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(54) Coating process and apparatus.

(57) The invention includes a method and apparatus for applying a single or multiple layer coating material to a substrate (30) using a generally cylindrical application roller (26). First and second coating materials are extruded and join together to form a multiple layer coating material. Additional layers may be similarly provided if desired. The multiple layer coating material may then be transferred on the peripheral surface (24) of the application roller to a substrate, such as paper. The application roller may be rotated to produce a surface velocity that is greater than the velocity of the extruded multiple layer coating material, to draw the material and provide a thin multiple coating layer. Furthermore, the substrate may be conveyed past the application interface at a velocity greater than the surface velocity of the application roller, to provide further drawing of the multiple layer coating material.

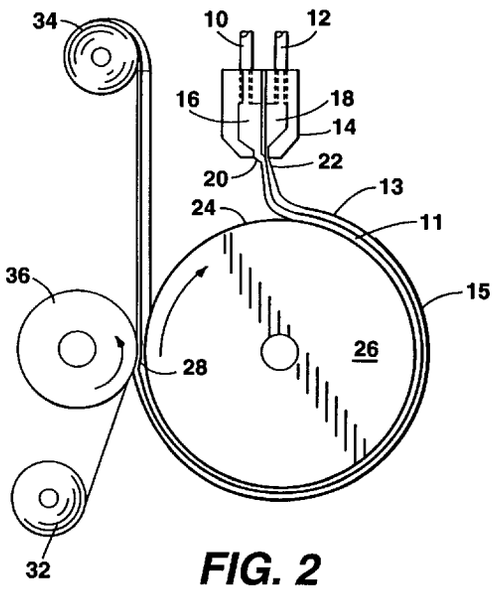

FIG. 2

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TECHNICAL FIELD

The present invention relates to a process and apparatus for coating one or more layers of a coating material onto a receiving surface, such as a substrate.

BACKGROUND OF THE INVENTION

Coating materials such as hot-melt adhesives and radiation curable adhesives may be applied to a substrate, such as paper, by one of several different methods. For example, direct die coating is a method that involves the extrusion of a flowable coating material through one or more die openings onto a substrate. As shown in Figure 1, a substrate 1 is driven from supply roll 2 past die coater 3 and to takeup roll 3. The die coater applies one or more layers of coating material (two, in the illustrated embodiment) directly onto the substrate. Such a method may be used to provide an adhesive layer onto a web of paper or polymeric film.

Gravure coating is another known method of applying a coating material to a substrate. In gravure coating, an applicator roller is used to receive and transfer the coating material to a substrate. The applicator roller includes a predetermined pattern of engraved depressions, or cells, formed in the peripheral surface thereof. The coating material is carried in the cells, and is transferred to the substrate at an application interface between the applicator roller and the substrate. Because the coating material has a greater affinity for the substrate than for the surface of the applicator roller, the coating material is evacuated from each of the cells as those cells pass the application interface.

The foregoing processes, while having utility for certain applications, may exhibit deficiencies in the context of other applications. For example, gravure coating is designed to apply a single layer of coating material to a substrate. To apply multiple layers of coating material, the layers must be applied sequentially, which is time consuming and therefore expensive. As another example, it may be difficult to apply a very thin layer of a coating material to a substrate using direct die coating processes. Because the die opening must be very narrow to apply a coating layer of similar thickness, impurities (such as gels and other contaminants) in the coating material can occlude the die opening. Such an occlusion can cause streaking and voids, which may result in an unacceptable product. Furthermore, the production line must be halted to allow the die to be cleaned, which results in a substantial loss of production capacity. Thus, direct die coating processes may not facilitate the application of very thin layers of coating material to a substrate.

In view of the potential deficiencies of the coating processes of the prior art, it is desirable to provide a coating process that facilitates the application of thin layers of coating material. It is also desirable to provide a coating process that enables the simultaneous application of multiple layers of a coating material.

