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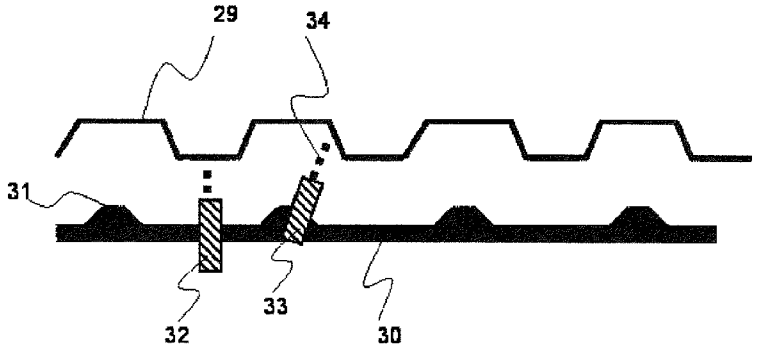


Fig. 5

(57) Abstract: A method of UV curable inkjet printing on a cuboid shaped object including the steps of: a) bringing and holding at least part of an inkjet printing device in physical contact with the cuboid shaped object; and b) jetting and UV curing an image of one or more UV curable inks on at least one vertical panel of the cuboid shaped object; wherein the cuboid shaped object is selected from intermodal freight containers, crates, trucks, trailers, semi-trailers and boxcars.

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## Description

# Large Cuboid Shaped Object Inkjet Printing

## Technical Field

[0001] The present invention relates to inkjet printing on large cuboid shaped objects such as intermodal freight containers, trucks and railway cars.

## Background Art

[0002] Intermodal containerized traffic has surged since the 1990s to ship products on international and national markets, particularly for non bulk commodities. "Intermodal" means that the container can be moved from one mode of transport to another, e.g. from ship to rail to truck, without unloading and reloading the contents of the container.

[0003] The manufacturing of intermodal freight containers is well-known. Generally, the containers are made of metal and their assembly involves the production and welding of flat or corrugated metal panels. Newer techniques involve moulding thermoplastic material into a container as exemplified by **US 2010264137** (LAMPE) . In a finishing stage of the manufacturing process, the container is painted by spraying solvent based paint. The painting includes the application of a primer, the application of a background paint, and the application of a company logo and text information, such as an owner code, container identification code, product group code, maximum weight, container weight, cubic capacity and the like. The application of the primer and the application of the background paint is usually by an automatic paint spray device as shown in, for example, **CN 101480643** (CIMC) . The painting of a company logo and text information is performed by applying adhesive masks of the logo and alphanumerical characters on a container panel, followed by spraying paint on the inside of the mask. This painting process is very time-consuming, especially if multiple colours are required, and leads also often to errors in applying the masks, causing expensive re-painting and additional loss of time.

[0004] In an attempt to increase productivity, the masks were replaced by adhesive decorative films pre-printed with the required logo and/or

alphanumerical characters, usually so-called decals. This method caused a significant reduction of errors in the alphanumerical data. However, due to corrugated panels used in container for increasing the strength of a container, the films were often applied askew. **EP 2108515** A (BOEING) discloses an apparatus for application and accurate positioning of a graphic image on a large contoured surface, comprising a flexible-rail positioning system mounted on a portion of the surface on which the graphic image is to be applied.

[0005] In addition, it was observed that after time that some of the adhesive markings disappeared from the container panels due to weathering conditions, conditions of transport (including the exposure to sea-water and traffic emissions) and vandalism. **US 2010316853** A (AIRBUS) discloses the spraying of an aircraft with a layer of clear paint containing a UV filter for erosion protection of the decorative film.

[0006] **US 20070062383 A1** (University de Poitiers) discloses a print robot for large format three-dimensional printing on a fixed surface, comprising an inkjet printing assembly, means for displacing and orientating this printing assembly along several axes, at least one control unit controlling these means and a drying device for the ink sprayed onto said surface, wherein said robot is a print robot with five motorized axes and wherein the displacement and orientation means comprise a carrier with three degrees of freedom in translation, which ensures positioning of the printing assembly allowing its horizontal, vertical and depth translation, a wrist with two degrees of freedom in rotation which supports and ensures the orientation of the printing assembly allowing its rotations (Rx, Ry) along two perpendicular axes. The print robot makes no physical contact with the fixed surface.

[0007] Hence, there is a still a need for an improved method of applying logo's, safety messages and alphanumerical information on large cuboid shaped objects such as intermodal freight containers.

**Summary of invention**

[0008] In order to overcome the problems described above, preferred embodiments of the present invention have been realised with an inkjet printing method as defined by **claim 1**.

[0009] The printing method using UV curable ink and UV curing provides for higher productivity by a simplification of the workflow to manufacture intermodal freight containers, thereby making it also a more economical process.

[0010] An advantage of the inkjet printing method is that variable data and images can be printed on each large cuboid shaped object. This allows generating extra income for container manufacturers that can sell the large surface for long-lasting advertisements. In addition the alphanumerical data is controlled by a computer which almost eliminates errors in, for example, the owner code or the container identification codes, such as bar-codes and QR-codes.

[0011] Further objects of the invention will become apparent from the description hereinafter.

**Brief description of drawings**

[0012] Figure 1 shows state-of-the-art cuboid shaped intermodal freight containers.

[0013] Figure 2 shows a three dimensional view of a standard container skeleton 6.

[0014] Figure 3 shows an exploded view of a standard container.

[0015] Figure 4 shows examples of large cuboid shaped objects: a truck 25, a trailer 26, a semi-trailer 27 and a boxcar 28.

[0016] Figure 5 shows a cross-section of a corrugated surface 29 of a container being printed using a rail 30 with protrusions 31 as a passive distance controller so that the print head in a first position 32 and the print head in a second position 33 are at approximately the same distance of the corrugated surface 29.

[0017] Figure 6 shows a cross-section of a corrugated surface 29 of a container being printed using an active distance controller 35 so that the print head in a first position 32 and the print head in a second position 33 are at approximately the same distance of the corrugated surface 29.

[0018] Figure 7 shows a preferred embodiment for printing a corrugated surface 29 using a print head array 37 of a plurality of individual print heads 36.

**Detailed description**

Definitions

[0019] The term "image" includes text, numbers, graphics, logo's, photo's, identification codes (codes such as barcodes, QR codes, and the like) and the like. An image can be defined in 1 or more colours.

[0020] The term "inkjet ink set", as used in disclosing the present invention means the inkjet ink set which is coupled to the inkjet printing device.

UV Curable Inkjet Printing Methods

[0021] The method of UV curable inkjet printing on a cuboid shaped object according to the present invention includes the steps of: a) bringing and holding at least part of an inkjet printing device in physical contact with the cuboid shaped object; and b) jetting and UV curing an image of one or more UV curable inks on at least one vertical panel of the cuboid shaped object; wherein the cuboid shaped object is selected from intermodal freight containers, crates, trucks, trailers, semi-trailers and boxcars. In a preferred embodiment, the cuboid shaped object is an intermodal freight container.

[0022] For achieving good image quality, it was found necessary to bring and hold at least part of an inkjet printing device in physical contact with the cuboid shaped object. Contact is preferably made in at least two corners, more preferably three corners and mostly preferably four corners (e.g. the corner fittings 9 in Figure 2) of a vertical panel of the cuboid shaped object. This allows to accurately control the average distance between an inkjet nozzle and a plane parallel with the vertical panel. The panel may be completely flat so that it coincides fully with that plane, but usually the vertical panel is not completely flat but has a corrugated surface as shown by the sidewall panel 16 of the container in Figure 3. Corrugated sidewall panels are advantageous because they tend to increase the physical strength of a container.

[0023] The corner fittings are often made of steel so that magnets can be used to realize the physical contact between the inkjet printing device and the

cuboid shaped object. The magnets are preferably electromagnets because attachment and detachment of the inkjet printing device on the cuboid shaped object can be easily controlled by switching an electrical current on respectively off. Alternatively suction cups or clamps may be used to realize the physical contact. Suction cups are preferred because they tend to cause less surface damage, such as scratches, than clamps.

[0024] In a preferred embodiment, the physical contact is accomplished by two, three, four or more attachment means selected from the group consisting of suction cups, electromagnets and clamps.

[0025] In a further preferred embodiment, physical contact is made not only at a corner fitting 9 but also at a top end rail 8 and/or a corner post 10 of a container skeleton 6 as shown in Figure 2.

