especially metal foils are expensive, foil imaging processes are relatively high cost methods, as typically a roll of foil can only be used once and, when discarded, only a small fraction of the coating will have been used.

**OBJECT**

The present disclosure seeks *inter alia* to provide a printing method and system that represent an effective alternative to foil imaging but that is more cost effective and environmentally friendly, possibly providing different physical properties to printed matter. Additionally, the method herein disclosed may be used for the preparation of coated substrates.

**SUMMARY**

According to a first aspect of the disclosure, there is provided a method of printing onto a surface of a substrate, which comprises providing an endless donor surface, cyclically passing the donor surface through a coating station from which the donor surface exits coated with a monolayer of individual particles after each passage, wherein the particles adhere more strongly to the donor surface than to one another, and repeatedly performing the steps of:

(i) treating the substrate surface to render the affinity of the particles to at least selected regions of the substrate surface greater than the affinity of the particles to the donor surface,

(ii) contacting the substrate surface with the donor surface to cause particles to transfer from the donor surface only to the treated selected regions of the substrate surface, thereby exposing regions of the donor surface from which particles are transferred to corresponding regions on the substrate; and

(iii) returning the donor surface to the coating station to render the particle monolayer continuous in order to permit printing of a subsequent image on a substrate surface.

It will be appreciated that as in the present printing method the particles form a monolayer on the donor surface, the particles transferred therefrom also form a monolayer on the selected regions of the substrate surface. The regions of the substrate suitably treated may be said to have a receptive layer.

The above method can be used repeatedly to create multiple copies of a same image or of different images on the relevant surfaces of one or more substrates. A series of identical images printed on a same substrate is typically referred to as a “print job”

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or organic absorption pigments). Such coloring effect can also result from the choice of the core particle, or from a partial oxidation of the same.

Whether colored polymers or metal-looking, the particles may provide, once transferred to the printing substrate, for a glossy or matte image, and for any other type of desired effect in accordance with the selected particles.

According to a further aspect of the disclosure, there is provided a printing system comprising:

a continuously circulating endless donor surface,

a coating station for applying particles to the donor surface, the donor surface bearing a monolayer coating of individual particles on exiting the coating station, wherein the particles adhere more strongly to the donor surface than to one another, ,

a treatment station at which a substrate surface is treated to produce selected regions of the substrate surface having an affinity to the particles on the donor surface that is greater than the affinity of the particles to the donor surface, and

an impression station at which the substrate surface contacts the donor surface to cause particles to transfer from the donor surface to only the selected regions of the substrate surface, thereby exposing corresponding regions of the donor surface,

wherein after passing through the impression station, the donor surface returns, during operation, to the coating station for the layer of particles to be rendered continuous by the application of fresh particles to the exposed regions of the donor surface.

It is possible for the coating station to be static, while the donor surface is cyclically movable, being either the outer surface of a rotatable drum, or of an endlessly circulating belt or even of a plate moving back and forth so as to ensure his surface is exposed to the coating station from edge to edge. All such forms of donor surfaces can be said to be movable (*e.g.*, cyclically, endlessly or repeatedly movable) with respect to the coating station where particles can be applied to the donor surface, the donor surface bearing a monolayer coating of individual particles on exiting the coating station (having completed a cycle). The passing of the donor surface through a coating station or the donor surface being continuously circulating therein can be achieved by any such movable donor surface.

In some embodiments, the coating station comprises a supply of particles suspended in a fluid, the particles adhering more strongly to the donor surface than to one another, an application device for applying the fluid to the donor surface in a manner to cause the

CLAIMS

1. A method of printing onto a surface of a substrate, which comprises providing an endless donor surface, cyclically passing the donor surface through a coating station from which the donor surface exits coated with a monolayer of individual particles after each passage, wherein the particles adhere more strongly to the donor surface than to one another, and repeatedly performing the steps of:

(i) treating the substrate surface to render the affinity of the particles to at least selected regions of the substrate surface greater than the affinity of the particles to the donor surface,

(ii) contacting the substrate surface with the donor surface to cause particles to transfer from the donor surface only to the treated selected regions of the substrate surface, thereby exposing regions of the donor surface from which particles are transferred to corresponding regions on the substrate; and

(iii) returning the donor surface to the coating station to render the particle monolayer continuous in order to permit printing of a subsequent image on a substrate surface.

2. A method as claimed in claim 1, wherein the proportion of the particles transferred to the selected regions of the substrate surface is such that a bare surface of the substrate within the selected regions is substantially imperceptible to the naked eye.

3. A method as claimed in claim 1 or claim 2, wherein the proportion of the substrate surface in the selected regions coated with particles is within the range of 80% to 100%.

4. A method as claimed in claim 1 or claim 2, wherein the proportion of the substrate surface in the selected regions coated with particles is within the range of 50% to 80%.

5. A method as claimed in claim 1, wherein the proportion of the substrate surface in the selected regions coated with particles is within the range of 20% to 50%.

6. A method as claimed in any one of claim 1 to claim 5, wherein step (i) comprises applying a receptive layer to the selected regions of the substrate surface.

7. A method as claimed in claim 6, wherein the receptive layer is applied to the substrate surface by indirect printing.

8. A method as claimed in claim 7, wherein the receptive layer is applied to the substrate surface by indirect printing selected from the group comprising offset printing, screen printing, flexographic printing and gravure printing.

9. A method as claimed in claim 6, wherein the receptive layer is applied to the substrate surface by direct printing, including by direct jetting.

10. A method as claimed in any one of claim 1 to claim 5, wherein step (i) comprises exposing the selected regions of the substrate surface to radiation to activate a receptive layer that is pre-applied to the substrate.