SUMMARY OF THE INVENTION

The present invention provides a method of applying a coating material to a substrate. The method comprises the steps of providing a die including a number of chambers, each chamber having die opening; providing a number of sources of coating material, each source adapted to provide a respective coating material to one of the chambers; providing an application roller having a peripheral surface for receiving the coating material; conveying a substrate past the peripheral surface of the application roller at an application interface to enable the application roller to transfer the coating material onto the substrate at the application interface; extruding the coating material through the die opening of the respective chambers; conveying the coating material on the peripheral surface of the application roller to the application interface; and rotating the application roller to transfer the coating material to the substrate at the application interface. In one embodiment, the method comprises the foregoing steps, wherein the die has two chambers, and two sources of coating material are provided, each of which is fluidically connected to one of the two chambers.

Also provided is an apparatus for applying a coating material to a substrate. The apparatus comprises a die including a number of chambers, each chamber having die opening; a number of sources of coating material, each source adapted to provide a respective coating material to one of said chambers; an application roller having a peripheral surface for receiving the coating material; a substrate for receiving the coating material; means for conveying the substrate past the peripheral surface of the application roller at an application interface to enable the application roller to transfer the coating material onto the substrate at the application interface; means for extruding the coating material through the die openings of the respective chambers; and means for rotating the application roller about a central axis. The peripheral surface of the application roller conveys the coating material to the application interface, and the application roller transfers the coating material to the substrate at the application interface.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described with particular reference to the appended figures, wherein like reference numbers represent identical structure throughout the several views, and wherein:

Figure 1 is a schematic illustration of a direct die coating process according to the prior art;

Figure 2 is a schematic illustration of the coating method and apparatus of the present invention; and

Figure 3 is a cross-sectional view of an alternative embodiment of a manifold die for use with the apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figure 2, the apparatus of the present invention includes at least one source of coating material (shown as two sources 10 and 12 in the illustrated embodiment), which are in fluidic connection with a manifold coating die 14. The present invention also has utility in the application of a single layer coating material, or in the application of more than two layers of coating material. However, the invention will be described primarily with reference to the application of two coating materials. Coating die 14 has at least two separate chambers 16 and 18 for receiving coating material from sources 10 and 12, respectively. Chambers 16 and 18 fluidically communicate with die openings 20 and 22, respectively, which are proximate the peripheral surface 24 of an application roller 26.

A feature of the present invention relates to applying the coating materials onto the application roller, and subsequently transferring the coating material from the application roller onto the substrate. Specifically, as shown in Figure 2, first coating material 11 is provided through a first die opening 20 where it joins second coating material 13 that has been provided through a second die opening 22 to form a multiple layer coating material 15. Additional die openings may also be provided, as shown in the embodiment of manifold die 14' in Figure 3, which includes three chambers (16,', 18', and 18a) and three die openings (20', 22', and 22a). The multiple layer coating material 15 is then carried on the peripheral face 24 of application 26 roller toward the application interface 28, for transfer to a substrate 30.

Substrate 30 is provided by supply roll 32, and is collected by takeup roll 34. A backing roller 36 opposes application roller 26 at the application interface 28. When the multiple layer coating material 15 reaches application interface 28, the multiple layer coating material is transferred to the substrate. The outermost layer of coating material contacts the substrate, and tends to adhere to the substrate. The attractive force between the outermost layer and the substrate, and between the various layers of coating material, is greater than the attractive force between the application roller and the coating material layer closest to it. Furthermore, the peripheral surface of the application roller may be coated with a release coating, such as Teflon, to facilitate release of the multi-layer coating material. Thus, the multi-layer coating material is transferred onto the substrate at the application interface.

The foregoing method and apparatus enables the application roller to be rotated at a surface velocity that is greater than the extrusion velocity of the coating materials. This results in a "drawing" of the multiple layer coating material, which in turn results in low multiple layer thickness, or low coating weight, which is particularly desirable for some applications. The degree of draw may be controlled as desired, such that the thickness of the multiple layer coating material may be similarly controlled, in contrast to the application systems of the prior art.