[0026] Bringing part of an inkjet printing device in physical contact with the cuboid shaped object is preferably accomplished by sliding it over one or more rails towards the cuboid shaped object, by riding it on wheels towards the cuboid shaped object, or by swinging it towards the cuboid shaped object. In the latter case, the inkjet printing device or the at least part of the inkjet printing device is suspended from the ceiling of the room wherein the inkjet printing device and the cuboid shaped object are located, but preferably the inkjet printing device or the at least part of the inkjet printing device is suspended from a bridge mounted over the cuboid shaped object.

[0027] Instead of using suction cups, electromagnets and clamps to maintain physical contact, also simple surface sensing devices can be used which only touch the surface. The force to maintain physical contact is then delivered by means capable of pressing the at least part of an inkjet printing device against the vertical panel. The sensing devices are preferably also located on at least two corners, more preferably three corners and mostly preferably four corners of the large cuboid shaped object.

[0028] The attachment means, such as suction cups, electromagnets and clamps for realizing the physical contact between the inkjet printing device and the cuboid shaped objet are preferably adjustable in X,Y and Z direction for

optimal alignment of the inkjet printing device with the cuboid shaped object.

[0029] Sensing devices may also be present on the corner posts 10 and/or top side rail 7, for accurately positioning or centering the image on the side wall panel 16.

[0030] When the vertical panel is not completely flat but has, for example, a corrugated surface, then the distance between an inkjet nozzle and the surface of the at least one vertical panel is controlled by an active or passive distance controller.

[0031] The technology behind active distance controllers is well-known to the skilled person. For example, ultrasonic sensors are used in a PDC (Parking Distance Control) system for helping a driver to park his car. Active distance control systems using laser or laser diodes are used also in a radar apparatus like disclosed by **US 5864391** (DENSO) or in speed guns. In a preferred embodiment of the UV curable inkjet printing method, the active distance controller uses an ultrasonic sensor, an infrared sensor or a photoelectric distance sensor, also called distance measuring photoelectric sensor. A distance measuring photoelectric sensor provides a dynamic continuous analog output signal, in some cases a digital output can be activated as well, that relates to object position. These sensors emit either a visible red or preferably a laser light that reflects back to the sensor.

[0032] Alternatively a passive distance controller may be used. A passive distance controller is a fixed means, such as a rail 30 with protrusions 31 as shown in Figure 5, which matches the relief of a vertical panel so that minimal distance variations are obtained between the inkjet nozzle and the surface of the at least one vertical panel as a print head travels across the rail 30. Preferably, the rail with protrusions is easily replaceable, so that vertical panels with a differently corrugated surface can be printed with the same inkjet printing device. An active distance controller has the advantage over a passive distance controller that differently shaped vertical panels e.g. with and without a corrugated surface can be inkjet

printed upon without the necessity to replace the passive distance controller by a differently shaped passive distance controller.

[0033] In the UV curable inkjet printing method, the image is preferably jetted and cured simultaneously on at least two panels of the cuboid shaped object. For example, the image is preferably jetted and cured simultaneously on both sidewall panels 16 of the container shown in Figure 3.

[0034] Preferably also an image is jetted and cured on the horizontal roof panel. Such an image may consist of the container identification code, which can be useful for the operator of a straddle carrier. In a more preferred embodiment, the image on the roof panel is jetted and cured simultaneously with both sidewall panels 16 of a container as shown in Figure 3.

Cuboid Shaped Objects

[0035] The cuboid shaped object is selected from intermodal freight containers, crates, trucks, trailers, semi-trailers and boxcars. In a preferred embodiment, the cuboid shaped object is an intermodal freight container, preferably a refrigerated container or reefer 2 including a refrigeration unit 4 as shown in Figure 1.

[0036] Figure 1 merely shows some examples of an intermodal freight containers, such as a standard container 1, a reefer 2 and an open-top container 3. Most parts of an intermodal freight container and their assembly are shown in figures 2 and 3.

[0037] Another preferred cuboid shaped object is a crate, which is a container made of wood for storage or as a shipping container.

[0038] Other preferred cuboid shaped objects are a truck 25, a trailer 26, a semi-trailer 27 and a boxcar 28. A boxcar is also known as a cargo railway car.

[0039] The intermodal freight container preferably has as external dimensions a length between 5.5 m and 13.8 m, a width of about 2.4 m and a height between 2.2 m and 2.9 m.

[0040] The large cuboid shaped object preferably has an internal volume exceeding 1 $m^3$, preferably exceeding 3 $m^3$ and preferably exceeding 10 $m^3$.

[0041] The cuboid shaped object is preferably an intermodal freight container following the specifications of ISO 668:2013.

[0042] Since at present no cuboid shaped intermodal freight container having a UV cured inkjet image on a vertical panel is known or thought off, a preferred embodiment of the current invention includes a method of manufacturing a cuboid shaped intermodal freight container comprising the above described inkjet printing method.

[0043] The vertical panel may be a corrugated panel. In a preferred embodiment, the corrugation is preferably less than 5 mm deep, so that printing speed can be maximized, more preferably no corrugation is present. This latter preferred option can be achieved, for example, by having a corrugated side wall panel covered by a flat plate. In this manner, both the physical strength of the container due to the corrugation and the image quality due to a flat surface can be maximized simultaneously.

UV curable inks

[0044] One or more UV curable inks are jetted and UV cured by the inkjet printing device in physical contact with the cuboid shaped object.

[0045] The one or more UV curable inks are preferably free radical curable inks. . It was found that cationically curable inkjet inks posed problems of jetting reliability in industrial inkjet printing systems due to UV stray light. UV stray light hitting nozzles may result into failing nozzles due to clogging by cured ink in a nozzle. Unlike free radical ink where radical species have a much shorter lifetime, the cationic curable ink continues to cure once an acid species has been generated by UV light in the nozzle.

[0046] The UV curable inkjet ink is preferably part of a UV curable inkjet ink set. Such a curable ink set preferably includes at least one cyan curable ink (C) and at least one magenta curable ink (M), at least one yellow curable ink (Y), and preferably also at least one black curable ink (K). The curable CMYK-ink set may also be extended with extra inks such as red, green, blue, and/or orange to further enlarge the colour gamut. The CMYK ink set may also be extended by the combination of the full density inkjet inks with light density inkjet inks. The combination of dark and light colour inks

and/or black and grey inks improves the image quality by a lowered graininess.

[0047] In a preferred embodiment, the one or more UV curable inkjet inks include a spot colour inkjet ink. In a more preferred embodiment the spot colour inkjet inks has a colour selected from the group consisting of RAL 1033, RAL 2000, RAL 2002, RAL 2004, RAL 3003, RAL 3005, RAL 3009, RAL 5003, RAL 5010, RAL 5013, RAL 5015, RAL 6002, RAL 6005, RAL 6013, RAL 6017, RAL 6018, RAL 7000, RAL 7031, RAL 7035, RAL 7037, RAL 7038, RAL 8004, RAL 8012, and RAL 9010.

[0048] In another embodiment, one or more (spot colour) UV curable inkjet inks may be mixed from a basis UV curable inkjet set, e.g. CMYK, using an ink mixing station. The ink mixing station may mix the basis UV curable inkjet set to an ink with a colour selected from the group consisting of RAL 1033, RAL 2000, RAL 2002, RAL 2004, RAL 3003, RAL 3005, RAL 3009, RAL 5003, RAL 5010, RAL 5013, RAL 5015, RAL 6002, RAL 6005, RAL 6013, RAL 6017, RAL 6018, RAL 7000, RAL 7031, RAL 7035, RAL 7037, RAL 7038, RAL 8004, RAL 8012, and RAL 9010.

[0049] Printing with spot colours improves the productivity of the inkjet printing process by allowing faster printing using less ink.

[0050] In a preferred embodiment, the one or more UV curable inks include a white ink. This allows to mask the colour of primers and paints and allows for more vibrant colours from the more UV curable inks.

[0051] In a preferred embodiment, the one or more UV curable inkjet inks form an ink set of 4 to 6 UV curable inkjet inks.

[0052] The UV curable inkjet ink set may be made using four inkjet inks having a colour selected from the group consisting of RAL 1033, RAL 2000, RAL 2002, RAL 2004, RAL 3003, RAL 3005, RAL 3009, RAL 5003, RAL 5010, RAL 5013, RAL 5015, RAL 6002, RAL 6005, RAL 6013, RAL 6017, RAL 6018, RAL 7000, RAL 7031, RAL 7035, RAL 7037, RAL 7038, RAL 8004, RAL 8012, and RAL 9010.

[0053] However preferably the UV curable inkjet ink set includes at least one cyan curable ink (C) and at least one magenta curable ink (M), at least one yellow curable ink (Y), and preferably also at least one black curable ink

(K). The curable CMYK-ink set may also be extended with extra inks such as the above mentioned spot colours. Using CMYK inks allows not only for a much larger colour gamut but also allows the use of conventional colour management systems used in graphic arts applications.

