

Description**BACKGROUND OF THE INVENTION:**5 **1. Field of the Invention:**

The present invention relates to ink jet printers and more particularly to demand or impulse ink jet printers of the type wherein droplets of ink are fired at varying time intervals as required or demanded for printing.

10 **2. Description of Related Art:**

A demand or impulse ink jet typically comprises an ink jet chamber including an orifice from which droplets are ejected and an ink supply inlet coupled to a source or reservoir of ink. In such a jet, a driver is coupled to the chamber such that the change in state of energization of the driver results in the ejection of a droplet of ink from the orifice. By changing the state of energization of the driver at the appropriate moment, a droplet of ink may be ejected on demand in a trajectory directed at a suitable substrate or target such as paper.

Patent application Serial No. 336,603, now U.S. Patent No. 4,459,601, filed January 4, 1982 and Serial No. 576,582, now U.S. Patent No. 4,646,106, filed February 3, 1984 disclose an ink jet apparatus comprising an array of demand or impulse ink jets where each jet ejects a droplet of ink from an orifice in response to the expansion and contraction of drivers in the form of elongated transducers which are energized in response to a field selectively applied transversely to the axis of elongation.

Certain ink jets utilize ink in the form of a pellet which is normally in a solid state at room temperature but which attains a liquid state when its temperature is raised. The solid ink pellet is heated in a reservoir within the printer system to melt the pellet into liquid ink and to maintain the ink in a liquid state. The liquid ink so obtained is commonly referred to as hot melt ink.

It is important that the printed image produced by such inks be of consistently high durability and quality. Print quality and durability are not only important for the appearance of the printed image, they are critical in some practical applications. For example, it may be difficult for an optical character recognition scanner to recognize a printed character having an edge which is smudged, abraded or not sharply defined. Thus, it is critical that the edge of the printed bar code lines be abrasion resistant and sharply defined in order to accurately define the thickness of each line and the spacing between adjacent lines to avoid reading errors by a bar code scanner.

Attempts have been made to achieve such results in prior ink jet printers by modifying the hot melt ink temperature so as to decrease the heating effect on the paper. Modification of ink temperature, however, affects the viscosity and the surface tension of the ink. This may adversely affect the jetting of ink from the print head. Specifically, when ink temperature is reduced, ink viscosity and ink surface tension generally increase. This makes it more difficult to form and maintain an ink meniscus at each orifice, the existence of which is important for the proper jetting of ink. Thus, modification of the hot melt ink temperature alone is insufficient to achieve the problem free production of a print image of consistently high durability and high quality.

It is known from EP-A-0 213 240 to provide an apparatus for jetting hot melt ink from an ink jet print head to a substrate, the substrate having a predefined absorbcency and the ink having a predefined thermal diffusivity. Means are provided for heating the ink, and means for controlling the print head to control the velocity of ink ejection.

It is also known from JP-56-113 462 for an ink jet printing apparatus to heat the substrate before printing.

SUMMARY OF THE INVENTION:

45 It is an object of the present invention to provide a system of printing which produces print images of consistently high durability and high quality.

It is a further object of the present invention to provide a system of printing which produces print images that are accurately and predictably reproducible under a variety of conditions, so that the characteristics of the print image are consistent regardless of the type of printing substrate used or the environment of the printer.

50 It is a further object of the present invention to provide a system for identifying those parameters which significantly affect the characteristics of the printed image, and to provide a system for modifying the identified parameters, individually or in combination, so as to produce a print image having the desired characteristics.

In accordance with these and other objects of the invention, specific attributes or characteristics of the desired high quality, high durability print image are identified and quantified. These print image attributes or characteristics may include: the size or the diameter of the ink dots which comprise the print image, the circularity of the ink dots which comprise the print image, the degree to which the ink penetrates below the surface of the substrate, the degree to which the ink remains above the surface of the substrate (referred to herein as the "tactility" of the print image), the amount of "cracking" exhibited by the print image, and the amount of "smearing" exhibited by the print image.