Additional drawing may be achieved by conveying the substrate past the application roller at a greater velocity than the surface velocity of the application roller. For example, if the substrate is conveyed at a velocity of 1.0 m/s (197 ft/min), and the peripheral surface of the application roller is travelling at a velocity of 0.5 m/s (98.4 ft/min) at the application interface, the draw ratio is approximately 2:1. Thus, the thickness of the multiple layer coating material will be approximately 1/2 as thick on the substrate as on the peripheral surface of the application roller. This feature of the present invention assists in providing material application at low coating weight, which may be a desirable feature for some applications.

Although it is preferred that the respective coating materials meet to form the multiple layer coating material prior to contact with the application roller, the respective coating materials could instead be sequentially applied to the application roller, with suitable modifications to the method and apparatus previously described. A first coating material could be applied to the application roller, followed by a second coating material layer applied over the first layer, and so on, to form the multiple coating layer of the invention. This process may be repeated for subsequent coating layers as desired.

The various layers of coating material may be selected as desired. For example, the first layer (which will be the outermost layer after the multi-layer coating material is applied to the substrate) may be a pressure sensitive adhesive comprising isooctyl acrylate (IOA), octodecyl acrylate (ODA), acrylic acid (AA), and 4-acryloyl-oxy-benzophenone (ABP). Another suitable pressure sensitive adhesive comprises isooctyl acrylate (IOA), octodecyl acrylate (ODA), and 4-acryloyl-oxy-benzophenone (ABP). Other suitable adhesives are disclosed in U.S. Patent Application Serial Number 07/816,593, filed 31 December 1991 and entitled "Removable, Low Melt Viscosity Acrylic Pressure Sensitive Adhesives," the contents of which are incorporated by reference herein.

The second layer could comprise a tie layer, which may be desirable for bonding an adhesive layer to a paper substrate. A suitable tie layer comprises

maleated propylene/hexene copolymer, such as that available from the Eastman Chemical Corporation of Kingsport, Tennessee, under product number P1824-013. Additional layers may also be provided, as desired.

The method and apparatus of the present invention provide a solution to the die opening occlusion problems of the apparatuses of the prior art. The present invention overcomes problems of die opening occlusion through use of larger die openings than those that are used in the direct die coating processes of the prior art. By providing lower coating material flow velocity and an application roller, a relatively thin coating may be applied to a substrate using die openings that are approximately 2 to 4 times wider than the die openings of the prior art apparatuses. Specifically, the multiple layer coating material is relatively thick when it exits the extruding apparatus, but becomes thinner due to the drawing action of the application roller. The multiple layer coating material may again be drawn at the interface between the peripheral surface of the application roller and the substrate. As a result, a relatively thin multiple layer coating material may be applied to a substrate, although a relatively thick multiple layer coating material was initially extruded. A benefit of larger die openings is that gels and other contaminants that would become lodged in the die openings of direct die coating apparatuses pass through the larger die openings of the present invention. Thus, the streaks and voids in the coating layer that result from occlusion of the die openings are reduced or eliminated.

The manifold die may be designed as known in the art, and should be adapted to facilitate the even, smooth extrusion of the respective coating materials. The geometry of the die and die openings may thus be selected for optimum performance with a particular set of coating materials. For example, the extrusion pressure may be increased or decreased, the die opening dimensions may be increased or decreased, the separation between the respective die openings may be increased or decreased, or the partition separating adjacent chambers may be raised or lowered to enable the respective layers to meet slightly inside of or outside of the die. The extrusion process thus may be optimized for the materials to be extruded, as known in the art.

The present invention will be better understood with reference to the following Example, which is intended to be illustrative and nonlimiting.