[0054] The static surface tension of the UV curable inkjet ink is preferably from 20 to 40 mN/m, more preferably from 22 to 35 mN/m. It is preferably 20 mN/m or more from the viewpoint of printability by a second radiation curable inkjet ink, and it is preferably not more than 30 mN/m from the viewpoint of the wettability. Therefore, the one or more UV curable inkjet inks preferably also contain at least one surfactant.

[0055] UV curable inkjet inks used in traditional graphic arts applications normally have a viscosity at a shear rate of 1,000 $s^{-1}$and at 25°C which is smaller than 30 mPa.s, often smaller than 15 mPa.s. For printing vertical panels of large cuboid shaped objects, the viscosity is preferably higher than 40 mPa.s at a shear rate of 1,000 $s^{-1}$and at 25°C. A low viscosity requires a very high power UV curing, since else the jetted ink would run down the vertical surface. Using higher viscosity ink in combination with suitable print heads allows to reduce the cost of the UV curing device. For maximizing printing speed, the viscosity is preferably not higher than 600 mPa.s at a shear rate of 1,000 $s^{-1}$and at 25°C

[0056] In one preferred embodiment, the one or more UV curable inks are one or more UV curable phase change inks. UV curable phase change inks are solid at room temperature but become liquid at higher jetting temperatures. This behaviour can be advantageously used for improving image quality. A UV curable phase change inkjet ink solidifies on landing on a vertical panel having room temperature and the run down of ink is minimized. UV curable phase change inkjet inks are well-known to skilled person. Such inks are exemplified in, for example, **US 2012224011** (XEROX) and **US 2008122914** (XEROX) .

Primers and Paints

[0057] The chemical nature of the primers and paints may differ from the UV curable inks. For example, they may be solvent based, because the

requirements for the application of primers and paints are less demanding than those for the image wise application of UV curable inks.

[0058] The primers and paints may have a colour selected from the group consisting of RAL 1033, RAL 2000, RAL 2002, RAL 2004, RAL 3003, RAL 3005, RAL 3009, RAL 5003, RAL 5010, RAL 5013, RAL 5015, RAL 6002, RAL 6005, RAL 6013, RAL 6017, RAL 6018, RAL 7000, RAL 7031, RAL 7035, RAL 7037, RAL 7038, RAL 8004, RAL 8012, and RAL 9010.

[0059] In a preferred embodiment of the UV curable inkjet printing method, a primer is applied to a vertical panel before jetting the image. The primer normally includes some protective components such as anti-rust compounds. Such components often limit the number of colours wherein a primer is available. Therefore preferably a paint having the desired colour is sprayed on the primed vertical panel before jetting an image with the one or more UV curable inks.

Colorants

[0060] The colorant in the UV curable inkjet ink can be a dye but is preferably a colour pigment for reasons of light fading. The pigmented UV curable ink preferably contains a dispersant, more preferably a polymeric dispersant, for dispersing the pigment. The pigmented curable ink may contain a dispersion synergist to improve the dispersion quality and stability of the ink.

[0061] The pigments may be black, cyan, magenta, yellow, red, orange, violet, blue, green, brown, mixtures thereof, and the like. A colour pigment may be chosen from those disclosed by HERBST, Willy, et al. Industrial Organic Pigments, Production, Properties, Applications. 3rd edition. Wiley - VCH , 2004. ISBN 3527305769.

[0062] Preferred pigments are disclosed in paragraphs [0128] to [0138] of **WO 2008/074548** (AGFA) . Also mixed crystals may be used. Mixed crystals are also referred to as solid solutions. For example, under certain conditions different quinacridones mix with each other to form solid solutions, which are quite different from both physical mixtures of the compounds and from the compounds themselves. In a solid solution, the molecules of the components enter into the same crystal lattice, usually,

but not always, that of one of the components. The x-ray diffraction pattern of the resulting crystalline solid is characteristic of that solid and can be clearly differentiated from the pattern of a physical mixture of the same components in the same proportion. In such physical mixtures, the x-ray pattern of each of the components can be distinguished, and the disappearance of many of these lines is one of the criteria of the formation of solid solutions. A commercially available example is Cinquasia™ Magenta RT-355-D from Ciba Specialty Chemicals.

[0063] Mixtures of pigments may also be used. For example, the UV curable inkjet ink may include a black pigment and at least one pigment selected from the group consisting of a blue pigment, a cyan pigment, magenta pigment and a red pigment. It was found that such a black inkjet ink allowed easier and better colour management and also gave a more pleasing neutral black colour instead of a brownish black colour.

[0064] Instead of organic colour pigments, also inorganic colour pigments may be used.

[0065] Particularly preferred inorganic colour pigments are infrared reflective pigments. The advantage of using such pigments is that less heat is transferred into the intermodal freight containers, trucks and boxcars, leading to a longer shelf-life of the contents in the containers. Using infrared reflective pigments also reduces the energy consumption by reefers.

[0066] The infrared reflective pigments can also be blended with organic colour pigments.

[0067] Suitable commercially available infrared reflective pigments are Altiris™ pigments from Huntsman and Arctic™ infrared-reflective pigments from Shepherd Color Company.

[0068] Pigment particles in inkjet inks should be sufficiently small to permit free flow of the ink through the inkjet printing device, especially at the ejecting nozzles. It is also desirable to use small particles for maximum colour strength and to slow down sedimentation.

[0069] Pigment particles of 4 to 15 µm can be used for producing single colours, however for producing a plurality of colours with the UV curable inkjet inks,

the numeric average pigment particle size is preferably between 0.050 and 1 µm, more preferably between 0.070 and 0.300 µm and particularly preferably between 0.080 and 0.200 µm. Most preferably, the numeric average pigment particle size is no larger than 0.200 µm. An average particle size smaller than 0.050 µm is less desirable for decreased light fastness. An average pigment particle size is larger than 0.200 µm reduces the colour gamut. The average particle size of pigment particles is determined with a Brookhaven Instruments Particle Sizer BI90plus based upon the principle of dynamic light scattering. The ink is diluted with ethyl acetate to a pigment concentration of 0.002 wt%. The measurement settings of the BI90plus are: 5 runs at 23°C, angle of 90°, wavelength of 635 nm and graphics = correction function.

[0070] However for white pigment inkjet inks, the numeric average particle diameter of the white pigment is preferably from 50 to 500 nm, more preferably from 150 to 400 nm, and most preferably from 200 to 350 nm. Sufficient hiding power cannot be obtained when the average diameter is less than 50 nm, and the storage ability and the jet-out suitability of the ink tend to be degraded when the average diameter exceeds 500 nm.

[0071] The determination of the average particle size (the numeric average particle diameter) is best performed by photon correlation spectroscopy at a wavelength of 633 nm with a 4mW HeNe laser on a diluted sample of the pigmented inkjet ink. A suitable particle size analyzer used was a Malvern™ nano-S available from Goffin-Meyvis. A sample can, for example, be prepared by addition of one drop of ink to a cuvette containing 1.5 mL ethyl acetate and mixed until a homogenous sample was obtained. The measured particle size is the average value of 3 consecutive measurements consisting of 6 runs of 20 seconds.

[0072] Suitable white pigments are given by Table 2 in [0116] of **WO 2008/074548** (AGFA) . The white pigment is preferably a pigment with a refractive index greater than 1.60. The white pigments may be employed singly or in combination. Preferably titanium dioxide is used as pigment with a refractive index greater than 1.60. Preferred titanium dioxide

pigments are those disclosed in [0117] and in [0118] of **WO 2008/074548** (AGFA) .

[0073] The pigments are preferably present in the range of 3.0 wt% to 20.0 wt%.

Dispersants

[0074] The pigmented radiation curable inkjet ink preferably contains a dispersant, more preferably a polymeric dispersant, for dispersing the pigment. The pigmented radiation curable inkjet ink may contain a dispersion synergist to improve the dispersion quality and stability of the inkjet ink.

[0075] Suitable polymeric dispersants are copolymers of two monomers but they may contain three, four, five or even more monomers. The properties of polymeric dispersants depend on both the nature of the monomers and their distribution in the polymer. Copolymeric dispersants preferably have the following polymer compositions:

- statistically polymerized monomers (e.g. monomers A and B polymerized into ABBAABAB);
- alternating polymerized monomers (e.g. monomers A and B polymerized into ABABABAB);
- gradient (tapered) polymerized monomers (e.g. monomers A and B polymerized into AAABAABBABBB);
- block copolymers (e.g. monomers A and B polymerized into AAAAABBBBBB) wherein the block length of each of the blocks (2, 3, 4, 5 or even more) is important for the dispersion capability of the polymeric dispersant;
- graft copolymers (graft copolymers consist of a polymeric backbone with polymeric side chains attached to the backbone); and
- mixed forms of these polymers, e.g. blocky gradient copolymers.