The parameters of the printing system which have a direct influence upon the print image characteristics are also identified and quantified. These printing system parameters may include: the absorbency of the substrate, the temperature of the substrate, the distance between the ink jet head and the substrate, the temperature of the ink, the velocity at which the ink travels to the substrate, the volume of the ink droplet, and the thermal diffusivity of the ink.

- 5 A system for controlling each of the printing system parameters, individually and in combination, is then provided so that a print image exhibiting optimal characteristics may be reproduced consistently and accurately, regardless of variations in substrates or printing environments.

BRIEF DESCRIPTION OF THE DRAWINGS

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FIGURE 1 is a schematic diagram of a demand ink jet system;

FIGURE 2 is an enlarged partially schematic diagram of a droplet of ink traveling from an orifice to a target;

FIGURE 3 is a partially schematic enlarged view of a droplet traveling to and penetrating a target;

FIGURE 4 is a cross-sectional, partially schematic diagram of another ink jet system; and

- 15 FIGURE 5 is a histogram indicating the durability variation for different kinds of print.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

- 20 The following description is of the best presently contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

Referring to Fig. 1, an ink jet apparatus is disclosed including an ink jet employing a housing 12 including a nozzle having an orifice 14. The housing 12 which includes a chamber is encircled by a piezoelectric transducer 16. The transducer 16 is energized and de-energized in response to the application of a drive voltage from a pulse source 18 which is supplied between leads 20 and 22.

25 Droplets of ink 24 are ejected from the orifice 14 toward a target 26 which may comprise paper or other suitable substrates. Ink is supplied to the jet from a reservoir 28 through a coupling tube 30.

The ink within the reservoir 28 is typically a phase change ink which is a solid at lower temperatures and a liquid at elevated temperatures after passing through a phase change transition. A suitable ink is a wax-containing ink which is solid or semi-solid at ambient temperature but is liquid at elevated temperatures so as to permit discharge from the orifice 14. However, the present invention is not limited to wax-containing inks.

The ink which is heated to the elevated temperature will solidify when it comes in contact with a suitable target 26 such as paper or other substrate material. The rate of solidification of the ink is related to, and is one major factor in, the degree of penetration into the paper.

35 The heating of the ink to an elevated temperature may be accomplished by immersing the reservoir 28 in a hot water bath 32 or subjecting the reservoir 28 to other suitable heating means. The coupling tube 30 and the jet itself may be heated by an infrared light 34 or other suitable means.

Referring to Fig. 2, the orifice 14 is shown juxtaposed to the target 26 with a droplet 24 moving toward the target 26. As shown in Fig. 3, contact between a fibrous target 26 and the ink 24 in the liquid state assures, because of the capillarity of the target, substantial penetration of the droplet 24D when deposited on the target 26.

40 Referring to Fig. 4, a demand or impulse ink jet comprises a chamber 110 within a housing 112 including an orifice 114. The transducer 116 is coupled to the chamber 110 through a diaphragm 118 at the rear of the chamber opposite the orifice 114. The transducer 116 is energized and de-energized in response to the application of a pulsed voltage V across electrodes 120 and 122 so as to create a field transverse to the transducer 116.

45 The volume of ink within the reservoir or manifold 130 supplying the inlet 124 as well as the chamber 110 is heated so as to maintain the ink in a liquid state. In the absence of such heat, the ink returns to a solid state, in other words, the ink undergoes a phase change when heated to a liquid state so as to be in a state of readiness for ejection from the orifice 114 upon demand. The reservoir 130 may be served by an even larger reservoir not shown.

The heating of the volume of ink within the chamber 110 may be accomplished by electrical heating means. As shown in Fig. 4, the heating means are depicted by a resistance 128 coupled to a power supply within the chamber 110.

The print image which is produced by the above-described ink jet system or similar systems may be identified by a number of quantifiable attributes or characteristics. Among these characteristics is the circularity of the dot produced by the ink jet. A method of measuring the circularity of the dot has been described in U.S. application Serial No. 248,551, filed March 27, 1983, now U.S. patent No. 4,361,843. Print quality is generally related to the circularity of the dot, with circularities of 0.7 or better as measured by the technique described in the above-referenced U.S. patent No. 4,361,843 being considered optimal circularities.

