the thermocouples and control the heater in response to the thermocouples.

16. The solvent band casting system according to any one of the preceding claims, wherein the drying chamber comprises a heater and a plurality of moisture vapor sensors, and wherein the system controller is adapted to monitor the moisture vapor sensors and control the heater in response to the thermocouples.

17. The solvent band casting system according to any one of the preceding claims, wherein the band casting machine further comprises a plurality of idlers and a plurality of position sensors, wherein the system controller is adapted to monitor rotation of the idlers via the position sensors.

18. The solvent band casting system according to any one of the preceding claims, further comprising a sensor for monitoring the band position and a skid for moving a downline drum, wherein the system controller is adapted to monitor the band position and control the skid in response to the sensor.
19. The solvent band casting system according to any one of the preceding claims, further comprising a sensor for monitoring the band position and a tilt roller for moving a downline drum, wherein the system controller is adapted to monitor the band position and control the tilt roller in response to the sensor.

20. The solvent band casting system according to any one of the preceding claims, further comprising a camera disposed downline of the band for monitoring film quality and adapted to alert an operator to the presence of imperfections exceeding a specified threshold.
FIG. 14
<table>
<thead>
<tr>
<th>DEVICE</th>
<th>DESCRIPTION</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TENSION</td>
<td>DATA POINT</td>
</tr>
<tr>
<td>2</td>
<td>TENSION</td>
<td>DATA POINT</td>
</tr>
<tr>
<td>3</td>
<td>STRIP TEMP</td>
<td>TEMPERATURE / DATA POINT</td>
</tr>
<tr>
<td>*4</td>
<td>STRIP ROLL</td>
<td>TEMP. / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>*5</td>
<td>TAIL DRUM</td>
<td>TEMP. / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>*6</td>
<td>ZONE 2 BURNER</td>
<td>TEMP / SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>7</td>
<td>ZONE 2 BURNER</td>
<td>TEMP / 2 POINTS / DATA</td>
</tr>
<tr>
<td>8</td>
<td>ZONE 2 CENTER</td>
<td>TEMP / 2 POINTS / DATA</td>
</tr>
<tr>
<td>*9</td>
<td>ZONE 2 EXHAUST</td>
<td>TEMP / SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>10</td>
<td>ZONE 2 EXHAUST</td>
<td>TEMP / 2 POINTS / DATA</td>
</tr>
<tr>
<td>*11</td>
<td>ZONE 1 BURNER</td>
<td>TEMP / SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>12</td>
<td>ZONE 1 BURNER</td>
<td>TEMP / 2 POINTS / DATA</td>
</tr>
<tr>
<td>13</td>
<td>ZONE 1 CENTER</td>
<td>TEMP / 2 POINTS / DATA</td>
</tr>
<tr>
<td>14</td>
<td>ZONE 1 EXHAUST</td>
<td>TEMP / 2 POINTS / DATA</td>
</tr>
<tr>
<td>*15</td>
<td>ZONE 1 EXHAUST</td>
<td>TEMP / SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>*16</td>
<td>LINE DRIVE</td>
<td>READ OUT (SPEED) / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>*17</td>
<td>CASTING DRUM</td>
<td>TEMP / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>18</td>
<td>ITEMS 18-23</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*20</td>
<td>DIE HEAD</td>
<td>TEMP / CONTROL / 5 DATA POINT</td>
</tr>
<tr>
<td>21</td>
<td>5 ZONES</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>DIE HEAD PRESSURE</td>
<td>PRESSURE / DATA POINT</td>
</tr>
<tr>
<td>*24</td>
<td>DIE HEAD VACUM</td>
<td>READ OUT / CONTROL / DATA POINT</td>
</tr>
</tbody>
</table>

*CONTROL AT MAIN CONTROL PANEL AND PC
ALL OTHER POINTS WILL BE COLLECTED AND STORED IN AN ACCESS DATA BASE

WILL BASE PUMP SPEED ON THIS POINT
<table>
<thead>
<tr>
<th>DEVICE</th>
<th>DESCRIPTION</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>FILTER PRESSURE</td>
<td>DATA POINT</td>
</tr>
<tr>
<td>*26</td>
<td>PUMP SPEED</td>
<td>PUMP SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>27</td>
<td>PUMP PRESSURE</td>
<td>PRESSURE / DATA POINT</td>
</tr>
<tr>
<td>*28</td>
<td>AGITATOR</td>
<td>SPEED / CONTROL</td>
</tr>
<tr>
<td>29</td>
<td>TANK LEVEL</td>
<td>LEVEL / DATA POINT</td>
</tr>
<tr>
<td>*30</td>
<td>PUMP SPEED</td>
<td>PUMP SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>31</td>
<td>PUMP PRESSURE</td>
<td>PRESSURE / DATA POINT</td>
</tr>
<tr>
<td>*32</td>
<td>AGITATOR</td>
<td>SPEED / CONTROL</td>
</tr>
<tr>
<td>33</td>
<td>TANK LEVEL</td>
<td>LEVEL / DATA POINT</td>
</tr>
<tr>
<td>*34</td>
<td>PUMP SPEED</td>
<td>PUMP SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>35</td>
<td>PUMP PRESSURE</td>
<td>PRESSURE / DATA POINT</td>
</tr>
<tr>
<td>*36</td>
<td>AGITATOR</td>
<td>SPEED / CONTROL</td>
</tr>
<tr>
<td>37</td>
<td>TANK LEVEL</td>
<td>LEVEL / DATA POINT</td>
</tr>
<tr>
<td>*38</td>
<td>PUMP SPEED</td>
<td>PUMP SPEED / CONTROL / DATA POINT</td>
</tr>
<tr>
<td>39</td>
<td>PUMP PRESSURE</td>
<td>PRESSURE / DATA POINT</td>
</tr>
<tr>
<td>*40</td>
<td>AGITATOR</td>
<td>SPEED / CONTROL</td>
</tr>
<tr>
<td>41</td>
<td>TANK LEVEL</td>
<td>LEVEL / DATA POINT</td>
</tr>
</tbody>
</table>

*CONTROL AT MAIN CONTROL PANEL AND PC
ALL OTHER POINTS WILL BE COLLECTED AND STORED IN AN ACCESS DATA BASE
Please select the valve that you would like to open or close.