[0076] Suitable polymeric dispersants are listed in the section on “Dispersants”, more specifically [0064] to [0077], in **EP 1911814** A (AGFA) .

[0077] The polymeric dispersant has preferably a number average molecular weight Mn between 500 and 30000, more preferably between 1500 and 10000.

[0078] The polymeric dispersant has preferably a weight average molecular weight Mw smaller than 100,000, more preferably smaller than 50,000 and most preferably smaller than 30,000.

[0079] The polymeric dispersant has preferably a polydispersity PD smaller than 2, more preferably smaller than 1.75 and most preferably smaller than 1.5.

[0080] Particularly preferred commercially available polymeric dispersants include Solsperse™ dispersants from NOVEON, Efka™ dispersants from CIBA SPECIALTY CHEMICALS INC and Disperbyk™ dispersants from BYK CHEMIE GMBH.

[0081] The polymeric dispersant is preferably used in an amount of 2 to 600 wt%, more preferably 5 to 20 wt%, most preferably 50 to 90 wt% based on the weight of the pigment.

[0082] Suitable dispersion synergists that are commercially available include Solsperse™ 5000 and Solsperse™ 22000 from NOVEON.

[0083] Suitable dispersion synergists include also those disclosed in **EP 1790698** A (AGFA) , **EP 1790696** A (AGFA) , **WO 2007/060255** (AGFA) and **EP 1790695** A (AGFA) .

[0084] In a preferred embodiment, the dispersion synergist includes one, two or more carboxylic acid groups.

Photoinitiators and Co-Initiators

[0085] The UV curable inkjet inks preferably also contains one or more photoinitiators and optionally co-initiators.

[0086] The photoinitiator in the radiation curable inkjet inks is preferably a free radical initiator, more specifically a Norrish type I initiator or a Norrish type II initiator. A free radical photoinitiator is a chemical compound that initiates polymerization of monomers and oligomers when exposed to actinic radiation by the formation of a free radical. A Norrish Type I initiator is an initiator which cleaves after excitation, yielding the initiating radical immediately. A Norrish type II-initiator is a photoinitiator which is activated by actinic radiation and forms free radicals by hydrogen abstraction from a second compound that becomes the actual initiating free radical. This second compound is called a polymerization synergist or co-initiator. Both

type I and type II photoinitiators can be used in the present invention, alone or in combination.

[0087] Suitable photoinitiators are disclosed in **CRIVELLO, J.V., et al.** VOLUME III: Photoinitiators for Free Radical Cationic. 2nd edition. Edited by BRADLEY, G.. London,UK: John Wiley and Sons Ltd, 1998. p.287-294.

[0088] Specific examples of photoinitiators may include, but are not limited to, the following compounds or combinations thereof: benzophenone and substituted benzophenones, 1-hydroxycyclohexyl phenyl ketone, thioxanthones such as isopropylthioxanthone, 2-hydroxy-2-methyl-1-phenylpropan-1-one, 2-benzyl-2-dimethylamino- (4-morpholinophenyl) butan-1-one, benzil dimethylketal, bis (2,6- dimethylbenzoyl) -2,4, 4-trimethylpentylphosphine oxide, 2,4,6trimethylbenzoyldiphenylphosphine oxide, 2-methyl-1- [4- (methylthio) phenyl] -2-morpholinopropan-1-one, 2,2-dimethoxy-1, 2-diphenylethan-1-one or 5,7-diiodo-3- butoxy-6-fluorone.

[0089] Suitable commercial photoinitiators include Irgacure™ 184, Irgacure™ 500, Irgacure™ 907, Irgacure™ 369, Irgacure™ 1700, Irgacure™ 651, Irgacure™ 819, Irgacure™ 1000, Irgacure™ 1300, Irgacure™ 1870, Darocur™ 1173, Darocur™ 2959, Darocur™ 4265 and Darocur™ ITX available from CIBA SPECIALTY CHEMICALS, Lucerin™ TPO available from BASF AG, Esacure™ KT046, Esacure™ KIP150, Esacure™ KT37 and Esacure™ EDB available from LAMBERTI, H-Nu™ 470 and H-Nu™ 470X available from SPECTRA GROUP Ltd..

[0090] A preferred amount of photoinitiator is 1 - 50 wt%, more preferably 3 - 20 wt%, and most preferably 5 – 15 wt% of the total weight of the curable ink.

[0091] The radiation curable inkjet inks preferably includes the co-initiator in an amount of 1 to 50 wt%, more preferably in an amount of 2 to 25 wt%, most preferably in an amount of 3 to 10 wt% of the total weight of the inkjet ink.

Polymerization Inhibitors

[0092] The radiation curable inkjet inks may contain a polymerization inhibitor. Suitable polymerization inhibitors include phenol type antioxidants, hindered amine light stabilizers, phosphor type antioxidants, hydroquinone

monomethyl ether commonly used in (meth)acrylate monomers, and hydroquinone, t-butylcatechol, pyrogallol may also be used.

[0093] Suitable commercial inhibitors are, for example, Sumilizer™ GA-80, Sumilizer™ GM and Sumilizer™ GS produced by Sumitomo Chemical Co. Ltd.; Genorad™ 16, Genorad™ 18 and Genorad™ 20 from Rahn AG; Irgastab™ UV10 and Irgastab™ UV22, Tinuvin™ 460 and CGS20 from Ciba Specialty Chemicals; Floorstab™ UV range (UV-1, UV-2, UV-5 and UV-8) from Kromachem Ltd, Additol™ S range (S100, S110, S120 and S130) from Cytec Surface Specialties.

[0094] Since excessive addition of these polymerization inhibitors will lower the ink sensitivity to curing, it is preferred that the amount capable of preventing polymerization is determined prior to blending. The amount of a polymerization inhibitor is preferably lower than 2 wt% of the total inkjet ink.

Polymerizable compounds

[0095] Any polymerizable compound commonly known in the art may be employed.

[0096] Preferably a monomer or oligomer capable of free radical polymerization is used as polymerizable compound. A combination of monomers, oligomers and/or prepolymers may also be used. The monomers, oligomers and/or prepolymers may possess different degrees of functionality, and a mixture including combinations of mono-, di-, tri-and higher functionality monomers, oligomers and/or prepolymers may be used. The viscosity of the radiation curable compositions and inks can be adjusted by varying the ratio between the monomers and oligomers.

[0097] Preferred monomers and oligomers are those listed in [0106] to [0115] in **EP 1911814** A (AGFA) .

Other Additives and Topcoats

[0098] One or more UV curable inks may further contain one or more other additives, such as stabilizers, crosslinking agents, plasticizers, special pigments and spacing agents.

[0099] Preferred stabilizers are anti-light fading agents for maximal color retention. Instead of including the stabilizers in the UV curable inks,

preferably a topcoat, a so-called varnish, is applied on the cured UV curable inks. For example, a top coat , such as silicone alkyd enamel (e.g. Silkyd™-7010 from SIMCO), may be used in order to obtain a tough, resilient coating having exceptional exterior durability with superior gloss and color retention. The topcoat may also provide protection against sea-water. Suitable protective topcoats include alkyd alkoxy silanes and silixones. For example, a topcoat of DuPont™ StoneTech™ Professional Salt Water Resistant Sealer can be applied.

[00100] Preferred light stabilizers are benzophenones, benztriazole compounds and HALS-compounds.

[0101] The topcoat preferably includes hard particles, such as silica and aluminum oxides, for protection against wear

Surfactants

[0102] The radiation curable inkjet ink may contain at least one surfactant. The surfactant can be anionic, cationic, non-ionic, or zwitter-ionic and is preferably added in a total quantity less than 3 wt% based on the total weight of the ink and particularly in a total less than 1 wt% based on the total weight of the inkjet ink .

[0103] Preferred surfactants are selected from fluoro surfactants (such as fluorinated hydrocarbons) and silicone surfactants. The silicone surfactants are preferably siloxanes and can be alkoxylated, polyester modified, polyether modified, polyether modified hydroxy functional, amine modified, epoxy modified and other modifications or combinations thereof. Preferred siloxanes are polymeric, for example polydimethylsiloxanes.

[0104] Preferred commercial silicone surfactants include BYK™ 333 and BYK™ UV3510 from BYK Chemie.

[0105] In a preferred embodiment, the surfactant is a polymerizable compound.