55 Another print characteristic which is significant in achieving a good print image is the size or the diameter of the dot. In general, a better print image can be produced by dots of relatively smaller size or diameter.

Still another print characteristic which is important to the overall quality of the print image is the penetration of the ink below the surface of the substrate, as well as the amount of ink remaining above the surface of the substrate. This characteristic is particularly significant when the ink used is a hot melt or phase change ink.

In standard ink jet printing technology, a liquid ink will typically strike an absorbent substrate and will penetrate that substrate either via capillary action or chemical absorbency on to the fibers of the substrate. With hot melt ink, the technology is slightly different. This is due to the fact that the hot melt ink undergoes a phase change from a liquid to a solid after it is ejected from the ink jet print head. As a consequence, the degree to which the hot melt ink penetrates the surface of a substrate may be quantified and controlled. Similarly, the amount of ink which remains above the surface of the substrate may be quantified and controlled. The degree to which the ink remains above the surface of the substrate may be referred to as the "tactility" of the ink. This term is used because the hot melt ink technology permits the creation of a raised or braille like printed image which can be detected by touching the surface of the printed substrate.

Still another print characteristic which plays a significant role in overall print quality is the durability of the print image. Durability of the print image is particularly significant where a substantial portion of the ink remains above the surface of the substrate after printing, as may be the case with hot melt ink technology. A significant amount of ink above the surface of the substrate means that there is more ink available to be marred or scuffed after printing has been completed. The durability of the printed image may be quantified in terms of both the degree of "cracking" experienced by the print image, as well as the degree of "smearing" experienced by the print image. Methods of quantifying and evaluating print durability in terms of both cracking and smearing are discussed below.

The following method may be used to evaluate cracking: A print sample is prepared and then creased along a hard, smooth surface by means of a weighted roller device. Preferably the weighted roller device is approximately 10 centimeters long by 3.2 centimeters in diameter, with a rubber coating of 0.3 centimeter thickness and a Shore Adurometer hardness of 60. The weight of the roller may vary, with preferable weights being in the range between 2.2 kilograms and 4.4 kilograms, depending upon the print samples to be evaluated.

The weighted roller is used to crease the print sample such that the print characters are on the inner side of the sample. The crease is initiated by setting the weighted roller near an edge of the sample sheet and then slowly moving the roller across the sheet to give a firm crease. Care should be taken to avoid adding any additional force to the force normal to the sample paper.

The print sample is opened and arranged such that the crease can be viewed. The crease is then followed through each character and the degree of cracking observed is noted. The degree of cracking may be rated as follows: If no break in a character is observed, the degree of cracking is rated as "0". If a crack or minor ink removal is observed in a character, the degree of cracking is rated as "1". If a major break in the character is observed, the degree of cracking is rated as "2". Preferably, a minimum of 20 characters per crease should be evaluated, with a minimum of two separate print samples being used for each evaluation.

The percent cracking may then be determined by dividing the number of characters exhibiting cracking by the total number of characters observed and multiplying this figure by one hundred. A cracking value may also be determined by dividing the rating values by the total number of characters observed and summing for each rating. This method allows printing durability improvements to be quantified and rated directly against other printing techniques. This technique has quantified the improved resistance to cracking due to changes in, for example, ink formulations, increasing ink temperatures and increasing paper temperatures.

The following materials may be used for measuring the degree of smearing of print characters: a Southerland rub tester, a smooth, rigid paper support such as an aluminum sheet, an Eberhard-Faber Pink Pearl 101 eraser, and a double-stick tape. (The Southerland rub tester is a device which is regularly used in the paper industry as a method of measuring print smearing.)

