A bulk transfer system that reduces piping complexity and that eliminates the possibility of connection errors occurring during the transfer of materials to a downstream destination. The bulk transfer system uses a Programmable Logic Controller (PLC) to verify that the correct output line is used. Further, the PLC sequences material draws such that it is possible to use fewer pumps to move the same amount of material to its destination.
### Material Data

<table>
<thead>
<tr>
<th>Material Number</th>
<th>Material Name (14 Chars Max)</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>aa</td>
<td>0.52C</td>
</tr>
<tr>
<td>2</td>
<td>bb</td>
<td>2.00C</td>
</tr>
<tr>
<td>3</td>
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<td>3.00C</td>
</tr>
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<td>4.00C</td>
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<td>6.00C</td>
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<tr>
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<tr>
<td>9</td>
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</tr>
<tr>
<td>10</td>
<td>jj</td>
<td>10.00C</td>
</tr>
</tbody>
</table>

**FIG. 23**

### Material Line Hookups

**FIG. 34**
SMART CONNECTION SYSTEM AND METHOD

FIELD OF THE INVENTION

[0001] This invention relates generally to devices, systems and methods used in the bulk products industry and has specific application in the plastic extrusion industry for the fabrication of extruded plastic products. More specifically, the claimed invention relates to a system and method for sequencing draws on a given plastic resin line used in an extrusion production set-up, thus preventing two vacuum pumps from pulling on the same line at the same time and eliminating the need for multiple resin lines for each ingredient. It also relates specifically to such a system and method where cross-checking of material connections can be made for desired resin blending, or "recipes."

BACKGROUND OF THE INVENTION

[0002] In the plastic extrusion industry, raw plastic material, called “resin” in the industry, is melted and formed into a continuous profile. Extrusion produces items such as piping, tubing, window frames, and the like. In the extrusion of plastics, raw thermoplastic materials in the form of small pellets of resin are used to make the plastic end-product. The pellets start out in a product supply container, such as a silo or gaylord box. A pneumatic system is used to move the plastic pellets from the supply container to one or more weigh hoppers. Pellets are dispensed from the weigh hoppers into a blende where pellets of different types, i.e. the “ingredients” for the recipe, and in predetermined quantities, are combined to produce the end product in accordance with the pre-determined product recipe. Additives such as colorants and ultraviolet inhibitors, for example, which are also distributed in pellet form, can be dispensed in like fashion.

[0003] Once blended, the ingredients enter the feed throat of a plastic extruder, the feed throat being disposed to one end of the extruder. The ingredients then come into contact with a rotating screw which forces the pellets through a barrel within which the screw is rotating. The barrel is heated to a desired temperature which allows the pellets to melt gradually as they are pushed through the barrel. Extra heat is contributed by the intense pressure and friction that takes place within the barrel. At the opposite end of the extruder barrel, the molten plastic enters a die, which gives the final product its profile. The plastic exits in continuous form to be cut in lengths or coiled, depending upon the end product desired.

[0004] In the extrusion molding system, as is also true with alternative methods of compression, transfer and injection molding, the raw material, i.e. the resin pellets, must be moved about and distributed as such is desired or required for processing. This is typically accomplished through the use of pneumatic systems having vacuum pumps that move the pellets through and along vacuum lines and the like.

[0005] The trend in the plastic extrusion industry today is to provide more layers and more additives for each “blend” or recipe that is used for the fabrication of a particular product. In the experience of this inventor, it is not uncommon for one extrusion line to have nine or more extruders with as many as six blend components at each extruder. Additionally, most extrusion processing factories are doing shorter runs which results in more product changeovers. The extrusion processors can run any of the ingredients in any of the extruders. As mentioned above, these ingredients typically come from either a silo or a gaylord box. It is common practice in the extrusion industry to run a common resin, or ingredient, line with drops to multiple locations. This industry trend presents some problems for plastic extrusion converting factories.

[0006] The first problem relates to piping complexity. When there are multiple vacuum pumps required on the extrusion line, both pumps can’t draw on the same resin line at the same time. Historically, there was no way of knowing which line was connected where and this presented a problem. The solution was to run a common resin line from each of the ingredient locations for every pump that was required on the extrusion line. Typical is two pumps and this means two sets of ingredient lines for each ingredient. There can be ten or more silo ingredients and fifteen or more box ingredients. This presents a piping challenge in both real estate and cost.