[0106] Preferred polymerizable silicone surfactants include a (meth)acrylated silicone surfactant. Most preferably the (meth)acrylated silicone surfactant is an acrylated silicone surfactant, because acrylates are more reactive than methacrylates.

[0107] In a preferred embodiment, the (meth)acrylated silicone surfactant is a polyether modified (meth)acrylated polydimethylsiloxane or a polyester modified (meth)acrylated polydimethylsiloxane.

[0108] Preferred commercially available (meth)acrylated silicone surfactants include: Ebecryl™ 350 , a silicone diacrylate from Cytec; the polyether modified acrylated polydimethylsiloxane BYK™ UV3500 and BYK™ UV3530, the polyester modified acrylated polydimethylsiloxane BYK™ UV3570, all manufactured by BYK Chemie; Tego™ Rad 2100, Tego™ Rad 2200N, Tego™ Rad 2250N, Tego™ Rad 2300, Tego™ Rad 2500, Tego™ Rad 2600, and Tego™ Rad 2700, Tego™ RC711 from EVONIK; Silaplane™ FM7711, Silaplane™ FM7721, Silaplane™ FM7731, Silaplane™ FM0711, Silaplane™ FM0721, Silaplane™ FM0725, Silaplane™ TM0701, Silaplane™ TM0701T all manufactured by Chisso Corporation; and DMS-R05, DMS-R11, DMS-R18, DMS-R22, DMS-R31, DMS-U21, DBE-U22, SIB1400, RMS-044, RMS-033, RMS-083, UMS-182, UMS-992, UCS-052, RTT-1011 and UTT-1012 all manufactured by Gelest, Inc..

Preparation of UV Curable Inkjet inks

[0109] The preparation of radiation curable inkjet inks is well-known to the skilled person. Preferred methods of preparation are disclosed in paragraphs [0076] to [0085] of **WO 2011/069943** (AGFA) .

Inkjet Printing Devices

[0110] The UV curable inkjet inks may be jetted by one or more print heads ejecting small droplets in a controlled manner through nozzles onto a substrate, which is moving relative to the print head(s).

[0111] A preferred print head for the inkjet printing system is a so-called valve jet print head. Preferred valve jet print heads have a nozzle diameter between 45 and 600 µm. This allows for a resolution of 15 to 150 dpi which is preferred for having high productivity while not comprising image quality.

[0112] The way to incorporate valve jet print heads into an inkjet printing device is well-known to the skilled person. For example, **US 2012105522** (MATTHEWS RESOURCES INC) discloses a valve jet printer including a solenoid coil and a plunger rod having a magnetically susceptible shank.

[0113] Suitable commercial valve jet print heads are chromoJET™ 200, 400 and 800 from Zimmer and Printos™ P16 from VideoJet.

[0114] Ina preferred embodiment of theUV curable inkjet printing method, the inkjet printing device includes one or more valve jet print heads.

[0115] The print head preferably jets droplets of 1 to 1500 nanoliter, which is much more than the picoliter droplets used jetted most piezoelectric or thermal inkjet printing systems.

[0116] The inkjet print head normally scans back and forth in a transversal direction across the moving ink-receiver surface. Bi-directional printing, also called multi-pass printing, is preferred for obtaining a high areal throughput. Another preferred printing method is by a "single pass printing process", which can be performed by using page wide inkjet print heads or multiple staggered inkjet print heads which cover the entire width of the ink-receiver surface.

[00117] In a multi-pass printing method such as shingling and interlacing as exemplified by **EP 1914668** A (AGFA) or print masks method as exemplified by **US 7452046** (HP) ,the method of the UV curable inkjet printing is preferably using a anti-drip print mask method so in a pass of printing the jetted ink is prevented to drip down from the vertical panel. Previous cured ink layers from previous passes may prevent the drip of jetted ink before curing. Preferably the anti-drip print masks are print-masks with chess-board-patterns and/or horizontal line patterns. Preferably the antidrip print masks is colourless or has the same colour of the primer or the paint.

[0118] In a preferred embodiment, the resolution of the print head is 15 to 150 dpi, preferably the resolution is no more than 75 dpi , more preferably no more than 50 dpi for maximizing printing speed and productivity. Valve-jet printheads allowing variable dots or having multiple resolutions can also be advantageously used to enhance image quality further.

[0119] The throwing distance of the UV curable inkjet ink droplets is preferably between 3 and 50 mm, more preferably between 5 and 30 mm for maximizing image quality. The throwing distance corresponds to the

distance between an inkjet nozzle and the surface of the at least one vertical panel.

[0120] In a preferred embodiment, the jetting by the print head is performed in an upwards direction. In this manner, an already cured ink droplet inhibit excessive run down of an ink droplet jetted above the already cured ink droplet.

[0121] A preferred inkjet printing device used for printing a corrugated surface 29 includes a print head array 37 of a plurality of individual print heads 36. The inkjet printing is then performed by moving the print head array for jetting in a top-down, preferably in a down-top movement, followed by horizontal step movement 38 an repeating the top-down and/or down-top printing movement. The individual printheads 36 are positioned in such a manner that they match the corrugated surface so that a constant distance between the inkjet nozzles and the corrugated surface is accomplished. Furthermore, the print heads at both ends of the print head array are preferably positioned in a manner that there is a small overlap of the printing zones before and after a horizontal step movement.

[0122] In another preferred embodiment, a single print head whereof the shape of the print head matches the relief of part of the corrugated surface.

[00123] A preferred embodiment of the UV inkjet printing method comprises a method by adapting the timing of firing ink droplets to correct print defects caused by the relief of the vertical panel so the ink droplets land at the appropriate location on the vertical panel by checking a topological map of the relief of the vertical panel. The topological map may be produced by an active distance controller that has scanned the vertical panel or may be produced by rendering the three-dimensional content defined in a three-dimensional vector drawing format that defines the relief of the cuboid shaped object or preferably the relief of the vertical panel. An example of an ink jet printing method on a flat table with such a droplet throw distance correction, also called landing distance correction point, is disclosed in **US 2007070099** (APPLIED MATERIALS) .

[0124] Preferably print heads are used that have a small dead edge, i.e. the area at the edge of the nozzle plate lacking nozzles. Such printheads allow that printing can be performed in the corners of the corrugated surface.

Curing Devices

[0125] The jetted UV curable inkjet inks are cured by exposing them to actinic radiation, preferably by exposing them to ultraviolet radiation.

[0126] The curing means is preferably arranged in combination with the print head of the inkjet printer, travelling therewith so that the curable ink is exposed to curing radiation very shortly after been jetted. In a preferred embodiment, the jetted UV curable ink is exposed to UV radiation within 10 to 800 ms for maximizing image quality.

[0127] In such an arrangement it can be difficult to provide a small enough radiation source connected to and travelling with the print head. Preferably UV LEDs can be used but they are usually not powerful to realize a full cure. Therefore, a static fixed radiation source may be employed, e.g. a source of curing UV-light, connected to the radiation source by means of flexible radiation conductive means such as a fibre optic bundle or an internally reflective flexible tube.

[0128] In a preferred embodiment, the curing means, such as one or more UV LEDs, is attached to print-head so that the curing means follows the corrugation of the vertical in the same manner as the printhead. The UV-LEDs following the corrugations may have different intensities. Higher intensities can be used in deeper regions.

[0129] Alternatively, the actinic radiation may be supplied from a fixed source to the radiation head by an arrangement of mirrors including a mirror upon the print head.

[0130] The source of radiation may also be an elongated radiation source extending transversely across the printed substrate to be cured. It may be adjacent the transverse path of the print head so that the subsequent rows of images formed by the print head are passed, stepwise or continually, beneath that radiation source.

[0131] Any ultraviolet light source, as long as part of the emitted light can be absorbed by the photo-initiator or photo-initiator system, may be employed

as a radiation source, such as, a high or low pressure mercury lamp, a cold cathode tube, a black light, an ultraviolet LED, an ultraviolet laser, and a flash light. Of these, the preferred source is one exhibiting a relatively long wavelength UV-contribution having a dominant wavelength of 300-400 nm. Specifically, a UV-A light source is preferred due to the reduced light scattering therewith resulting in more efficient interior curing.

[0132] UV radiation is generally classed as UV-A, UV-B, and UV-C as follows:

- UV-A: 400 nm to 320 nm
- UV-B: 320 nm to 290 nm
- UV-C: 290 nm to 100 nm.

[0133] In a preferred embodiment, the inkjet printing device contains one or more UV LEDs with a wavelength larger than 360 nm, preferably one or more UV LEDs with a wavelength larger than 380 nm, and most preferably UV LEDs with a wavelength of about 395 nm.