The pink pearl eraser is mounted to a weight of approximately 0.9 kilograms by use of the double-stick tape. The print sample is arranged to face the eraser, and a smooth, rigid support is placed beneath the paper. The weight is mounted to the test unit and rubbed for 60 cycles while the paper is prevented from sliding. The weight is then removed and the build up of material on the face of the eraser is removed with finger pressure. The eraser may be reused until it has been reduced by about 25 percent (25%).

The print samples are then evaluated using an optical character tester such as manufactured by Moore Business Machines. Using the optical character tester, the reflectance of the background midway between two smeared character lines is measured. An average reflectance is calculated based upon at least ten measurements. The optical density is then calculated according to the following formula:

$$\text{Optical density} = \log(1/\text{reflectance})$$

The amount of smear may then be evaluated based upon the optical density of the background region between the two smeared print lines. Analysis is based upon an increase in optical density between two smeared character lines. Typical paper optical density is in the range of 0.05 - 0.10 density units. The increased density in this area is used to gauge the degree of smearing.

Using the foregoing techniques and other techniques, it has been determined experimentally that print image characteristics may be affected by a variety of parameters associated with the phase change ink, the printing substrate and the printing apparatus itself. Among these parameters are:

- 5 A) substrate temperature
- B) ink velocity (drive voltage)
- C) substrate absorbency
- D) ink volume
- E) ink temperature (viscosity)
- 10 F) substrate to print head distance
- G) ink thermal diffusivity
- H) surface wetting characteristics.

15 The effect of each of these parameters, individually and in combination, upon ultimate print durability and quality is discussed below.

Substrate Temperature

20 It has been determined that the durability of the printed image may be affected by the temperature of the substrate. This is illustrated in Table 1 below, in which the degree of smearing of the print characters is determined for paper substrates printed at varying paper temperatures:

TABLE 1

Durability (Smearing)/Temperature	
Paper Temperature	Smear Measurement
23°C	0.30
38°C	0.20
49°C	0.07

25 The data illustrated in Table 1 were obtained using an ink held at a substantially constant temperature of 90°C and having a viscosity of approximately 10 Centipoise. The smear measurements were obtained using the smear evaluation method described above. A degradation of print quality was observed at a paper substrate temperature of approximately 49°C.

The relationship between the durability of the printed character and the temperature of the printing substrate is further illustrated in Table 2:

TABLE 2

Durability (Cracking)/Temperature

(Severe Cracking in %)

Platen Temp	Dot Size	Hammermill	Acceptance	Cranes
30°C	18.8 x 10 ⁻⁹ m ² (6.09mil)	34%	55%	62%
35	20.8 x 10 ⁻⁹ m ² (6.40)	26	38	36
40	23.2 x 10 ⁻⁹ m ² (6.77)	18	29	38
45	25.7 x 10 ⁻⁹ m ² (7.12)	6	23	12
50	26.6 x 10 ⁻⁹ m ² (7.24)	0	27	15
60	31.9 x 10 ⁻⁹ m ² (7.93)	2	4	5

Platen Temp	Dot Size	(Severe Cracking in %) DpC certificate
30°C	18.8 x 10 ⁻⁹ m ² (6.09mil)	84%
35	20.8 x 10 ⁻⁹ m ² (6.40)	58
40	23.2 x 10 ⁻⁹ m ² (6.77)	72
45	25.7 x 10 ⁻⁹ m ² (7.12)	38
50	26.6 x 10 ⁻⁹ m ² (7.24)	52
60	31.9 x 10 ⁻⁹ m ² (7.93)	27

The measurements illustrated in Table 2 were made utilizing an ink held at a substantially constant temperature of approximately 106°C and a substantially constant viscosity of approximately 10 Centipoise. All cracking values were determined by the cracking evaluation method described above.

As Table 2 indicates, at a given paper substrate temperature the degree of severe cracking may vary depending upon the type of paper used. The greatest amount of severe cracking was observed in DpC certificate paper. The least amount of severe cracking was observed in Hammermill paper. It is believed that this variation in the amount of cracking may be related to a corresponding variation in paper porosity--the Hammermill paper being the most porous of the samples used and the DpC certificate paper being the least porous.