Example

A source of a pressure sensitive adhesive comprising 58% by weight isooctyl acrylate (IOA), 40% by weight octodecyl acrylate (ODA), 2% by weight acrylic acid (AA), and 0.4% by weight 4-acryloyl-oxy-benzophenone (ABP) was provided. The total percentage of the constituents does not equal 100% due to rounding. The adhesive was prepared in accordance with the disclosure of U.S. Patent Application Serial Number 07/816,593, the disclosure of which was incorporated by reference above. The adhesive was heated to a temperature of approximately 138° C (280° F) prior to being supplied under pressure to the first chamber of the manifold die. The first and second chambers of the manifold die each included a single, slot-shaped die opening, measuring approximately 2.9 cm (1.14 in) long by 0.051 cm (0.02 in) wide. The pressure was applied by a constant displacement gear pump, and was maintained at a level sufficient to produce a flow rate of approximately 1.42 g/s (0.050 oz/s) through the first die opening.

Similarly, a source of polyolefin, available from the Eastman Chemical Company of Kingsport, Tennessee under product number P1824-013, was provided, and was heated prior to being supplied under pressure to the second chamber of the manifold die. The pressure was applied by a second constant displacement gear pump, and was maintained at a level sufficient to produce a flow rate of approximately 0.675 g/s (0.0238 oz/s) through the second die opening. The second die opening measured approximately 3.175 cm (1.25 in) long by 0.0254 cm (0.01 in) wide. A partition separated the first and second chambers of the die to prevent mixing of the respective coating materials.

The first die opening was upstream of the second die opening, to enable the respective coating materials to be extruded through the respective die openings, and to meet to form the multiple layer coating material. An application roller was rotatively supported adjacent the die openings, such that the multiple layer coating material would collect on the peripheral surface of the application roller. The application roller had a radius of approximately 12.7 cm (5.0 in), and a peripheral surface width of 3.175 cm (1.25 in). The peripheral surface of the application roller included a multiplicity of projecting structures randomly distributed across the peripheral face of the application roller, which structures measured approximately 0.76 mm (0.003 in) high, and were generally hemispherical. The peripheral surface of the application roller was coated with a fluorocarbon or Teflon release coating, to facilitate transfer of the multiple layer coating material to the substrate at the application interface. Further background information regarding the construction and operation of the application roller apparatus may be found in copending U.S. Patent application serial-number 08/056,362, filed 30 April 1993 and entitled "Method and Apparatus for Applying a Coating Material to a Substrate," the contents of which is incorporated by reference herein.

The application roller was rotated about its central axis at a rotational velocity sufficient to produce a velocity of 0.5 m/s (100 ft/min) at the peripheral sur-

face. The first and second gear pumps were activated to extrude the first and second coating materials through the first and second die openings, respectively. The coating materials bonded together to form the multiple layer coating material, but little or no mixing occurred between the respective layers. The first (pressure sensitive adhesive) layer was approximately 0.003 cm (0.0012 in) thick, and the second (tie) layer was approximately 0.001 cm (0.0004 in) thick.

A supply web of 20 pound xerographic bond paper was provided, and the paper was conveyed past the application interface by a supply roller and collected on a takeup roller. The paper measured 30.5 cm (12.0 in) wide and 0.0122 cm (0.0048 in) thick. The paper web was conveyed at a velocity of 1.5 m/s (300 ft/min) past the application interface, and thus the web velocity was greater than the surface velocity of the periphery of the application roller by approximately a factor of 3.

The multiple layer coating material was then transferred to the paper web at the application interface. The second (tie) layer adhered to the paper web, and the first coating layer released from the peripheral surface of the application roller. The resulting coating layer thickness after application to the paper web were 0.0102 mm (0.0004 in) for the first (adhesive) layer, and 0.0033 mm (0.00013 in) for the second (tie) layer. The second coating layer was exposed, and the article formed by the coated paper web was adapted for adhesive engagement with a surface.