11. A method as claimed in any one of claim 6 to claim 10, wherein the receptive layer applied or activated on the substrate surface has a thickness between 0.5 μm and 500 μm.

12. A method as claimed in any one of claim 6 to claim 11, wherein the receptive layer applied or activated on the substrate surface has an outer surface distal from the substrate, said outer surface being substantially smooth with a surface roughness $R_a$ of no more than 2 μm.

13. A method as claimed in any one of claim 6 to claim 12, wherein the receptive layer applied or activated on the substrate surface is substantially dry upon contacting the particles coated on the donor surface.

14. A method as claimed in any one of claim 1 to claim 13, wherein the particles coated on the donor surface are substantially dry upon contacting selected regions of the substrate surface.

15. A method as claimed in any one of claim 1 to claim 14, wherein the particles comprise a coated or uncoated metal, alloy, mica or particles of a polymeric or ceramic material having a metallic appearance or surface reflectivity.

16. A method as claimed in any one of claim 1 to claim 15, wherein the particles are flakes or platelet shaped.

17. A method as claimed in claim 16, wherein at least 50% of the particles, or at least 75% of the particles, or at least 90% of the particles have a thickness not exceeding 100 nm.

18. A method as claimed in claim 16 or claim 17, wherein at least 50% of the particles, or at least 75% of the particles, or at least 90% of the particles have a thickness of at least 10 nm.

19. A method as claimed in any one of claim 16 to claim 18, wherein the particles have an average aspect ratio of at least 10:1, or at least 20:1, or at least 50:1, or at least 100:1 between at least one of a longest dimension, a mean diameter and an equivalent diameter, as the case may be, and a thickness of said platelet.

20. A method as claimed in claim 19, wherein said aspect ratio is at most 200:1, or at most 150:1, or at most 120:1.

21. A method as claimed in any one of claim 16 to claim 20, wherein the particles transferred to the substrate surface are disposed upon the receptive layer in a substantially uniform orientation, the platelets being essentially parallel to a surface of the receptive layer distal to the substrate.

22. A method as claimed in any one of claim 1 to claim 21, which comprises processing the substrate surface further after having made contact with the donor surface.

23. A method as claimed in claim 22, wherein the processing comprises burnishing or applying heat and pressure in order to modify the appearance of the particles adhered to the surface of the substrate.

24. A method as claimed in claim 22, wherein the processing comprises curing or further curing the receptive layer.

25. A method as claimed in any one of claim 22 to claim 24, wherein the processing comprises coating at least the selected regions of the substrate surface or the entire surface of the substrate with a lacquer.

26. A printing system comprising:

- a continuously circulating endless donor surface,

- a coating station for applying particles to the donor surface, the donor surface bearing a monolayer coating of individual particles on exiting the coating station, wherein the particles adhere more strongly to the donor surface than to one another,

- a treatment station at which a substrate surface is treated to produce selected regions of the substrate surface having an affinity to the particles on the donor surface that is greater than the affinity of the particles to the donor surface, and

- an impression station at which the substrate surface contacts the donor surface to cause particles to transfer from the donor surface to only the selected regions of the substrate surface, thereby exposing corresponding regions of the donor surface,

wherein after passing through the impression station, the donor surface returns, during operation, to the coating station for the layer of particles to be rendered continuous by the application of fresh particles to the exposed regions of the donor surface.

27. A printing system as claimed in claim 26, wherein the coating station comprises:

a) a supply of particles suspended in a fluid, the particles adhering more strongly to the donor surface than to one another,

b) an application device for applying the fluid to the donor surface in a manner to cause the particles suspended in the fluid to adhere to the donor surface so as to form a particle coating on the surface, and

c) a surplus extraction system operative to extract fluid and to remove surplus particles that are not in direct contact with the surface, so as to leave only a monolayer of particles adhering to the surface on exiting the coating station.

28. A printing system as claimed in claim 27, wherein the application device comprises a spray head for spraying the fluid and suspended particles directly onto the donor surface.

29. A printing system as claimed in claim 27, wherein the application device comprises a rotatable applicator operative to wipe the fluid and suspended particles onto the donor surface.

30. A printing system as claimed in claim 29, wherein the applicator is a cylindrical sponge or a roller having a plurality of flexible strips extending radially from a central axle.

31. A printing system as claimed in claim 30, wherein the sponge or the flexible strips are formed of a closed-cell foam.

32. A printing system as claimed in any one of claim 27 to claim 31, wherein the application device is contained within an interior plenum of a housing having a rim adjacent the donor surface, the rim being configured to prevent egress of particles from a sealing gap defined between the rim of the housing and the donor surface.

33. A printing system as claimed in claim 32, wherein a wiper blade is provided at the rim to prevent egress of particles and/or fluid from the coating apparatus.

34. A printing system as claimed in claim 32 or claim 33, wherein the surplus extraction system includes a suction source connected to the housing to extract from the plenum surplus sprayed fluid and particles suspended in the sprayed fluid.

35. A printing system as claimed in any one of claim 26 to claim 34, wherein the fluid is a liquid and the system further comprises a drying station located between the coating station and the impression station for removing any residual liquid remaining on the donor surface on exiting the coating station.

36. A printing system as claimed in any one of claim 26 to claim 35, further comprising at least one of a cleaning device, a liquid absorbing device, a conditioning device and a post-transfer device.

37. A printing method as claimed in any one of claim 1 to claim 25, wherein the particles are of a coated or uncoated metal, alloy, or mica, or made of a polymeric or ceramic material having a metallic appearance.

38. A printing method as claimed in any one of claim 1 to claim 25 and claim 37, wherein the particles have the form of flat platelets.