[0007] The second problem relates to connection errors. With the very sophisticated piping arrangements required for the applications mentioned above, there are literally thousands of combinations of connections that can be made, thus leaving room for human error. Errors can cost extrusion processors tens of thousands of dollars in waste and lost production time. The costs increase exponentially if a “bad” product, i.e. a product fabricated with incorrect ingredients, makes it to the end user or to another step of the converting process.

[0008] Other industries share similar problems related to complex piping arrangements and potential connection errors. The claimed invention obviously has broad application in many industries wherein bulk products are moved from one location to another and mixed together.

SUMMARY OF THE INVENTION

[0009] In view of the problems mentioned above, what is needed is a system and method that dramatically reduces piping complexity and that eliminates the possibility of connection errors occurring during the extrusion process. It is, therefore, a principal object of this invention to provide a new, useful and uncomplicated system and method that effectively solves both of the above-mentioned problems. The claimed invention has obtained this object. In accordance with the desired object, this inventor has devised a new, useful and non-obvious system and method that solves the two aforementioned problems of piping complexity and connection error.

[0010] The system and method of the claimed invention was designed to solve the requirement of multiple ingredient lines for an extrusion machine using a common ingredient line with multiple pumps servicing the extrusion machine. This relates to the “piping complexity” problem as described above. With the system and method of the claimed invention, a “programmable automation controller” (also known as a “programmable logic controller” or “PLC”) can recognize which ingredient is connected to which material line. The PLC then sequences draws on a given resin line, thus preventing two pumps from pulling on the same line at the same time. This eliminates the need for multiple resin lines for each ingredient (multiple as it relates to the number of vacuum pumps servicing the extrusion line).

[0011] The system and method of the claimed invention also solves the “connection error” problem mentioned above. Since the PLC knows which ingredient is connected to which blend component on which extruder, the PLC “logic” can perform a cross-check of the material connections versus the desired recipe.
While the discussion above has been devoted to the claimed invention’s application to the plastics industry, further uses of the claimed invention will be apparent from the detailed description that follows.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**0013** FIG. 1 is a plan view of an exemplary extrusion line installation using the system and method of the claimed invention.

**0014** FIG. 2 is a side elevational view of a portion of the system that is constructed in accordance with the claimed invention.

**0015** FIG. 3 is a graphical representation of a first user screen display that could be used with the system and method of the claimed invention.

**0016** FIG. 4 is a graphical representation of a second user screen display that could be used with the system and method of the claimed invention.

**0017** FIG. 5 is a detailed drawing of the male end of the smart connection hose.

**0018** FIG. 6 is a detailed drawing of the female end of the smart connection hose.

**DETAILED DESCRIPTION**

**0019** Referring now to FIG. 1, a possible configuration using the smart system and method of the claimed invention is shown in detail. FIG. 1 shows one possible installation of the smart system 10 at two levels. More specifically, FIG. 1 shows a high level extruding plant layout diagram with capacity for expansion.

**0020** FIG. 1 shows a system comprising twenty-four (24) sources for resin, twenty (20) being from silos 3 and four (4) from Gaylord bins 2, although the amount of resin sources employed is not a limitation of the claimed invention. Vacuum lines 4 from each silo 3 or Gaylord bin 2 direct product to a plurality of product lines. Each product line contains three smart systems 10. Each of the smart systems 10 shown has twenty-four (24) shared input lines and either six (6) or seven (7) output lines 30.

**0021** The output lines 30 direct bulk product from the smart system 10 to vacuum receivers 40. The vacuum receivers 40 provide short-term material storage. Each vacuum receiver 40 is connected, via conduit, to a pneumatic manifold 6. The pneumatic manifolds 6 are connected to vacuum lines 9 which are, in turn connected to vacuum pumps 2. In the given configuration, by sequencing draws on various lines, four (4) vacuum pumps maintain a supply of bulk product at seventy-six (76) vacuum receiver 40 locations.

**0022** The smart system 10 is controlled by programmable logic controller (PLC) (not shown) such that the vacuum receivers 40 each contain adequate supply of short term storage for eventual delivery to the blenders 7 to make an intermediate or final product. The PLC is in electronic communication with the pneumatic manifolds 6 as well as level sensors (not shown) within the vacuum receivers 40. When a level sensor detects a need for further bulk product, the level sensor sends a signal to the PLC which controls the appropriate pneumatic manifold to resupply the vacuum receiver 40.

