

DEVICES AND METHODS FOR APPLYING LABELS ON PRODUCTS

Cross Reference to Related Application(s)

- 5 The present disclosure claims the benefit of Singapore Patent Application No. 10202111581S filed on 19 October 2021, which is incorporated in its entirety by reference herein.

Technical Field

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The present disclosure generally relates to devices and methods for applying labels on products.

Background

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Many products have sticker labels on them that provide information about the products. For example, food and beverage bottles or packagings have labels that detail the ingredients and nutritional values. Label applicators are used to apply the labels on the products. Current label applicators have generally flat end effectors to pick up and
20 apply the labels. These label applicators are designed to apply labels on products with flat surfaces, wherein the flat surfaces are perpendicular to the direction of motion of the labels. However, for products with non-flat or curved surfaces such as bottles, or for products with oblique surfaces that are not perpendicular to the direction of motion of the labels, the labels may not adhere properly to the surfaces.

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Figures 1A to 1C show a product 100 in the form of squeeze tube and having a curved surface 102. A label 104 was applied on the curved surface 102 using an existing label applicator. However, the side edges 106 of the label 104 did not adhere properly to the curved surface 102. The label 104 needed to be further secured to the curved
30 surface 102 using other means, such as manually by hand or using conveyor guide rails, so that the label 104 can better adhere to the curved surface 102. Figures 1D to 1E show a product 110 in the form of bottle and having a curved surface 112. A label 114 was applied on the curved surface 112 using an existing label applicator. However,

because of the curvature, bubbles 116 and creases 118 were formed when the label 114 was applied on the curved surface 112.

Therefore, current label applicators are not suitable to apply labels on products with non-flat, curved, uneven, or oblique, surfaces, and often resulted in poorer visual aesthetics for the products. There is a need to provide improved devices for applying labels on products to address or alleviate at least one of the aforementioned problems and/or disadvantages.

Summary

According to a first aspect of the present disclosure, there is a device for applying a label on a product, the device comprising:

- a first surface connectable to a mechanical arm for displacing the device along an axial direction towards the product, the product having a labelling surface that is at least partially oblique to the axial direction;

- a second surface opposite to the first surface, the second surface for holding the label; and

- a set of flexible sections between the first and second surfaces, the flexible sections being resiliently compressible at peripheral portions thereof,

- wherein when the device is axially displaced towards the product, the peripheral portions are differentially compressed by the labelling surface to conform the second surface to the labelling surface and thereby apply the label on the labelling surface.

According to a second aspect of the present disclosure, there is a method for applying a label on a product, the method comprising:

- connecting a first surface of a device to a mechanical arm;

- holding the label on a second surface of the device, the second surface being opposite to the first surface;

- displacing, using the mechanical arm, the device along an axial direction towards the product;

- engaging the second surface with a labelling surface of the product, the labelling surface being at least partially oblique to the axial direction;

differentially and resiliently compressing peripheral portions of a set of flexible sections of the device by the labelling surface, the flexible sections being between the first and second surfaces; and

conforming the second surface to the labelling surface resulting from the differential compression of the peripheral portions, thereby applying the label on the labelling surface.

According to a third aspect of the present disclosure, there is a device for applying a label on a product, the device comprising:

a first surface connectable to a mechanical arm for displacing the device to the product having a curved labelling surface;

a porous member comprising a second surface opposite to the first surface, the porous member configured for holding the label on the second surface by vacuum pressure; and

a set of peripheral members bordering the porous member for side edges of the label to align with, the peripheral members being moveable upon deformation of the porous member,

wherein when the device is displaced to the product, the porous member is deformed by the curved labelling surface to conform the second surface to the curved labelling surface and thereby apply the label on the curved labelling surface; and

wherein the peripheral members are moved by the deformed porous member to conform to the curved labelling surface and thereby apply the side edges of the label on the curved labelling surface.

According to a fourth aspect of the present disclosure, there is a method for applying a label on a product, the method comprising:

connecting a first surface of a device to a mechanical arm;

holding the label by vacuum pressure on a second surface of a porous member of the device, the second surface being opposite to the first surface;

displacing, using the mechanical arm, the device towards the product;

engaging the second surface with a curved labelling surface of the product;

deforming the porous member by the curved labelling surface;

conforming the second surface to the labelling surface resulting from the deformation of the porous member, thereby applying the label on the curved labelling surface;

5 moving a set of peripheral members of the device upon deformation of the porous member, the peripheral members bordering the porous member for side edges of the label to align with; and

conforming the peripheral members to the curved labelling surface resulting from the movement of the peripheral members, thereby applying the side edges of the label to the curved labelling surface.

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According to a fifth aspect of the present disclosure, there is an end effector device for applying a label on a product, the end effector device comprising:

(a) a first device comprising:

15 a first surface connectable to a mechanical arm for displacing the device along an axial direction towards the product, the product having a labelling surface that is at least partially oblique to the axial direction;

a second surface opposite to the first surface, the second surface for holding the label; and

20 a set of flexible sections between the first and second surfaces, the flexible sections being resiliently compressible at peripheral portions thereof; and

(b) a second device comprising:

a first surface connectable to a mechanical arm for displacing the device to the product having a curved labelling surface;

25 a porous member comprising a second surface opposite to the first surface, the porous member configured for holding the label on the second surface by vacuum pressure; and

30 a set of peripheral members bordering the porous member for side edges of the label to align with, the peripheral members being moveable upon deformation of the porous member,

wherein when the end effector device is axially displaced towards the product, the peripheral portions are differentially compressed by the labelling surface and the

porous member is deformed by the labelling surface to conform the second surface to the labelling surface and thereby apply the label on the labelling surface; and

wherein the peripheral members are moved by the deformed porous member to conform to the curved labelling surface and thereby apply the side edges of the label on the curved labelling surface.