Table 2 also illustrates the existence of a relationship between substrate temperature and dot size. (Reported dot sizes are for Hammermill paper.) Again, as with Table 1, there was an observable degradation in print quality for substrate temperatures above approximately 50°C.

As indicated in Table 2, the substrate temperature is directly related to, and may be controlled by adjusting the temperature of, the paper platen itself. At the time of printing, the platen and the substrate are typically in close physical proximity, if not in actual direct physical contact. Thus, due to heat transfer between the platen and substrate, the temperature of the platen provides an accurate indicator of the temperature of the substrate at the time and location of printing. For similar reasons, the temperature of the substrate itself may in fact be controlled by controlling the temperature of the platen. This may be accomplished by, for example, incorporating an electrical resistance element into the structure of the platen, or by directing a regulated flow of thermally controlled air against the platen (or directly against the substrate itself). A temperature sensing element may also be positioned in or adjacent to the platen so that changes in platen

and/or substrate temperature may be monitored and adjusted accordingly by means of a feedback loop. It will therefore be recognized by those skilled in the art that a wide variety of methods and mechanisms may be used to control the temperature of the substrate, either directly or through the platen. It has also been determined that the tactility of the printed image may be affected by the temperature of the substrate. In general, as the temperature of the substrate is increased, there is an increased tendency of the ink to spread. Therefore, the tactility of the print image will decline as the substrate temperature is increased.

In the printing system of the present invention, the temperature of the substrate is controlled within the range of approximately -40°C to approximately 200°C (i.e., approximately 50°C above the melting point of the hot melt ink, which is typically in the range of 70 to 150°C). The substrate temperature is preferably controlled to lie within the range of approximately 15°C to approximately 45°C.

Ink Velocity (Drive Voltage)

It has been determined that the characteristics of the printed image may be affected by the velocity at which the liquid jet is applied to the substrate. This is illustrated in Table 3:

TABLE 3
Durability Improvement with Heated Platen
and Controlled Dot Size

	Drive Voltage	Platen Temp	Dot Size	(Severe Cracking in %)			
				A	B	C	D
25	25 volts	30°C	5.98mil	34%	62%	67%	73%
30	21 volts	40°C	6.00mil	20%	32%	20%	47%
	25 volts	40°C	6.77mil	18%	29%	38%	72%
	Improvements:			41%	48%	70%	36%
35	Note:			A = Hammermill			
				B = Acceptance			
				C = Cranes'			
				D = DpC			
				(5.98mil = 18.1 x 10 ⁻⁹ m ²)			
				Certificate			
40				(6.00mil = 18.2 x 10 ⁻⁹ m ²)			
				(6.77mil = 23.2 x 10 ⁻⁹ m ²)			

In the preferred embodiment of the present invention, the velocity at which the ink strikes the substrate is related to the drive voltage of the ink jet printing mechanism. As the drive voltage is increased, the velocity at which the ink strikes the substrate also increases. Therefore, Table 3 provides the relevant data in terms of drive voltages rather than in terms of velocities.

The first two lines of Table 3 illustrate that varying the ink's velocity and volume or drive voltage allows ink dots of approximately equal size to be printed on substrates of different temperature. At a temperature of 30°C, an ink dot having a size of $18.1 \times 10^{-9} \text{m}^2$ (5.98mil) may be printed utilizing a drive voltage of 25 volts. If the platen temperature is increased by ten degrees to 40°C, the paper substrate will become warmer and the hot melt ink will consequently spread more easily on the paper substrate. Therefore, to maintain the same dot size at this elevated temperature, the drive voltage may be decreased to 21 volts.

As further illustrated in Table 3, the change in drive voltage (ink velocity and volume) and substrate temperature also has an effect upon the percentage of severe cracking observed in the printed substrate. In general, a reduction in drive voltage at a corresponding higher substrate temperature may result in an improvement in the percentage of severe cracking of anywhere between approximately 35% and 70%. The degree of improvement depends upon the type of

paper substrate used, with the least degree of improvement being observed for DpC certificate paper, the paper having the lowest porosity.