**0023** Referring now to FIG. 2, it will be seen that one embodiment of a configuration using the smart system and method 10 of the claimed invention is illustrated in more detail. It is to be understood that alternative configurations could be used without deviating from the scope of the claimed invention and that the invention is not limited to the particular configuration shown. It should also be noted, however, that the claimed invention is designed for vacuum applications only, but could be easily reconfigured for pressurized applications.

**0024** The system and method of the claimed invention includes two components. The first component is the mechanical component. The second component is the electrical component.

**0025** As part of the mechanical design, there is a hose fed from the vacuum receiver station (or blender with integral vacuum receivers). This hose has a wire that feeds to the male end of the connection. The male end contains a termination point for the wire (this is the signal wire used by the PLC for determining that the connection is or is not made) and also the ground wire for the grounded resins flexible hose, or “flex hose.” It is common practice to ground the flex hose to prevent static electricity build-up. The system simply accounts for this in the connection as a standard precaution. The female end of the connection point is contained in a connection stand. The connection contains a device that makes electrical continuity with the male end for passing the signal. The female connection is then wired back to a junction box and fed back to the PLC.

**0026** With respect to the electrical component of the claimed invention, the PLC sends an output that feeds from the vacuum receiver side of the connection hose. That output is then received back to the PLC as an input. There is an input designated for each of the possible material connections. There is an output for each of the possible vacuum receivers. The PLC sequences through each output and determines which input turned on to determine the physical connections. This scenario is true for each of the possible extruders. There is a material manager screen where the user enters a list of materials and defines which ingredients are in which silo and which ingredient is in which box ingredient line. The PLC (which is controlling the pump sequencing) sequences draws on the material line preventing simultaneous draws on an individual line. The PLC also verifies the actual connections to the desired recipe. If they don’t match the system will alarm and can also provide a “lock-out” function to prevent the machine from running.

**0027** Referring again to FIG. 2, it will be seen that the embodiment of the system, generally identified 10, includes two hoses 30, 30a that are from the vacuum receiver station 40 (or blender with integral vacuum receivers) and are connected to it at one end 36. It is to be understood that any number of like-constructed flexible hoses could be used in this or other embodiments, the number of hoses not being a limitation of the claimed invention.

**0028** Each hose 30, 30a has a wire 31, shown in more detail in FIG. 5 that feeds to the male end 32, 32a of the connection 34, 34a. The male end 32, 32a contains a termination point for the wire 31. In this preferred embodiment, the connection is a shallow cup-like structure. Disposed within the center of the cup-like structure and extending outwardly from the bottom of the cup-like structure is the tube-like connection 34, 34a. Disposed between the outer perimeter of the tube-like connection 34, 34a and the lip of the cup-like structure of the male end 32, 32a is a conductive copper ring (also not shown). The termination point for the wire that is contained within the flex hose 30, 30a attaches to the copper ring at a point to make the copper ring part of the electrical continuum. The wire 31 within the flex hose 30, 30a is the
signal wire used by the PLC (not shown) for determining that the connection is or is not made and is also the ground wire for the grounded hose 30, 30a.

[0029] As shown in FIG. 6. The female end 23, 25, 27 of the wire connection point is contained in a connection stand or station 20. The wire connection point 50 comprises a device that makes electrical continuity with the copper ring of the male end 32, 32a for passing the signal. In the preferred embodiment illustrated, the connection stand includes a plurality of lines, including additive lines 22, resin lines 24 and silo lines 26. Here again, the precise number of such lines is not a limitation of the system and method of the claimed invention. It should be noted, however, that each line 22, 24, 26 corresponds to a female end 23, 25, 27, respectively, that is disposed within the face 21 of the station 20. In the preferred embodiment, the female connection is a small, spring-loaded bronze pin 51 which engages the copper ring of the male end 32, 32a of the hose 30, 30a, respectively, when the male end 32, 32a is properly secured. Also in the preferred embodiment, the female end 23, 25, 27 is a flange-like device that is covered by the cup-like male end 32, 32a of the hose 30, 30a when properly placed and connected. The female ends 23, 25, 27 also include a cylindrical bore 52 into which the tube-like connection 34, 34a of the male end 32, 32a is slidingly received, the cylindrical bore having a slightly larger inner diameter than the outer diameter of the tube-like connection 34, 34a. Means for securing the connection may be provided by, for example, spring clips (not shown) to either side of the flange at each female end 23, 25, 27. Other means for securing the connection could be provided without deviating from the scope of the claimed invention. For example, an "insert and turn" L-shaped bolt could be defined within the female end 23, 25, 27 as could other design alternatives known to those in the art. The female connection is then wired back to a junction box and fed back to the PLC.