Devices and methods for applying labels on products according to the present disclosure are thus disclosed herein. Various features, aspects, and advantages of the present disclosure will become more apparent from the following detailed description of the embodiments of the present disclosure, by way of non-limiting examples only, along with the accompanying drawings.

Brief Description of the Drawings

Figures 1A to 1E are illustrations of products having labels applied by current label applicators.

Figures 2A to 2C are illustrations of a first device for applying a label on a product, in accordance with embodiments of the present disclosure.

Figures 3A and 3B are illustrations of the first device being used to apply the label on the product.

Figures 4A and 4B are illustrations of a flexible section of the first device and the flexible section affecting use of the first device.

Figures 5A to 5D are illustrations of a second device for applying a label on a product, in accordance with embodiments of the present disclosure.

Figures 6A and 6B are illustrations of the second device being used to apply the label on the product.

Figures 7A and 7B are illustrations of a porous member of the second device.

Figures 8A to 8C are illustrations of porosity of the porous member.

Figures 9A to 9C are illustrations of fluidic ports of the porous member.

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Figures 10A and 10B are illustrations of a third device for applying a label on a product, in accordance with embodiments of the present disclosure.

Detailed Description

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For purposes of brevity and clarity, descriptions of embodiments of the present disclosure are directed to devices and methods for applying labels on products, in accordance with the drawings. While aspects of the present disclosure will be described in conjunction with the embodiments provided herein, it will be understood that they are not intended to limit the present disclosure to these embodiments. On the contrary, the present disclosure is intended to cover alternatives, modifications and equivalents to the embodiments described herein, which are included within the scope of the present disclosure as defined by the appended claims. Furthermore, in the following detailed description, specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be recognized by an individual having ordinary skill in the art, i.e. a skilled person, that the present disclosure may be practiced without specific details, and/or with multiple details arising from combinations of aspects of particular embodiments. In a number of instances, well-known systems, methods, procedures, and components have not been described in detail so as to not unnecessarily obscure aspects of the embodiments of the present disclosure.

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In embodiments of the present disclosure, depiction of a given element or consideration or use of a particular element number in a particular figure or a reference thereto in corresponding descriptive material can encompass the same, an equivalent, or an analogous element or element number identified in another figure or descriptive material associated therewith.

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References to “an embodiment / example”, “another embodiment / example”, “some embodiments / examples”, “some other embodiments / examples”, and so on, indicate that the embodiment(s) / example(s) so described may include a particular feature, structure, characteristic, property, element, or limitation, but that not every
5 embodiment / example necessarily includes that particular feature, structure, characteristic, property, element or limitation. Furthermore, repeated use of the phrase “in an embodiment / example” or “in another embodiment / example” does not necessarily refer to the same embodiment / example.

10 The terms “comprising”, “including”, “having”, and the like do not exclude the presence of other features / elements / steps than those listed in an embodiment. Recitation of certain features / elements / steps in mutually different embodiments does not indicate that a combination of these features / elements / steps cannot be used in an embodiment.

15 As used herein, the terms “a” and “an” are defined as one or more than one. The use of “/” in a figure or associated text is understood to mean “and/or” unless otherwise indicated. The term “set” is defined as a non-empty finite organisation of elements that mathematically exhibits a cardinality of at least one (e.g. a set as defined herein can
20 correspond to a unit, singlet, or single-element set, or a multiple-element set), in accordance with known mathematical definitions. The terms “first”, “second”, etc. are used merely as labels or identifiers and are not intended to impose numerical requirements on their associated terms.

25 First Device 200

In representative or exemplary embodiments of the present disclosure, with reference to Figures 2A to 2C, there is a first device 200 for applying a label on a product 300. The product 300 has a labelling surface 310 that is at least partially oblique to an axial
30 direction 320. The axial direction 320 refers to the direction of motion of the label when it is being displaced towards the product 300 in order to apply the label to the product 300. For example, the first device 200 is coupled to a mechanical arm, such as a robotic arm or gripper, to displace the first device 200 along the axial direction 320.

In many embodiments, the product 300 may be placed on a horizontal surface and the axial direction 320 is perpendicular to the horizontal surface, i.e. the axial direction 320 is vertical. In this arrangement, at least a portion of the labelling surface 310 is oblique or non-perpendicular to the axial direction 320. For example, the labelling surface 310 has a curved, slanted, or undulating profile.

The first device 200 includes a first surface 210 and a second surface 220 that is opposite to the first surface 210. The first surface 210 is connectable to the mechanical arm for displacing the first device along 200 the axial direction 320 towards the product 300. The second surface 220 is configured for holding the label to apply on the product 300. For example, the second surface 220 is configured to hold the label by vacuum pressure. The label may be held directly on the second surface 220 or alternatively via an intermediate device, such as the second device 400 described further below.

The first device 200 includes a set of flexible sections 230 between the first surface 210 and the second surface 220. The flexible sections 230 are configured to be resiliently compressible at peripheral portions of the flexible sections 230. For example, the flexible sections 230 include tubular sections or bellows, wherein each tubular section or bellow is resiliently compressible. When the first device 200 is axially displaced to the product 300, the peripheral portions are differentially compressed by the labelling surface 310 to conform the second surface 220 to the labelling surface 310 and thereby apply the label to the labelling surface 310.

In various embodiments of the present disclosure, there is a method for applying a label on a product 300, such as using the first device 200 or any other suitable device or applicator. The method includes a step of connecting the first surface 210 to the mechanical arm. The method includes a step of holding the label on the second surface 220. For example, the label is held on the second surface 220 by vacuum pressure. The method includes a step of displacing, using the mechanical arm, the first device 200 along the axial direction 320 towards the product 300.