The first and third lines of Table 3 illustrate the effect of using the same drive voltage on a paper substrate at a temperature of 40°C and at 30°C. As shown, the same drive voltage of 25 volts used in conjunction with a substrate temperature of 40°C produces a dot size of $23.2 \times 10^{-9} \text{m}^2$ (6.77mil), or almost $507 \times 10^{-12} \text{m}^2$ (one mil) larger than the dot size observed at a substrate temperature of 30°C. It has been determined experimentally that an increase of approximately one volt in the drive voltage changes the dot size by approximately $20.3 \times 10^{-12} \text{m}^2$ (0.2mils), or $20.3 \times 10^{-12} \text{m}^2$ (2×10^{-4} inches).

The ink velocity used in the present invention may range anywhere from approximately 2 meters/second to approximately 60 meters/second, with the preferred ink velocity ranging from approximately 5 meters/second to approximately 20 meters/second.

Substrate Absorbency and Ink Droplet Volume

The characteristics of the printed image may also be affected by the absorbency of the substrate as well as the volume of the ink droplet jetted from the ink jet print head. This fact is illustrated by Figure 5:

In Figure 5, the term "STD" stands for standard characters. The term "EMPH" stands for emphasized characters, i.e., a wire print with not necessarily any additional ink on top. The term "OS" stands for overstrike printing, i.e., a second layer of ink.

The bottom portion of the first three vertical bars illustrate the percentage of severe cracking observed after one pass printing. The upper portion of these three bars illustrate the severe cracking which is observed when a second pass of the print head is made, depositing a second layer of ink upon the already printed ink image. The line in the bar represents the low range of cracking values; the bars show the maximum and minimum of cracking test data.

In several hot melt ink applications, a first layer of ink is applied to the substrate. The print head is then returned to its original position and passed over the substrate again, so that a second layer of ink, producing the identical printed image, is applied directly on top of the previously applied first ink layer. Consequently, in such applications, twice the volume of ink is being applied to the substrate. Prior to the second pass of the print head, the first layer of ink applied to the substrate will have penetrated the substrate and substantially returned to the solid phase. Thus, the second layer of hot melt ink will have little to no penetration into the substrate itself. Typically, there will not be enough heat capacitance of the second application of hot melt ink to cause any significant melting of the first layer of ink. The second layer will therefore predominately be deposited onto the surface of the first layer, with a resulting degradation in the durability of prints made with this second layer of hot melt ink.

The last two vertical bars in Figure 5 illustrate the percentage of severe cracking observed with paper which has very low porosity, therefore making it very difficult for the hot melt ink to be absorbed into the paper. Therefore, a noticeable degradation in the durability of the print is observed when the volume of the ink applied to the substrate is increased or when the absorbency of the paper substrate is decreased.

The absorbency of the substrate may be affected by a variety of factors, including the porosity of the substrate, surface smoothness, burst strength, internal sizing and external sizing of the substrate. However, it has been determined that the absorbency of the substrate is related primarily to the porosity of the substrate. Therefore, the porosity may be used as a guide in selecting an appropriately absorbent substrate. As measured using standard Sheffield units, the substrates for use in the present invention may be selected from among substrates exhibiting a porosity of anywhere from approximately 0 Sheffield units to approximately 500 Sheffield units, with preferred substrates being selected from among substrates exhibiting a porosity of anywhere from approximately 20 Sheffield units to approximately 150 Sheffield units.

As used herein, the term "ink volume" refers to the volume of the ink that is ejected as a discrete droplet from the print head to the substrate (as illustrated, for example, in Fig. 2). The volume of the ink droplet may be controlled by controlling the ink viscosity and the drive voltage in combination. For example, at a given viscosity, the volume of the ink droplet may be increased by increasing the drive voltage. Alternatively, at a given constant drive voltage, a decrease in the viscosity will result in an increase in the volume of the ink droplet.