[0030] As previously mentioned with respect to the electrical component of the claimed invention, the PLC sends an output that feeds from the vacuum receiver side 23, 25, 27 of the connection hose 30, 30a. That output is then received back to the PLC as an input. There is an input designated for each of the possible material connections. There is also an output for each of the possible vacuum receivers 40. The PLC sequences through each output and determines which input turned on to determine the physical connections. This scenario is true for each of the possible extruders 60 that would be used with the system and method of the claimed invention. There is a material manager screen (not shown), such as a touch-screen panel of known technology, where the user enters a list of materials and defines which ingredients are in which silo line 26 and which ingredient is in which box ingredient line 24. For example, the user screen display could identify any number of materials and associate each with a number, the number and material each having a unique name and specific gravity. The material number could be downloaded as part of the recipe download for each bin. The specific gravity could be optional. A typical screen display could appear, for example, as is shown in FIG. 2 and/or FIG. 3. The exact format of the screen display is not, however, a limitation of the claimed invention.

[0031] The PLC (which is controlling the pump sequencing) sequences draws on the material line 22, 24, 26 thereby preventing simultaneous draws on an individual line. The PLC also verifies the actual connections to the desired recipe. If they don't match, the system 10 will alarm the user that there is an improper connection. The system 10 can also provide a "lock-out" function to prevent the machine from running until the proper connection is made. The PLC would allow the material blending and extrusion process to commence only upon a proper sequence of material “hook-ups.” In this fashion, where very sophisticated piping arrangements are used for certain applications and where there are literally thousands of combinations of connections that can be made, there is no room for human error. Errors that could otherwise cost extrusion processors tens of thousands of dollars in waste and lost production time are thus eliminated. Additionally, the costs related to extruding a “bad” product, i.e. a product fabricated with incorrect ingredients, are eliminated as well, thus insuring that a properly blended product is provided to the end user.

[0032] In view of the foregoing, there will be seen that there has been provided a new, useful and uncomplicated system and method that solves the problems of piping complexity and connection error heretofore encountered in the extrusion molding industry.

The principles of this invention having been disclosed in accordance with the foregoing, I hereby claim as my invention the following:

1. A transfer station comprising:
   a smart connector station having a plurality of product input lines and at least one product output line;
   at least one downstream destination for the product output line; and
   a programmable logic controller in electronic communication with the smart connection station and the downstream destination, said programmable logic controller being operable to verify that the appropriate product line is connected to the downstream destination.
2. A transfer station comprising:
   at least one smart connection station, the smart connection station having at least one material input line;
   at least one vacuum pump having an output line;
   at least one pneumatic manifold connected to the output line of the at least one vacuum pump;
   at least one vacuum receiver station connected to the at least one pneumatic manifold;
   at least one hose, each of said at least one hoses having a first end and a second end, said hose first end being attachable to the vacuum receiver station and the second end being removable attachable to the smart connection station, the hose further providing an electrical conduit between the vacuum receiver and the pneumatic manifold;
   a programmable logic controller in electronic communication with the pneumatic manifold, the vacuum receiver station and the smart connection station; the programmable logic controller being operable to verify whether the hose is properly connected to the smart connection station.
3. A bulk material movement system comprising:
   a plurality of smart connection stations, each of said smart connection stations having a plurality of material input lines and a plurality of material output lines;
   a plurality of material supply reservoirs;
   a plurality of vacuum pumps each having an output line;
   a plurality of vacuum receiver stations; each of said vacuum receiver stations being connected to said plurality of vacuum pumps via a pneumatic manifold;
a plurality of hoses, each of the hoses having a first end and a second end, the hose first end being attachable to the vacuum receiver station and the second end being removably attachable to the smart connection station; the hose further providing an electrical conduit between the smart connection station and the vacuum receiver station; a programmable logic controller in electronic communication with the pneumatic manifold, the vacuum receiver station and the smart connection station; the programmable logic controller being operable to verify that hose is attached to the correct material output line on the smart connection station.

4. The transfer station of claim 3 wherein the vacuum receivers have level sensing indicators in electronic communication with the PLC.

5. The transfer station of claim 3 wherein the PLC is programmable to operate the pneumatic manifold to fill one of the plurality of vacuum receivers.