The method includes a step of engaging the second surface 220 with the labelling surface 310. The method includes a step of differentially and resiliently compressing peripheral portions of the flexible sections 230 by the labelling surface 310. The method includes a step of conforming the second surface 220 to the labelling surface 310 resulting from the differential compression of the peripheral portions, thereby applying the label on the labelling surface 310.

For example, the label is held on the second surface 220 by vacuum pressure. The method may include a step of releasing the label from the second surface 220 by releasing the vacuum pressure or changing the negative pressure to positive pressure.

In some embodiments as shown in Figure 3A, the product 300 is placed on a horizontal surface and the axial direction 320 is vertical. The labelling surface 310 is flat and oblique to the axial direction 320. The first device 200 holds the label on the second surface 220 and the first device 200 is axially displaced towards the product 300. The second surface 220 then engages with the oblique labelling surface 310. More specifically, the right side of the second surface 220 contacts the oblique labelling surface 310 first, and the right peripheral portion 230R of the flexible sections 230 begins to compress. The first device 200 continues to be displaced along the axial direction 320, compressing the right peripheral portion 230R and displacing the left side of the second surface 220 closer towards the labelling surface 310. The compression of the right peripheral portion 230R causes the right side of the label to be applied on the right side of the oblique labelling surface 310.

When the left side of the second surface 220 contacts the oblique labelling surface 310, the right peripheral portion 230R has been further compressed and the left peripheral portion 230L of the flexible sections 230 begins to compress. Continued displacement of the first device 200 along the axial direction 320 further compresses the left and right peripheral portions 230LR of the flexible sections 230, wherein the right peripheral portion 230R is compressed more than the left peripheral portion 230L. This causes the second surface 220 to tilt downwards, wherein the left peripheral portion 230L is lower than the right peripheral portion 230R.

The compression of the left peripheral portion 230L causes the left side of the label to be applied on the left side of the oblique labelling surface 310. The peripheral portions are thus differentially compressed by the oblique labelling surface 310 and the differential compression enables the second surface 220 to conform to the profile of the oblique labelling surface 310 and the label to be more easily applied on the labelling surface 310. Particularly, the label is gradually applied on the oblique labelling surface 310 from the right to left sides. The gradual application of the label reduces the risk of bubbles or creases on the label.

In some other embodiments, the labelling surface 310 is curved downwards from the right to left. Similarly, the first device 200 holds the label and is axially displaced towards the product 300. The right side of the second surface 220 contacts the top and right side of curved labelling surface 310 first, and the right peripheral portion 230R of the flexible sections 230 begins to compress. The first device 200 continues to be displaced along the axial direction 320, compressing the right peripheral portion 230R and displacing the left side of the second surface 220 closer towards the labelling surface 310. The compression of the right peripheral portion 230R causes the right side of the label to be applied on the top and right side of the curved labelling surface 310.

When the middle of the second surface 220 contacts the middle of the curved labelling surface 310, the right peripheral portion 230R has been further compressed and the middle of the label is applied on the middle of the curved labelling surface 310. The second surface 220 begins to tilt downwards, wherein the right peripheral portion 230R is higher than the middle. Continued displacement of the first device 200 moves the left side of the second surface 220 to closer towards the labelling surface 310.

When the left side of the second surface 220 contacts the curved labelling surface 310, the right peripheral portion 230R has been more greatly compressed and the left peripheral portion 230L of the flexible sections 230 begins to compress. Continued displacement of the first device 200 further compresses the left and right peripheral portions 230LR of the flexible sections 230, wherein the right peripheral portion 230R is compressed more than the left peripheral portion 230L. This causes the second

surface 220 to tilt further downwards, wherein the left peripheral portion 230L is lower than the right peripheral portion 230R and the middle.

The compression of the left peripheral portion 230L causes the left side of the label to be applied on the bottom and left side of the curved labelling surface 310. The peripheral portions are thus differentially compressed by the curved labelling surface 310 and the label is more easily applied on the labelling surface 310. Particularly, the label is gradually applied on the curved labelling surface 310 from the top right side to the middle and to the bottom left side, reducing the risk of formation of bubbles or creases.

In some embodiments, the flexible sections 230 have the same stiffness at the peripheral portions. For example as shown in Figure 3A, the flexible sections 230 at the left and right peripheral portions 230LR have the same thickness and thus the same stiffness. In some embodiments, the flexible sections 230 have varying stiffness at the peripheral portions which can facilitate the differential compression. For example as shown in Figure 3B, the flexible sections 230 at the right peripheral portion 230R are thinner than at the left peripheral portion 230L. The left peripheral portion 230L is thus stiffer than the right peripheral portion 230R.

In some embodiments as shown in Figure 3B, the product 300 is placed on a horizontal surface and the axial direction 320 is vertical. The labelling surface 310 is flat and oblique to the axial direction 320. The first device 200 holds the label on the second surface 220 and the first device 200 is axially displaced towards the product 300. The second surface 220 then engages with the oblique labelling surface 310. More specifically, the right side of the second surface 220 contacts the oblique labelling surface 310 first, and the right peripheral portion 230R of the flexible sections 230 begins to compress. The first device 200 continues to be displaced along the axial direction 320, compressing the right peripheral portion 230R and displacing the left side of the second surface 220 closer towards the labelling surface 310. The compression of the right peripheral portion 230R causes the right side of the label to be applied on the right side of the oblique labelling surface 310. As the right peripheral portion 230R is thinner than that of the first device 200 in Figure 3A, the right peripheral

portion 230R of the first device 200 in Figure 3B is less stiff and requires less force to compress.

When the left side of the second surface 220 contacts the oblique labelling surface 310, the right peripheral portion 230R has been further compressed and the left peripheral portion 230L of the flexible sections 230 begins to compress. Continued displacement of the first device 200 along the axial direction 320 further compresses the left and right peripheral portions 230LR of the flexible sections 230, wherein the right peripheral portion 230R is compressed more than the left peripheral portion 230L. This causes the second surface 220 to tilt downwards, wherein the left peripheral portion 230L is lower than the right peripheral portion 230R.