[0134] Furthermore, it is possible to cure the image using, consecutively or simultaneously, two light sources of differing wavelength or illuminance. For example, the first UV-source can be selected to be rich in UV-C, in particular in the range of 260 nm-200 nm. The second UV-source can then be rich in UV-A, e.g. a gallium-doped lamp, or a different lamp high in both UV-A and UV-B. The use of two UV-sources has been found to have advantages e.g. a fast curing speed and a high curing degree.

[0135] The curing means may include a final curing means. Such curing means completes the UV curing of the inks, after a partial curing by e.g. the UV LEDs.

[0136] For facilitating curing, the inkjet printing device may include one or more oxygen depletion units. The oxygen depletion units place a blanket of nitrogen or other relatively inert gas (e.g. $CO_2$), with adjustable position and adjustable inert gas concentration, in order to reduce the oxygen concentration in the curing environment. Residual oxygen levels are usually maintained as low as 200 ppm, but are generally in the range of 200 ppm to 1200 ppm.

[0137] Since relatively large ink droplets (nanoliters instead of picoliters) are jetted compared to conventional graphic arts inkjet printers, to

simultaneously improve curing speed and image quality an air knife may be used in combination with the print head. The air knife flattens the jetted ink droplet prior to UV curing, so that the ink dot on the vertical panel has a smaller thickness yet covering a larger surface area. The air knife may also be used to prevent the dripping of the jetted ink on the panel.

Anti-static devices

[0138] To eliminate static charges on a vertical panel before jetting, the inkjet printing devices may comprise an anti-static device also called static-dischargers to have a better control on the fluid dynamics of the jetted ink and to prevent electro-static discharge on the electronics of the inkjet printing device such as the electronics of the inkjet heads.

[0139] The anti-static device is preferably arranged in combination with the print head of the inkjet printing device, travelling therewith so that the vertical panel is electric static discharged before jetting.

Rendering devices

[0140] To jet an image on a vertical plane of a cuboid shaped object, the image is preferably rendered by a rendering device to the resolution of the cuboid shaped object inkjet printing device and the colors of the set of UV inkjet inks of the cuboid shaped object inkjet printing device. The rendering device may be comprised in the cuboid shaped object inkjet printing device of the embodiment.

[00141] The content of an image is preferable defined in raster graphics format such as Portable Network Graphics (PNG), Tagged Image File Format (TIFF), Adobe Photoshop Document (PSD) or Joint Photographic Experts Group (JPEG) or bitmap (BMP) but more preferably in vector graphics format, also called line-work format, such as Scale Vector Graphics (SVG) and AutoCad Drawing Exchange Format (DXF) and most preferably a page description language (PDL) such as Postscript (PS) or Portable Document Format (PDF).

[00142] The content of an image may be stored and/or loaded as one or more files on a memory of a computer which may be comprised in the cuboid shaped object inkjet printing device. The embodiment of the inkjet printing method

may comprise a method to load the content of an image to a memory of a computer.

[00143] The content of an image may be a element of a queue of print jobs that is generated from Variable-data printing (VDP), also known as variable-information printing which is a form of digital printing, including on-demand printing, in which elements such as text, graphics and images may be changed from one printed piece to the next, without stopping or slowing down the printing process and using information from a database or external file.

[00144] If the content of an image is defined in a vector graphics format or page description language, the rendering device converting the content of the image to a raster graphics. The method of converting is called rastering and the rendering device is also called a raster image processor (RIP).

[00145] The rendering device may render the image in smaller sized sub-images also called partial images e.g. to reduce the amount of memory-use in the rendering device. The inkjet head printing device may jet the smaller sized sub-images one after each other on the vertical plane of the cuboid shaped object. To mask overlap at the edges of the jetted smaller sized sub-images stitch-algorithms, as exemplified in **US 2004028291** (AGFA) , may be processed while rendering the image in smaller sized sub-images.

[00146] In a multi-pass printing method of the embodiment of the UV curable inkjet method the smaller sized sub-images may be defined by a print-mask and preferably by an anti-drip print-mask.

[00147] The rendering device may render parts of the image that have to be repair or to be restored for an image on the vertical panel.

[00148] A preferred embodiment of the method of UV curable inkjet printing wherein the vertical panel is a corrugated panel comprises the step of compensating an anamorphic distortion of the image while rendering an image. This compensation may be calculated out a content of a 3D-image that defines the corrugation of the vertical panel. Preferably the content of the three-dimensional image is defined in a three-dimensional vector graphics format.

[00149] On inclinations and edges of the relief of the vertical panel the jetted ink may flow together or flow away. This causes density and colour differences in the image that may be compensated while rendering the image.

**Reference signs list**

[0150]

**Table 1**

| | | | |
|---|---|---|---|
| 1 | standard container | 21 | treshold plate |
| 2 | reefer | 22 | ventilator |
| 3 | open-top container | 23 | flooring |
| 4 | refrigeration unit | 24 | joint strip |
| 5 | open-top | 25 | truck |
| 6 | container skeleton | 26 | trailer |
| 7 | top side rail | 27 | semi-trailer |
| 8 | top end rail | 28 | boxcar |
| 9 | corner fitting | 29 | corrugated surface |
| 10 | corner post | 30 | rail |
| 11 | bottom end rail | 31 | protrusion |
| 12 | bottom side rail | 32 | print head in first position |
| 13 | forklift pocket | 33 | print head in second position |
| 14 | cross member | 34 | UV curable ink droplet |
| 15 | roof panel | 35 | active distance controller |
| 16 | sidewall panel | 36 | individual printhead |
| 17 | marking panel | 37 | print head array |
| 18 | endwall panel | 38 | horizontal step |
| 19 | door assembly | | |
| 20 | rear end frame | | |

## Claims

1. A method of UV curable inkjet printing on a cuboid shaped object including the steps of:

   a) bringing and holding at least part of an inkjet printing device in physical contact with the cuboid shaped object; and

   b) jetting and UV curing an image of one or more UV curable inks on at least one vertical panel of the cuboid shaped object;

   wherein the cuboid shaped object is selected from intermodal freight containers, crates, trucks, trailers, semi-trailers and boxcars.
2. The UV curable inkjet printing method according to claim 1, wherein the physical contact is accomplished by two, three or more attachment means selected from the group consisting of suction cups, electromagnets and clamps.
3. The UV curable inkjet printing method according to claim 1 or 2, wherein a primer is applied to the vertical panel before jetting the image.
4. The UV curable inkjet printing method to any one of claims 1 to 3, wherein an image is jetted and cured simultaneously on at least two panels of the cuboid shaped object.
5. The UV curable inkjet printing method according to any one of claims 1 to 4, wherein the one or more UV curable inks include a white ink.
6. The UV curable inkjet printing method according to any one of claims 3 to 5, wherein paint is sprayed on the primed vertical panel before jetting the image.
7. The UV curable inkjet printing method according to claim 6, wherein al least one of the primer, the paint and the one or more UV curable inks is a spot colour having a colour selected from the group consisting of RAL 1033, RAL 2000, RAL 2002, RAL 2004, RAL 3003, RAL 3005, RAL 3009, RAL 5003, RAL 5010, RAL 5013, RAL 5015, RAL 6002, RAL 6005, RAL 6013, RAL 6017, RAL 6018, RAL 7000, RAL 7031, RAL 7035, RAL 7037, RAL 7038, RAL 8004, RAL 8012, and RAL 9010.
8. The UV curable inkjet printing method according to any one of claims 1 to 7, wherein the vertical panel is a corrugated panel.

9. The UV curable inkjet printing method according to any one of claims 1 to 8, wherein the jetted one or more UV curable inks are flattened by an air knife prior to UV curing.
10. The UV curable inkjet printing method according to any one of claims 1 to 9, wherein the distance between an inkjet nozzle and the surface of the at least one vertical panel is controlled to be between 3 and 50 mm.
11. The UV curable inkjet printing method according to any one of claims 1 to 10, wherein an air knife flattens the jetted ink droplet prior to UV curing.
12. The UV curable inkjet printing method according to any one of claims 1 to 11, wherein the inkjet printing device includes one or more valve jet print heads.
13. The UV curable inkjet printing method according to any one of claims 1 to 12, wherein the one or more UV curable inks are one or more UV curable phase change inks.
14. A method of manufacturing a cuboid shaped intermodal freight container comprising the inkjet printing method according to any one of claims 1 to 13.
15. A cuboid shaped intermodal freight container having a UV cured inkjet image on a vertical panel.