It should be understood that although the present invention has been described with reference to the transfer of a multiple layer coating material directly to a substrate, it is within the scope of the present invention to transfer the multiple layer coating material to one or more intermediate rollers or other apparatuses, and then to a substrate. That is, the transfer of the multiple layer coating material from the application roller to the substrate is preferably a direct transfer, but may instead be an indirect transfer if desired.

The present invention has now been described with reference to several embodiments thereof. However, persons of skill in the art will recognize that variations may be made in the embodiments described without departing from the scope of the invention. Thus, the scope of the present invention should not be limited by the embodiments shown and described herein, but rather by the structures described by the claims, and the equivalents of those structures.

Claims

1. A method of applying a coating material to a substrate, comprising the steps of:
   a) providing a die (14) including first and second chambers (16, 18), each chamber having a die opening (20, 22);
   b) providing first and second sources (10, 12) of coating material, said first source providing coating material to said first chamber, said second source providing coating material to said second chamber;
   c) providing an application roller (26) having a peripheral surface (24) for receiving the coating material;
   d) extruding the coating material through the die opening of the first chamber and onto the peripheral surface of the application roller to provide a first coating layer;
   e) extruding the coating material through the die opening of the second chamber and onto the first coating layer;
   f) conveying a substrate (30) past the peripheral surface of the application roller at an application interface (28) to enable the application roller to transfer the coating materials onto the substrate in two layers at the application interface;
   g) conveying the coating materials on the peripheral surface of the application roller to the application interface; and
   h) rotating the application roller to transfer the coating materials to the substrate in two layers at the application interface.

2. The method of claim 1, wherein one of the first coating material and the second coating material is a pressure sensitive adhesive.

3. The method of claim 2, wherein the other of the first coating material and the second coating material is a tie layer for bonding the adhesive layer to the substrate.

4. The method of claim 1, wherein the substrate is paper.

5. The method of claim 1, wherein step h) comprises the step of rotating the application roller such that the surface velocity of the application roller is greater than the velocity of the coating material as the material is extruded from the die, to stretch the coating material and provide a coating layer of reduced thickness for application to the substrate.

6. The method of claim 1, wherein step f) comprises the step of conveying a substrate at a velocity greater than the surface velocity of the application roller to draw the coating material and provide a thin coating layer for application to the substrate.

7. The method of claim 1, wherein the method fur-

ther includes providing a die having a third chamber (18a) having a die opening (22a), providing a third source of coating material adapted to provide coating material to the third chamber, and extruding the coating material through the die opening of the third chamber and onto the second coating material.