As the left peripheral portion 230L is thicker and stiffer than the right peripheral portion 230R, the left peripheral portion 230L requires more force than the right peripheral portion 230R to compress by the same magnitude. However, as the right peripheral portion 230R is already partially compressed, the stiffness of the right peripheral portion 230R increases and this also increases the force required to further compress the right peripheral portion 230R. The combination of both factors results in more uniform distribution of the compression forces in the left and right peripheral portions 230LR and enables the second surface 220 to more easily conform to the profile of the oblique labelling surface 310. The compression of the left peripheral portion 230L causes the left side of the label to be applied on the left side of the oblique labelling surface 310. The peripheral portions are thus differentially compressed by the oblique labelling surface 310 and the differential compression enables the label to be more easily applied on the labelling surface 310.

The stiffness of the flexible sections 230 may be varied by changing the design of the flexible sections 230, such as the exemplary dimensions and parameters shown in Figure 4A. For example, the length / width / height / thickness at various parts of the flexible sections 230 can be changed. For example, the shape of the flexible sections 230 can be changed, such as oval, round, square, rectangle, rounded rectangle, etc. For example, the number of crests / roots of the flexible sections 230 can be changed. The stiffness of the flexible sections 230 may also be varied by using one or

combination of materials. For example, the flexible sections 230 may be made of a resilient silicone material. For example, the flexible sections 230 may have exterior coatings at suitable areas thereof to adjust the stiffness of the peripheral portions.

- 5 Different designs of the flexible sections 230 affect how the second surface 220 behave when the second surface 220 engages with the labelling surface 310. As shown in Figure 4B, when the second surface 220 first contacts the labelling surface 310 at the contact point 222, the design of the flexible sections 230 affect the tilt angle, tilt direction as shown by the arrows, and downward force on the product 300. For
- 10 example, a stiffer peripheral portion of the flexible sections 230 at the contact point 222 would result in a smaller tilt angle for the same downward force, or greater downward force on the product 300 for the same tilt angle. The shape or profile of the labelling surface 310 would also affect the tilt direction of the second surface 220.
- 15 The flexible sections 230 enable the first device 200 to be more flexible and provide additional movement during the axial displacement when applying the label on the product 300. This flexibility enables the label to be applied on more varied labelling surfaces 310 that can have various profiles, such as curved, slanted, uneven, or undulating. The first device 200 can adapt to different labelling surfaces 310 of various
- 20 products 300 to gradually apply the labels thereon and reduce the risk of defects like bubbles and creases.

Second Device 400

- 25 In representative or exemplary embodiments of the present disclosure, with reference to Figures 5A to 5D, there is a second device 400 for applying a label on a product 300. The product 300 has a labelling surface 310 that is curved. For example, the curved labelling surface 310 may be convex, such as a semi-circular profile.
- 30 The second device 400 includes a first surface 410 and a second surface 420 that is opposite to the first surface 410. The first surface 410 is connectable to a mechanical arm, such as a robotic arm or gripper, for displacing the second device 400 towards the product 300. The second device 400 includes a porous member 430 that includes

the second surface 420. The porous member 430 is configured for holding the label on the second surface 420 by vacuum pressure. For example, the second surface 420 may be convex. The porous member 430 has one or more spaces therein for fluid communication to effect the vacuum suction on the second surface 420. For example,
5 the porous member 430 can be in the form of a foam or a sponge.

The second device 400 includes a set of peripheral members 440 bordering the porous member 430 for side edges of the label to align with. The peripheral members 440 are moveable upon deformation of the porous member 430. When the second device 400
10 is displaced to the product 300, the porous member 430 is deformed by the curved labelling surface 310 to conform the second surface 420 to the curved labelling surface 310 and thereby apply the label to the curved labelling surface 310. Additionally, the peripheral members 440 are moved by the deformed porous member 430 to conform
15 to the curved labelling surface 310 and thereby apply the side edges of the label to the curved labelling surface 310. The second device 400 may optionally include a backing plate 450 on the first surface 410. For example, the backing plate 450 may be configured to connect the second device 400 to the mechanical arm or an intermediate device such as the first device 200.

20 In one embodiment as shown in Figures 5A to 5D, the porous member 430 has a generally rectangular shape and there are two peripheral members 440 bordering the left and right sides of the rectangular porous member 430. The design may be modified such that there are three or more peripheral members 440, such as four peripheral members 440 that border all four sides of the rectangular porous member 430.

25 In various embodiments of the present disclosure, there is a method for applying a label on a product 300, such as using the second device 400 or any other suitable device or applicator. The method includes a step of connecting the first surface 410 to the mechanical arm. The method includes a step of holding the label on the second
30 surface 420 of the porous member 430 by vacuum pressure. The method includes a step of displacing, using the mechanical arm, the second device 400 towards the product 300.

The method includes a step of engaging the second surface 420 with the labelling surface 310. The method includes a step of deforming the porous member 430 by the labelling surface 310. The method includes a step of conforming the second surface 420 to the labelling surface 310 resulting from the deformation of the porous member 430, thereby applying the label to the curved labelling surface 310.

The method includes a step of moving the peripheral members 440 upon deformation of the porous member 430. The method includes a step of conforming the peripheral members 440 to the curved labelling surface 310 resulting from the movement of the peripheral members 440, thereby applying the side edges of the label to the curved labelling surface 310.

For example, the label is held on the second surface 420 by vacuum pressure. The method may include a step of releasing the label from the second surface 420 by releasing the vacuum pressure or changing the negative pressure to positive pressure.