## Drawings

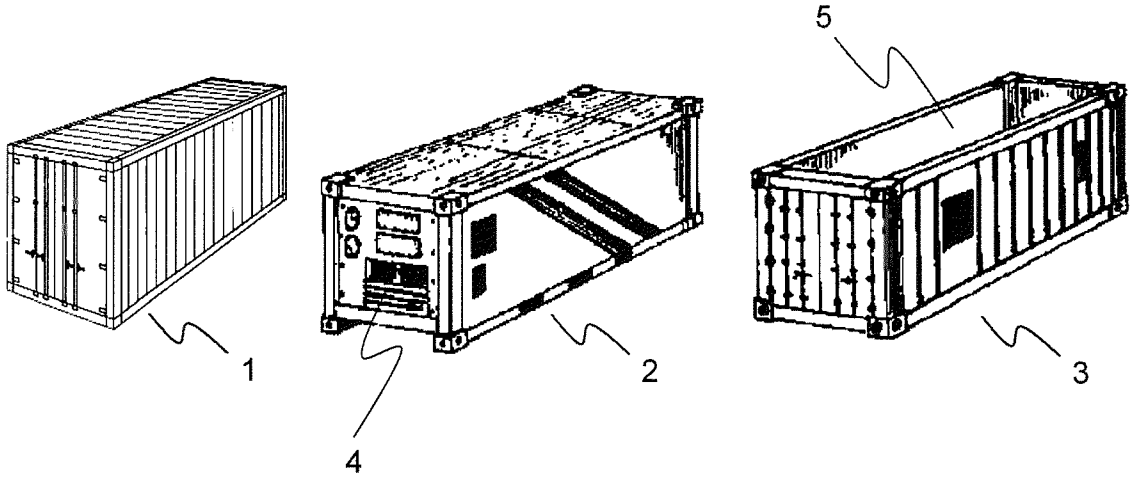


Fig. 1

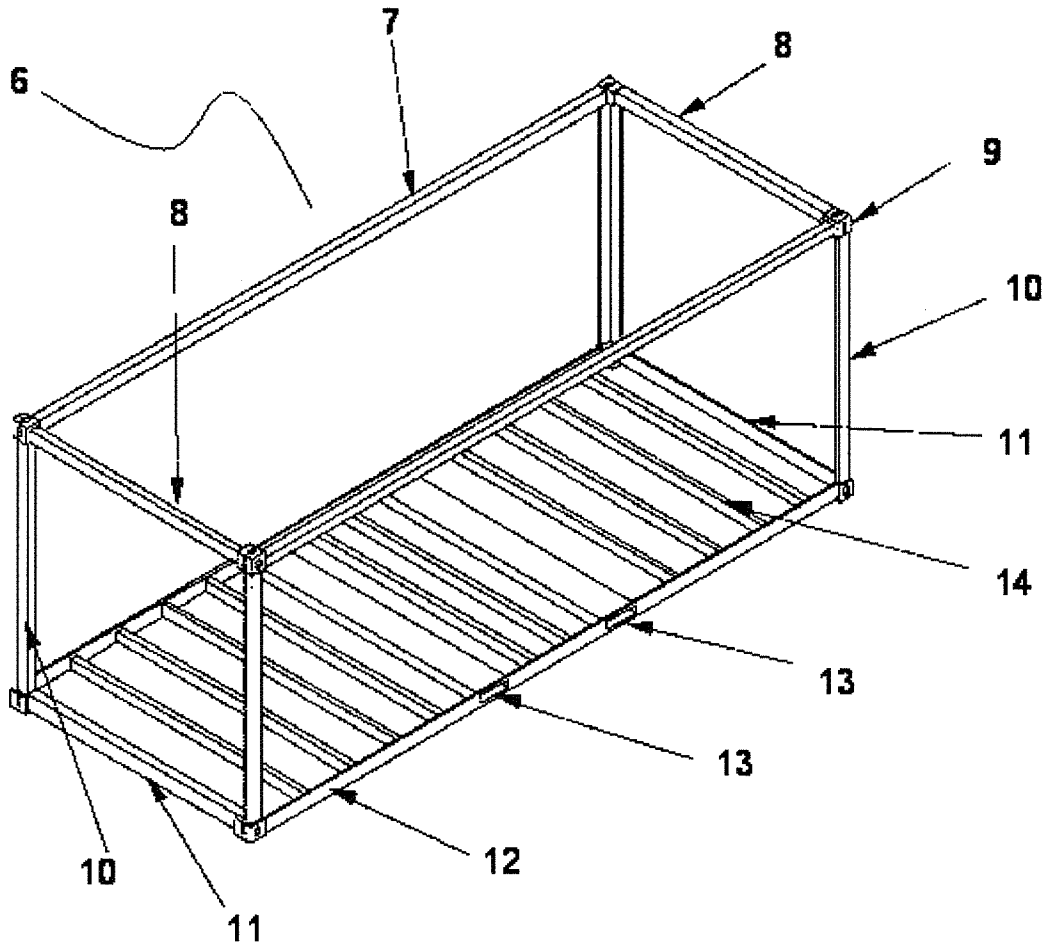


Fig. 2

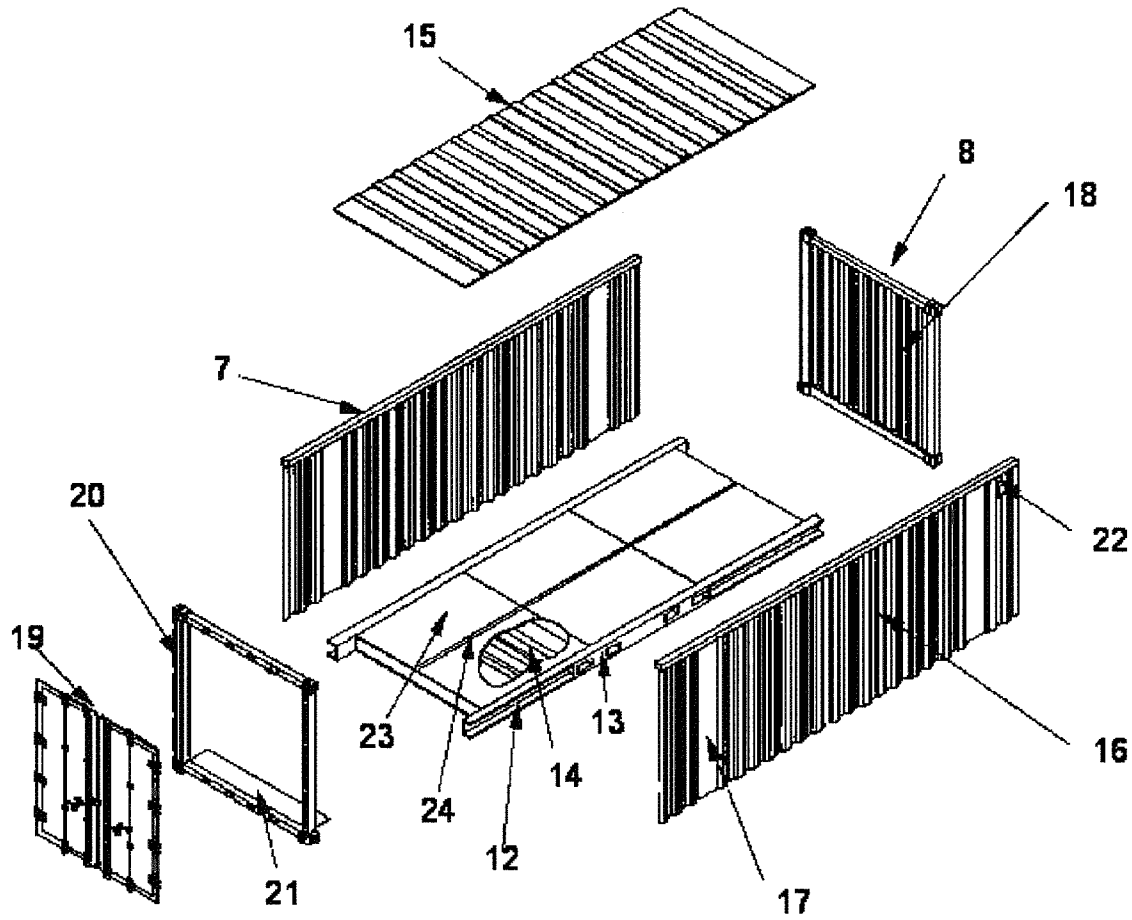


Fig. 3

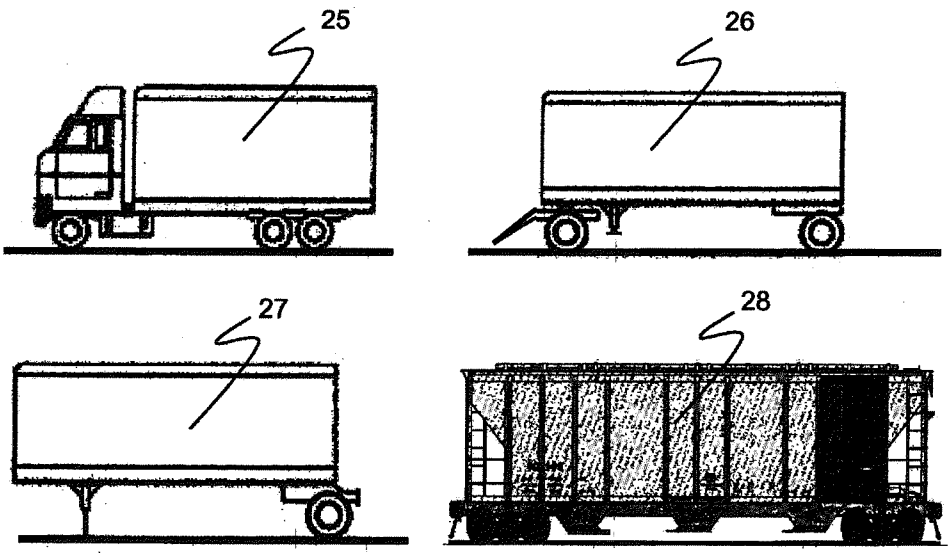


Fig. 4

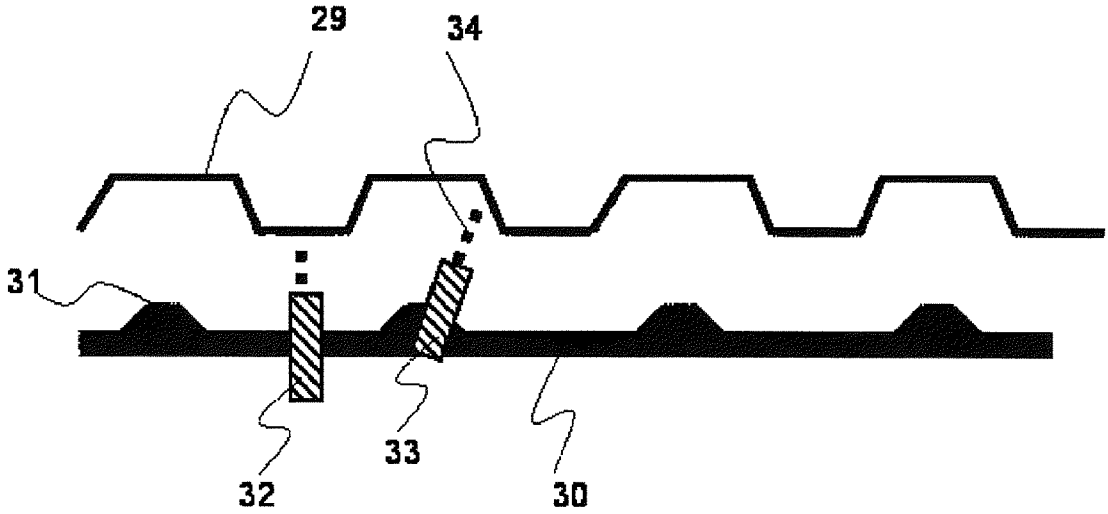


Fig. 5

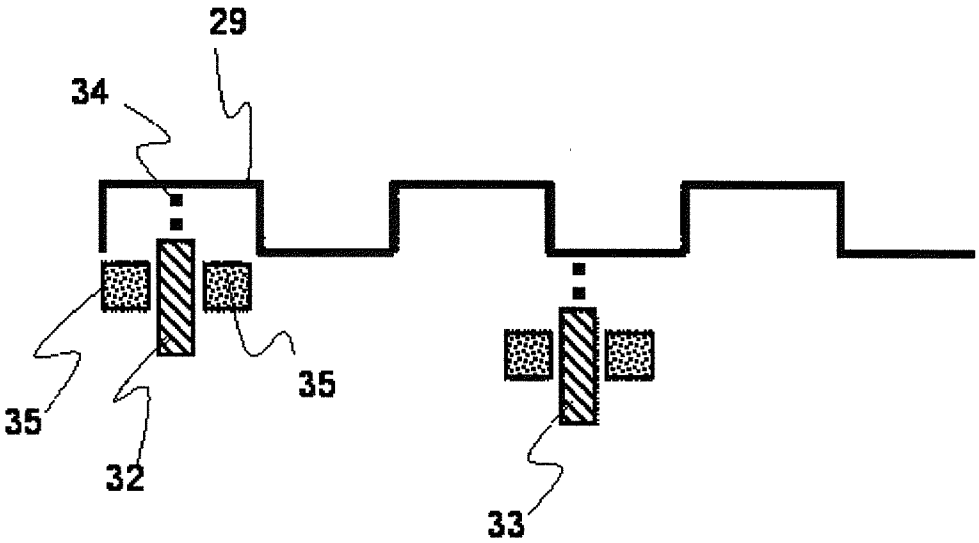


Fig. 6

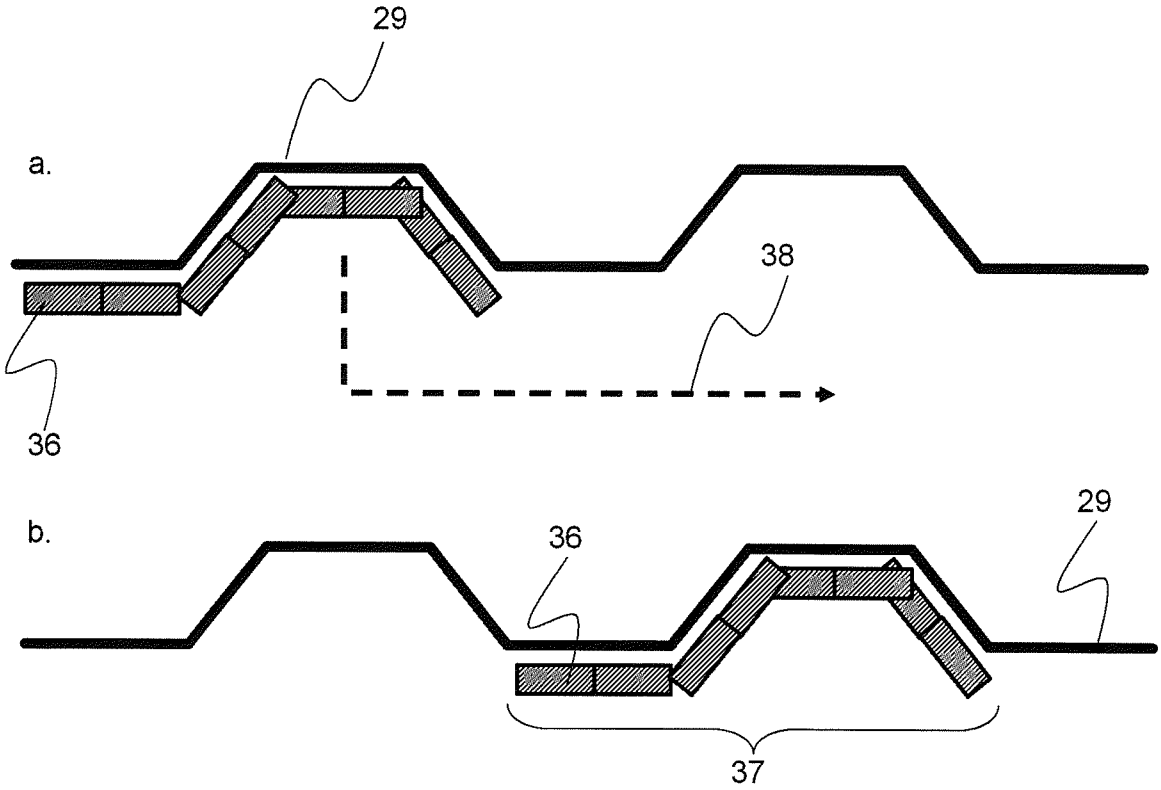


Fig. 7

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/068071

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41M7/00 B41M5/00 B41J3/407 B65D90/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41M B41J B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, CHEM ABS Data, INSPEC, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 2007/062383 A1 (GAZEAU JEAN-PIERRE [FR] ET AL) 22 March 2007 (2007-03-22)<br>cited in the application<br>claims 26-30; figure 1<br>paragraph [0001]<br>paragraph [0010]<br>paragraph [0043] - paragraph [0055]<br>paragraph [0068]<br>----- | 1-15 |
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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