To take FULL CONTROL of ALL of the valves for the specific tank it must be placed in Idle Mode. This is not a bypass for the current tank mode.

Tank 22 Valves
Tank 23 Valves
Tank 24 Valves
Tank 25 Valves

Mono-Sol, LLC
Valve Screen

Development
File Logic
Line 3: Wonderfarm - Ltd. Automated Systems
FIG. 21

Mono-Sol, LLC
Maintenance
Motor Runtime Screen

Vacuum Motor
Total Runtime Since Last Maintenance
54 Days, 6 Hours, and 10 Minutes
Reset

Tank 22 Pump
Total Runtime Since Last Maintenance
55 Days, 11 Hours, and 52 Minutes
Reset

Tank 23 Pump
Total Runtime Since Last Maintenance
56 Days, 10 Hours, and 56 Minutes
Reset

Tank 24 Pump
Total Runtime Since Last Maintenance
7 Days, 9 Hours, and 21 Minutes
Reset

Tank 25 Pump
Total Runtime Since Last Maintenance
55 Days, 21 Hours, and 54 Minutes
Reset

Line Motor
Total Runtime Since Last Maintenance
53 Days, 9 Hours, and 50 Minutes
Reset

Maintenance Checklist

Zone 1 Exhaust Motor
Total Runtime Since Last Maintenance
17 Days, 9 Hours, and 8 Minutes
Reset

Zone 1 Blower Motor
Total Runtime Since Last Maintenance
53 Days, 9 Hours, and 8 Minutes
Reset

Zone 2 Exhaust Motor
Total Runtime Since Last Maintenance
55 Days, 8 Hours, and 26 Minutes
Reset

Zone 2 Blower Motor
Total Runtime Since Last Maintenance
54 Days, 10 Hours, and 49 Minutes
Reset

Alarm Log
Overview
Tanks

Unit 5 Wonderfuel - UFL Automated Systems
Film Logic
10/19/2001
10/27/06

SUBSTITUTE SHEET (RULE 26)
## FIG. 23

### Mono-Sol, LLC

#### Maintenance Service Checklist Screen

<table>
<thead>
<tr>
<th>Equipment to Service</th>
<th>Type of Service</th>
<th>Date of Last Service</th>
<th>Service By</th>
<th>Click to Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing Pumps</td>
<td>Check Packing</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check Routine</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>Check Lubrication</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Die Head</td>
<td>Process Specifications</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Head Drum &amp; Tail Drum</td>
<td>-Inspect Steam Cooling System</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Visual Inspection</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Oven Rollers</td>
<td>-Grease</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Guiding System</td>
<td>-Inspect Intake Filters</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Grease Bearings</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Grease Drum</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Rewind</td>
<td>Service According to Procedure</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Trim Wind</td>
<td>Manual</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>Inverters</td>
<td>-Clean Dirt</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Free Foreign Objects</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Grease Bearings</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Inspect Drive Belt</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
<tr>
<td>All Line #8 Motors</td>
<td>Manual</td>
<td>8/10/2001</td>
<td>Joe</td>
<td></td>
</tr>
</tbody>
</table>

---

(Coming Soon)
**FIG. 24**

Mono-Sol, LLC
Recipe Management Screen

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Recipe</th>
<th>Active Recipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 Blower</td>
<td>20.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Zone 1 Exhaust</td>
<td>34.00</td>
<td>31.01</td>
</tr>
<tr>
<td>Zone 2 Blower</td>
<td>20.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Zone 2 Exhaust</td>
<td>34.00</td>
<td>31.01</td>
</tr>
<tr>
<td>Zone 1 Temperature</td>
<td>520.00</td>
<td>555.00</td>
</tr>
<tr>
<td>Zone 2 Temperature</td>
<td>470.00</td>
<td>545.00</td>
</tr>
<tr>
<td>Line Speed</td>
<td>45.00</td>
<td>45.00</td>
</tr>
<tr>
<td>Die head Pressure</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Head Drum Temperature</td>
<td>190.00</td>
<td>220.00</td>
</tr>
<tr>
<td>Tail Drum Temperature</td>
<td>145.00</td>
<td>145.00</td>
</tr>
<tr>
<td>Vacuum Box Speed</td>
<td>50.00</td>
<td>69.51</td>
</tr>
<tr>
<td>Die Head 1 Temperature</td>
<td>185.00</td>
<td>185.00</td>
</tr>
<tr>
<td>Die Head 2 Temperature</td>
<td>185.00</td>
<td>185.00</td>
</tr>
<tr>
<td>Die Head 3 Temperature</td>
<td>185.00</td>
<td>185.00</td>
</tr>
<tr>
<td>Die Head 4 Temperature</td>
<td>185.00</td>
<td>185.00</td>
</tr>
<tr>
<td>Die Head 5 Temperature</td>
<td>185.00</td>
<td>185.00</td>
</tr>
<tr>
<td>Running Tank Temperature</td>
<td>185.00</td>
<td>180.00</td>
</tr>
</tbody>
</table>

Connection: No errors occurred
Insert: No errors occurred