In some embodiments as shown in Figure 6A, the product 300 is placed on a horizontal surface and the curved labelling surface 310 is convex upwards. The second device 400 holds the label on the second surface 420 and the second device 400 is displaced towards the product 300. The second surface 420 is convex downwards such that the bottom of the second surface 420 is aligned to the top of the curved labelling surface 310. The second surface 420 then engages with the curved labelling surface 310. More specifically, the bottom of the second surface 420 contacts the top of the curved labelling surface 310 first, and the porous member 430 begins to deform. The second device 400 continues to be displaced towards the product 300 and deforms the porous member 430 inwards. The deformation of the porous member 430 causes the bottom of the second surface 420 to be pushed inwards such that the second surface 420 is now convex upwards.

The deformation of the porous member 430 thus enables the second surface 420 to conform to the profile of the curved labelling surface 310 and the label to be more easily applied on the labelling surface 310. Additionally, the deformation of the porous member 430 causes the peripheral members 440 to move. More specifically as shown

in Figure 6B, the inward pushing of the bottom of the second surface 420 causes the peripheral members 440 to move like a flap downwards relative to the bottom of the second surface 420. The side edges of the label are aligned to the peripheral members 440 and the moved peripheral members 440 presses the side edges of the label on the curved labelling surface 310, specifically the side edges which correspond to the bottom edges of the convex profile of the curved labelling surface 310.

The second surface 420 of the deformed porous member 430 and the moved peripheral members 440 form an upward convex profile that conforms upward convex profile of the curved labelling surface 310. The label can substantially mate with the curved labelling surface 310, especially the side edges of the label on the bottom edges of the curved labelling surface 310, thereby enabling the label to be properly applied on the labelling surface 310. The shape conformity with the curved labelling surface 310 reduces the risk of poor adhesion of the side edges of the label. This obviates the need to use other means like conveyor guide rails to apply the label, thereby speeding up the label application process and improving process efficiency.

Various design parameters of the second device 400 may be changed, such as the dimensions, size, and shape of the second device 400, porous member 430, and peripheral members 440. For example, the second device 400 and the porous member 430 have a generally rectangular shape, but may be changed to other shapes such as trapezoidal or stadium. For example, the arc or convex profile of the porous member 430 can be changed, such as to a different degree of curvature. These design parameters can affect other parameters such as the suction force to pick up and hold the label, the shape and size of the label, the compression of the deformed porous member 430 by the product 300, the number and movement of the peripheral members 440, and the shape and size of the product 300 and labelling surface 310 where the label is to be applied on.

In some embodiments as shown in Figure 7A, the porous member 430 includes a set of porous layers 432. Each porous layer 432 includes an arrangement of gaps 434 for airflow therethrough. For example, the porous member 430 is the form of foam or a sponge. The arrangement of the gaps 434 in each porous layer 432 and the number

and arrangement of the porous layers 432 affect the overall porosity of the porous member 430 and the direction of airflow through the porous member 430. For example, a porous member 430 having a single porous layer 432 with more gaps 434 has greater porosity than another porous member 430 having a single porous layer 432 with fewer gaps 434. Figure 7B illustrates various designs of the porous member 430 with different degrees of porosity.

An area of the second surface 420 with greater porosity would have greater suction from the vacuum pressure as compared to another area with lesser porosity. In some embodiments as shown in Figure 8A, the black areas represent the material of the porous member 430 while the white areas represent the gaps 434, and the black areas are equal to the white areas. The porous member 430 has the same porosity across the second surface 420, meaning that the suction force can be more homogenous across the second surface 420.

The number and arrangement of the porous layers 432 and the arrangement of gaps 434 in each porous layer 432 affect the porosity of the porous member 430. Different designs of the porous member 430 can have different degrees of porosity and this can affect parameters such as the suction force to pick up and hold the label, the shape and size of the label, the compression of the deformed porous member 430 by the product 300, the number and movement of the peripheral members 440, and the shape and size of the product 300 and labelling surface 310 where the label is to be applied on.

In some embodiments as shown in Figures 8B and 8C, the porous member 430 has varying porosity across the second surface 420, even though the black areas may be equal to the white areas. For example in Figure 8B, the left half of the second surface 420 is fully porous (white area) and the right half is solid or fully non-porous (black area). For example in Figure 8C, the left half has more white areas and is more porous than the right half which has more black areas.

In some embodiments as shown in Figures 5A and 5B, the side walls 435 of the porous member 430 are partially removed or recessed inwards to reduce the material used

for the porous member 430. This also improves flexibility of the porous member 430 and allows the second surface 420 to better conform to the curved labelling surface 310 of the product 300.

5 In some embodiments as shown in Figure 5D, the porous member 430 includes a set of fluidic ports 436 for generating the vacuum pressure. The fluidic ports 436 may be distributed such that the vacuum pressure is non-homogenous across the second surface 420. The suction force from the vacuum pressure would be different depending on the distribution of the fluidic ports 436. Figures 9A to 9C illustrate
10 examples of the distribution of the fluidic ports 436 based on the example of the second surface 420 shown in Figure 8A, i.e. with equal distribution of the black and white areas.

For example in Figure 9A, the porous member 430 includes a single fluidic port 436
15 aligned to the middle of the second surface 420. There would be stronger suction force at the middle compared to the left and right areas of the second surface 420. For example in Figure 9B, the porous member 430 includes two fluidic ports 436 aligned to the left and right areas of the second surface 420. There would be stronger suction force at the left and right areas compared to the middle of the second surface 420. For
20 example in Figure 9C, the porous member 430 includes three fluidic ports 436 aligned to the middle and the left and right areas of the second surface 420. There would be more homogenous suction force across the second surface 420. It will be appreciated that more uniform distribution of the fluidic ports 436 across the second surface 420 would result in more homogenous suction force across the second surface 420.