In the present invention, ink droplets ejected from the print head may have a volume within the range of approximately $1 \times 10^{-9} \text{cm}^3$ to approximately $500 \times 10^{-9} \text{cm}^3$, with preferred ink droplet volumes falling within the range of approximately $50 \times 10^{-9} \text{cm}^3$ to approximately $200 \times 10^{-9} \text{cm}^3$.

Ink Temperature (Viscosity)

It has been found that the characteristic of the printed image may be affected by the temperature of the ink applied to the substrate. This fact is demonstrated by Table 5.

TABLE 5

HEAD TEMPERATURE		
Ink Temperature	Ink Viscosity	Smear Measurement
90°C	10.0 cP	0.30
110°C	6.5 cP	0.26
120°C	5.5 cP	0.22
130°C	4.5 cP	0.19

As Table 5 illustrates, there is an inverse relationship between the temperature of the ink and the ink viscosity. In general, the log of the viscosity is proportional to one over the temperature. In addition, as the temperature of the ink is increased, the degree of smearing generally decreases. The measurements set out in Table 5 were conducted for a paper substrate which was maintained at room temperature (21°C) during the printing process, and for a drive voltage which was held constant for all print runs.

The print head temperature or temperature of the ink may be varied to increase the ink penetration with a limited print quality degradation. Therefore, print head temperature or ink temperature can be varied to allow a given tactility or durability for a given paper.

Table 6 below illustrates further the effect of combined drive voltage variations and head temperature variations on print durability using paper substrates having a variety of porosities.

TABLE 6

DURABILITY VARIATION AT VARYING HEAD TEMPERATURES AT A 15.3 x 10 ⁻⁹ m ² - 15.9 x 10 ⁻⁹ m ² (5.5 - 5.6) MIL DOT SIZE		
Sample	SEVERE CRACKING (%)	
	Standard	Emphasized + OS
1. 100°C, 15.6 x 10 ⁻⁹ m ² (5.55 mil) Viscosity 11.2 cP	dot size	
a. DpC Certificate	59	83
b. Acceptance Bond	37	54
c. Hammermill Xerocopy	37	87
d. Cranes' Crest	49	79
2. 110°C, 15.9 x 10 ⁻⁹ m ² (5.61 mil) Viscosity 9.0 cP	dot size	
a. DpC Certificate	47	58
b. Acceptance Bond	31	47
c. Hammermill Xerocopy	31	70
d. Cranes' Crest	30	62
3. 120°C, 15.4 x 10 ⁻⁹ m ² (5.51 mil) Viscosity 7.0 cP	dot size	
a. DpC Certificate	52	65
b. Acceptance Bond	18	64
c. Hammermill Xerocopy	11	52
d. Cranes' Crest	22	69

Table 6 demonstrates the benefit of increasing the penetration of the ink into the substrate by using a hotter ink but maintaining a relatively constant ink droplet volume (i.e., a decreased drive voltage). The ink droplet size for the measurements illustrated in Table 6 was maintained in a range between $15.3 \times 10^{-9} \text{m}^2$ and $15.9 \times 10^{-9} \text{m}^2$ (5.5 and 5.6mil).

The temperature of the ink in the present invention may fall within the range of approximately 10°C to approximately 200°C , with a preferred ink temperature falling within the range of approximately 70°C to 150°C . This corresponds to a jettable viscosity ranging from approximately 1 centipoise to approximately 50 centipoise, with a preferred range of viscosities between approximately 5 centipoise and approximately 20 centipoise.