8. A substrate coated with a coating material by the method of any one of the preceding claims.

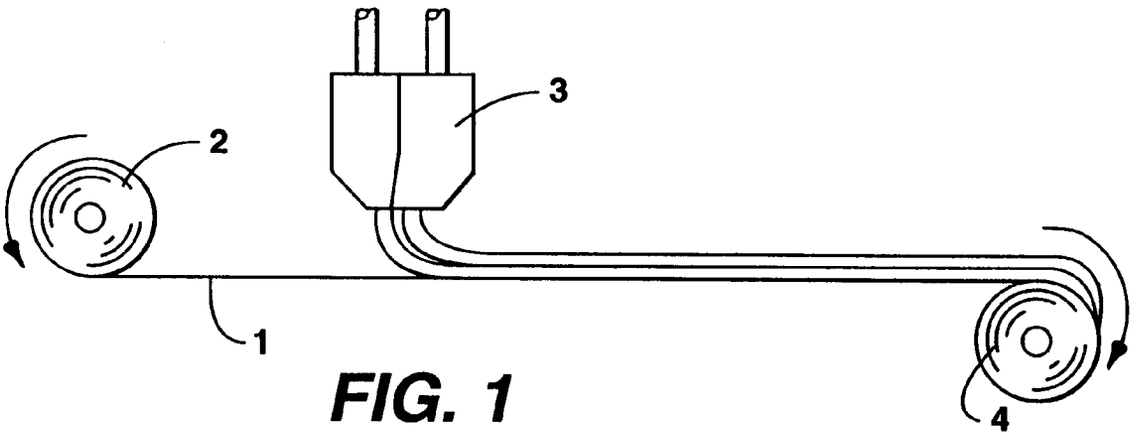

FIG. 1
PRIOR ART

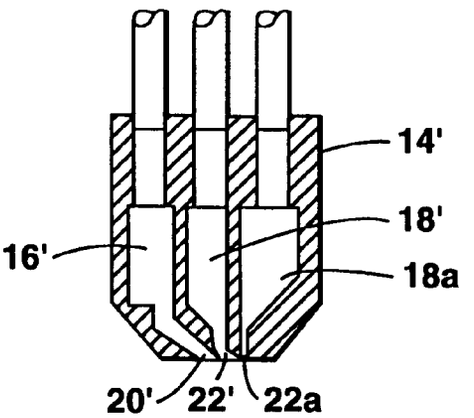

FIG. 3

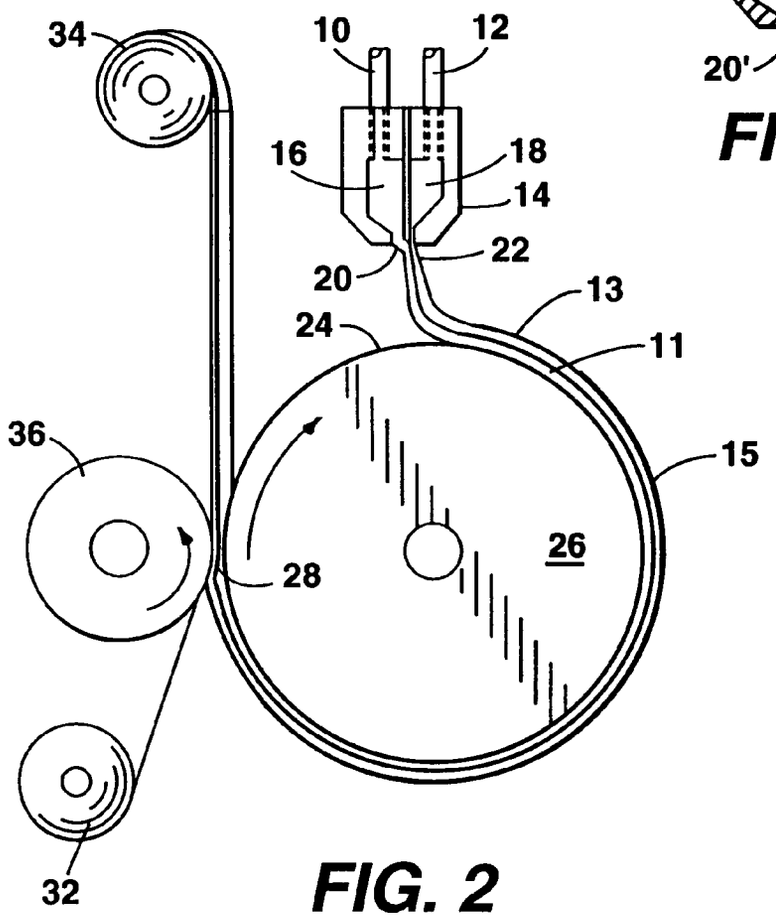

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 40 0932

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	PATENT ABSTRACTS OF JAPAN vol. 16, no. 190 (C-0937) 8 May 1992 & JP-A-04 027 462 (KANKAZI PAPER MFG CO LTD) 30 January 1992 * abstract *	1,8	B05C1/08 B05C9/06
Y	EP-A-0 031 301 (CIBA-GEIGY AG) * page 10, line 30 - page 11, line 5; figure 2 *	1,8	
A	* page 11, line 29 - page 12, line 6 *	5,6	
A	FR-A-1 359 975 (WOLF & CO.) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

B05C
B32B
D21H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 August 1994	Juguet, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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