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The number and positions of the fluidic ports 436 can affect the pickup direction of the label by the second surface 420 as well as the release direction of the label from the second surface 420. For example, the pickup / release direction may be unidirectional from front to back, back to front, or side to side. For example, the pickup / release
30 direction may start from the middle and spread outwardly.

Third Device 500

In representative or exemplary embodiments of the present disclosure, with reference to Figures 10A and 10B, there is a third device or an end effector device 500 for applying a label on a product 300. The product 300 has a labelling surface 310 that can be curved, slanted, uneven, or undulating. The end effector device 500 includes the first device 200 and the second device 400. The first surface 210 of the first device 200 is connectable to a mechanical arm 510 such as a robotic arm or gripper. The first surface 410 of the second device 400 is connected to the second surface 220 of the first device 200. The second surface 420 of the second device 400 holds the label to be applied on the labelling surface 310. For example, the mechanical arm 510 is configured to supply the vacuum pressure to the first device 200 and the second device 400 to pick up and hold the label.

When the end effector device 500 is axially displaced along the axial direction 320 by the mechanical arm 510 towards the product 300, the peripheral portions of the flexible sections 230 are differentially compressed by the labelling surface 310 and the porous member 430 is deformed by the labelling surface 310 to conform the second surface 420 of the porous member 430 to the labelling surface 310 and thereby apply the label on the labelling surface 310. Additionally, the peripheral members 440 are moved by the deformed porous member 430 to conform to the labelling surface 310 and thereby apply the side edges of the label on the labelling surface 310. For example, the mechanical arm 510 is configured to release the vacuum pressure to release the label.

It will be appreciated that various aspects of the first device 200 and the second device 400 apply similar or analogously to the end effector device 500 and are not further described for purpose of brevity. The devices 200,400,500 described herein improve the application of labels on the labelling surfaces 310 of products 300. As products 300 become more and more varied with packagings of various shapes and sizes, the devices 200,400,500 can be used to apply the labels more neatly with lower risk of defects such as bubbles, creases, and poor adhesion of the side edges of the label.

Additive Manufacturing

The first device 200, second device 400, third device 500, and parts thereof can be fabricated by various manufacturing methods, such as casting, injection moulding, laser cutting, and CNC machining. In some embodiments, any one of the devices 200,400,500 or parts thereof or a product comprising any one of the devices
5 200,400,500 or parts thereof may be formed by a manufacturing process that includes an additive manufacturing process. A common example of additive manufacturing is three-dimensional (3D) printing; however, other methods of additive manufacturing are available. Rapid prototyping or rapid manufacturing are also terms which may be used to describe additive manufacturing processes.

10 As used herein, “additive manufacturing” refers generally to manufacturing processes wherein successive layers of material(s) are provided on each other to “build-up” layer-by-layer or “additively fabricate”, a 3D component. This is compared to some subtractive manufacturing methods (such as milling or drilling), wherein material is
15 successively removed to fabricate the part. The successive layers generally fuse together to form a monolithic component which may have a variety of integral sub-components. In particular, the manufacturing process may allow an example of the disclosure to be integrally formed and include a variety of features not possible when using prior manufacturing methods.

20 Additive manufacturing methods described herein enable manufacture to any suitable size and shape with various features which may not have been possible using prior manufacturing methods. Additive manufacturing can create complex geometries without the use of any sort of tools, moulds, or fixtures, and with little or no waste
25 material. Instead of machining components from solid billets of plastic or metal, much of which is cut away and discarded, the only material used in additive manufacturing is what is required to shape the part.

Suitable additive manufacturing techniques in accordance with the present disclosure
30 include, for example, Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), 3D printing such as by inkjets and laserjets, Stereolithography (SLA), Direct Selective Laser Sintering (DSLS), Electron Beam Sintering (EBS), Electron Beam Melting (EBM), Laser Engineered Net Shaping (LENS), Electron Beam Additive

Manufacturing (EBAM), Laser Net Shape Manufacturing (LNS), Direct Metal Deposition (DMD), Digital Light Processing (DLP), Continuous Digital Light Processing (CDLP), Direct Selective Laser Melting (DSLM), Selective Laser Melting (SLM), Direct Metal Laser Melting (DMLM), Direct Metal Laser Sintering (DMLS), Material Jetting (MJ), NanoParticle Jetting (NPJ), Drop On Demand (DOD), Binder Jetting (BJ), Multi Jet Fusion (MJF), Laminated Object Manufacturing (LOM), and other known processes.

The additive manufacturing processes described herein may be used for forming components using any suitable material. For example, the material may be metal, plastic, polymer, composite, or any other suitable material that may be in solid, liquid, powder, sheet material, wire, or any other suitable form or combinations thereof. More specifically, according to exemplary embodiments of the present disclosure, the additively manufactured components described herein may be formed in part, in whole, or in some combination of materials suitable for use in additive manufacturing processes and which may be suitable for the fabrication of examples described herein.

As noted above, the additive manufacturing process disclosed herein allows a single component to be formed from single or multiple materials. Thus, the examples described herein may be formed from any suitable mixtures of the above materials. For example, a component may include multiple layers, segments, or parts that are formed using different materials, processes, and/or on different additive manufacturing machines. In this manner, components may be constructed which have different materials and material properties for meeting the demands of any particular application. In addition, although the components described herein are constructed entirely by additive manufacturing processes, it should be appreciated that in alternate embodiments, all or a portion of these components may be formed via casting, machining, and/or any other suitable manufacturing process. Indeed, any suitable combination of materials and manufacturing methods may be used to form these components.

Additive manufacturing processes typically fabricate components based on 3D information, for example a 3D computer model (or design file), of the component.

Accordingly, examples described herein not only include products or components as described herein, but also methods of manufacturing such products or components via additive manufacturing and computer software, firmware or hardware for controlling the manufacture of such products via additive manufacturing.

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The structure of the product may be represented digitally in the form of a design file. A design file, or computer aided design (CAD) file, is a configuration file that encodes one or more of the surface or volumetric configuration of the shape of the product. That is, a design file represents the geometrical arrangement or shape of the product.

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Design files can take any now known or later developed file format. For example, design files may be in the Stereolithography or “Standard Tessellation Language” (.stl) format which was created for Stereolithography CAD programs of 3D Systems, or the Additive Manufacturing File (.amf) format, which is an American Society of Mechanical Engineers (ASME) standard that is an extensible markup-language (XML) based format designed to allow any CAD software to describe the shape and composition of any 3D object to be fabricated on any additive manufacturing printer. Further examples of design file formats include AutoCAD (.dwg) files, Blender (.blend) files, Parasolid (.x_t) files, 3D Manufacturing Format (.3mf) files, Autodesk (3ds) files, Collada (.dae) files and Wavefront (.obj) files, although many other file formats exist.

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Design files can be produced using modelling (e.g. CAD modelling) software and/or through scanning the surface of a product to measure the surface configuration of the product. Once obtained, a design file may be converted into a set of computer executable instructions that, once executed by a processor, cause the processor to control an additive manufacturing apparatus to produce a product according to the geometrical arrangement specified in the design file. The conversion may convert the design file into slices or layers that are to be formed sequentially by the additive manufacturing apparatus. The instructions (otherwise known as geometric code or “G-code”) may be calibrated to the specific additive manufacturing apparatus and may specify the precise location and amount of material that is to be formed at each stage in the manufacturing process. As discussed above, the formation may be through

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deposition, through sintering, or through any other form of additive manufacturing method.

The code or instructions may be translated between different formats, converted into a set of data signals and transmitted, received as a set of data signals and converted to code, stored, etc., as necessary. The instructions may be an input to the additive manufacturing system and may come from a part designer, an intellectual property (IP) provider, a design company, the operator or owner of the additive manufacturing system, or from other sources. An additive manufacturing system may execute the instructions to fabricate the product using any of the technologies or methods disclosed herein.

Design files or computer executable instructions may be stored in a (transitory or non-transitory) computer readable storage medium (e.g., memory, storage system, etc.) storing code, or computer readable instructions, representative of the product to be produced. As noted, the code or computer readable instructions defining the product that can be used to physically generate the object, upon execution of the code or instructions by an additive manufacturing system. For example, the instructions may include a precisely defined 3D model of the product and can be generated from any of a large variety of well-known CAD software systems such as AutoCAD®, TurboCAD®, DesignCAD 3D Max, etc. Alternatively, a model or prototype of the product may be scanned to determine the 3D information of the product. Accordingly, by controlling an additive manufacturing apparatus according to the computer executable instructions, the additive manufacturing apparatus can be instructed to print out the product.

In light of the above, embodiments include methods of manufacture via additive manufacturing. This includes the steps of obtaining a design file representing the product and instructing an additive manufacturing apparatus to manufacture the product according to the design file. The additive manufacturing apparatus may include a processor that is configured to automatically convert the design file into computer executable instructions for controlling the manufacture of the product. In these embodiments, the design file itself can automatically cause the production of the

product once input into the additive manufacturing apparatus. Accordingly, in this embodiment, the design file itself may be considered computer executable instructions that cause the additive manufacturing apparatus to manufacture the product. Alternatively, the design file may be converted into instructions by an external
5 computing system, with the resulting computer executable instructions being provided to the additive manufacturing apparatus.

Given the above, the design and manufacture of implementations of the subject matter and the operations described in this specification can be realized using digital
10 electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them. For instance, hardware may include processors, microprocessors, electronic circuitry, electronic components, integrated circuits, etc. Implementations of the subject matter described in this specification can be realized
15 using one or more computer programs, i.e., one or more modules of computer program instructions, encoded on computer storage medium for execution by, or to control the operation of, data processing apparatus. Alternatively or in addition, the program instructions can be encoded on an artificially generated propagated signal, e.g., a machine-generated electrical, optical, or electromagnetic signal that is generated to
20 encode information for transmission to suitable receiver apparatus for execution by a data processing apparatus. A computer storage medium can be, or be included in, a computer-readable storage device, a computer-readable storage substrate, a random or serial access memory array or device, or a combination of one or more of them. Moreover, while a computer storage medium is not a propagated signal, a computer
25 storage medium can be a source or destination of computer program instructions encoded in an artificially generated propagated signal. The computer storage medium can also be, or be included in, one or more separate physical components or media (e.g., multiple CDs, disks, or other storage devices).

30 Although additive manufacturing technology is described herein as enabling fabrication of complex objects by building objects point-by-point, layer-by-layer, typically in a vertical direction, other methods of fabrication are possible and within the scope of the present subject matter. For example, although the discussion herein

refers to the addition of material to form successive layers, one skilled in the art will appreciate that the methods and structures disclosed herein may be practiced with any additive manufacturing technique or other manufacturing technology.

5 In the foregoing detailed description, embodiments of the present disclosure in relation to devices and methods for applying labels on products are described with reference to the provided figures. The description of the various embodiments herein is not intended to call out or be limited only to specific or particular representations of the present disclosure, but merely to illustrate non-limiting examples of the present
10 disclosure. The present disclosure serves to address at least one of the mentioned problems and issues associated with the prior art. Although only some embodiments of the present disclosure are disclosed herein, it will be apparent to a person having ordinary skill in the art in view of this disclosure that a variety of changes and/or modifications can be made to the disclosed embodiments without departing from the
15 scope of the present disclosure. Therefore, the scope of the disclosure as well as the scope of the following claims is not limited to embodiments described herein.

Claims

1. A device for applying a label on a product, the device comprising:

a first surface connectable to a mechanical arm for displacing the device
5 along an axial direction towards the product, the product having a labelling
surface that is at least partially oblique to the axial direction;

a second surface opposite to the first surface, the second surface for
holding the label; and

a set of flexible sections between the first and second surfaces, the
10 flexible sections being resiliently compressible at peripheral portions thereof,

wherein when the device is axially displaced towards the product, the
peripheral portions are differentially compressed by the labelling surface to
conform the second surface to the labelling surface and thereby apply the label
on the labelling surface.

2. The device according to claim 1, wherein the second surface is configured to
hold the label by vacuum pressure.

3. The device according to any one of claims 1 to 3, wherein the flexible sections
20 comprise tubular sections or bellows.

4. The device according to any one of claims 1 to 4, wherein the flexible sections
have varying stiffness at the peripheral portions to facilitate the differential
compression.

5. A method for applying a label on a product, the method comprising:

connecting a first surface of a device to a mechanical arm;

holding the label on a second surface of the device, the second surface
being opposite to the first surface;

30 displacing, using the mechanical arm, the device along an axial direction
towards the product;

engaging the second surface with a labelling surface of the product, the
labelling surface being at least partially oblique to the axial direction;

differentially and resiliently compressing peripheral portions of a set of flexible sections of the device by the labelling surface, the flexible sections being between the first and second surfaces; and

conforming the second surface to the labelling surface resulting from the differential compression of the peripheral portions, thereby applying the label on the labelling surface.

6. The method according to claim 5, comprising holding the label on the second surface by vacuum pressure.

7. The method according to claim 5 or 6, comprising releasing the label from the second surface.

8. The method according to claim 7, comprising releasing the label from the second surface by releasing vacuum pressure.

9. A computer program comprising computer executable instructions that, when executed by a processor, cause the processor to control an additive manufacturing apparatus to manufacture a product comprising the device according to any one of claims 1 to 4.

10. A method of manufacturing a product via additive manufacturing, the method comprising:

obtaining an electronic file representing a geometry of the product wherein the product comprises the device according to any one of claims 1 to 4; and

controlling an additive manufacturing apparatus to manufacture, over one or more additive manufacturing steps, the product according to the geometry specified in the electronic file.

11. A device for applying a label on a product, the device comprising:

a first surface connectable to a mechanical arm for displacing the device to the product having a curved labelling surface;

a porous member comprising a second surface opposite to the first surface, the porous member configured for holding the label on the second surface by vacuum pressure; and

a set of peripheral members bordering the porous member for side edges of the label to align with, the peripheral members being moveable upon deformation of the porous member,

wherein when the device is displaced to the product, the porous member is deformed by the curved labelling surface to conform the second surface to the curved labelling surface and thereby apply the label on the curved labelling surface; and

wherein the peripheral members are moved by the deformed porous member to conform to the curved labelling surface and thereby apply the side edges of the label on the curved labelling surface.

12. The device according to claim 11, wherein the porous member comprises a set of porous layers, each porous layer comprising an arrangement of gaps for airflow therethrough.

13. The device according to claim 11 or 12, wherein the porous member has varying porosity across the second surface.

14. The device according to any one of claims 11 to 13, wherein the porous member comprises a set of fluidic ports for generating the vacuum pressure.

15. The device according to claim 14, wherein the fluidic ports are distributed such that the vacuum pressure is non-homogenous across the second surface.

16. A method for applying a label on a product, the method comprising:

connecting a first surface of a device to a mechanical arm;

holding the label by vacuum pressure on a second surface of a porous member of the device, the second surface being opposite to the first surface;

displacing, using the mechanical arm, the device towards the product;

engaging the second surface with a curved labelling surface of the product;

deforming the porous member by the curved labelling surface;

conforming the second surface to the labelling surface resulting from the deformation of the porous member, thereby applying the label on the curved labelling surface;

moving a set of peripheral members of the device upon deformation of the porous member, the peripheral members bordering the porous member for side edges of the label to align with; and

conforming the peripheral members to the curved labelling surface resulting from the movement of the peripheral members, thereby applying the side edges of the label to the curved labelling surface.

17. The method according to claim 16, comprising releasing the label from the second surface by releasing vacuum pressure.

18. A computer program comprising computer executable instructions that, when executed by a processor, cause the processor to control an additive manufacturing apparatus to manufacture a product comprising the device according to any one of claims 11 to 15.

19. A method of manufacturing a product via additive manufacturing, the method comprising:

obtaining an electronic file representing a geometry of the product wherein the product comprises the device according to any one of claims 11 to 15; and

controlling an additive manufacturing apparatus to manufacture, over one or more additive manufacturing steps, the product according to the geometry specified in the electronic file.

20. An end effector device for applying a label on a product, the end effector device comprising:

(a) a first device comprising:

a first surface connectable to a mechanical arm for displacing the first device along an axial direction towards the product having a labelling surface;

a second surface opposite to the first surface; and

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a set of flexible sections between the first and second surfaces, the flexible sections being resiliently compressible at peripheral portions thereof; and

(b) a second device comprising:

a first surface connected to the second surface of the first device;

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a porous member comprising a second surface opposite to the first surface, the porous member configured for holding the label on the second surface by vacuum pressure; and

a set of peripheral members bordering the porous member for side edges of the label to align with, the peripheral members being moveable upon deformation of the porous member,

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wherein when the end effector device is axially displaced towards the product, the peripheral portions are differentially compressed by the labelling surface and the porous member is deformed by the labelling surface to conform the second surface to the labelling surface and thereby apply the label on the labelling surface; and

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wherein the peripheral members are moved by the deformed porous member to conform to the curved labelling surface and thereby apply the side edges of the label on the curved labelling surface.

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