Ink Jet Head to Substrate Distance

The characteristics of the printed image may also be affected by the distance between the substrate and the ink jet print head. This fact is illustrated by Table 7:

TABLE 7

Distance	Dot Size	% Above Paper
0.56mm(0.022 inch)	$15.3 \times 10^{-9} \text{m}^2$ (5.5mil)	26
0.89(0.035)	$13.7 \times 10^{-9} \text{m}^2$ (5.2)	29
1.52(0.060)	$15.9 \times 10^{-9} \text{m}^2$ (5.6)	46
2.54(0.100)	$12.2 \times 10^{-9} \text{m}^2$ (4.9)(dl)	51
5.59(0.220)	$8.94 \times 10^{-9} \text{m}^2$ (4.2)(dl)	46
12.70(0.500)	$7.71 \times 10^{-9} \text{m}^2$ (3.9)(dl)	66
19.05(0.750)	$6.94 \times 10^{-9} \text{m}^2$ (3.7)(dl)	61
76.20(3.000)	---	100%
dl = detached ligament		

It can be seen from the data in Table 7 that the size of the dot decreases as the distance between the substrate and the ink jet print head is increased. When the substrate is at a distance of greater than 2.54mm (0.100 inches) from the ink jet print head, the ink ligament (tail) is completely detached from the main print drop prior to reaching the substrate. At a distance of approximately 76.2mm (3 inches) between the substrate and the ink jet print head, the hot melt ink no longer reaches the substrate and thus no printing occurs.

Table 7 also illustrates that the degree of penetration of the hot melt ink into the paper substrate may also be affected by the distance between the substrate and the ink jet print head. In general, the amount of hot melt ink which does not penetrate the substrate but instead remains above the surface of the substrate may be increased by increasing the distance between the substrate and the ink jet print head. Thus, the tactility of the final print may be controlled by adjusting the relative distance between the ink jet print head and the paper.

The print head and the substrate of the present invention may be separated by a distance of anywhere from between approximately 0.025mm (0.001 inches) to approximately 25.4mm (1 inch), with a preferred distance of separation falling within the range of approximately 0.64mm (0.025 inches) to approximately 3.81mm (0.150 inches).

Thermal Diffusivity

It has further been determined that the characteristics of the printed image may be affected by the thermal diffusivity of the hot melt ink. The ink thermal diffusivity may be defined by the following equation:

$$\text{thermal diffusivity} = \frac{\text{thermal conductivity}}{\text{specific heat} \times \text{density}}$$

The magnitude of the thermal diffusivity determines the rate at which a body with nonuniform temperature approaches equilibrium. With respect to the hot melt ink of the present invention, this figure is related to the rate at which heat is lost from the ink and the rate at which solidification will take place on the substrate. This, in turn, is related to the degree of both penetration into the substrate and spread along the surface of the substrate.

The hot melt ink of the present invention may be selecting from among inks having a thermal diffusivity within the range of approximately $0.0022 \text{cm}^2 \text{sec}^{-1}$ and approximately $0.00056 \text{cm}^2 \text{sec}^{-1}$. The preferred thermal diffusivity of the

hot melt ink of the present invention lies within the range of approximately $0.0010\text{cm}^2\text{sec}^{-1}$ and approximately $0.0006\text{cm}^2\text{sec}^{-1}$.

It has also been determined that the characteristics of the printed image may be affected by surface wetting characteristics. The surface wetting characteristics may be affected by varying the surface tension of the ink and/or the temperature of the ink. Surface wetting characteristics may also be affected by controlling the "critical" surface tension of the substrate.

The present invention is of particular value when printing is to be performed on varying substrates and under varying environmental conditions. For example, the printing system of the present invention may be utilized in a portable bar code printer. Such a printer would be moveable to a position adjacent a conveyor belt, so that the printer could print a bar code label on each of a plurality of boxes or other packaging materials as the materials pass by. It is recognized that the size, shape, structure and other physical attributes of such packaging materials may change frequently. It is also recognized that the operating environment (i.e., temperature, humidity, etc.) of the bar code printer may not be identical for each conveyor belt. It is therefore highly desirable to provide a bar code printer which is capable of adjusting to changing substrate materials as well as changing operating environments, so that bar code labels of uniform quality and durability may be printed. By use of the present invention, a combination of the bar code printing parameters may be controlled so that bar code labels of optimum print quality and durability may be obtained despite changes in the nature of the substrate or the printing environment.

In one embodiment of the present invention, the printing system may include one or more customer adjustable dials capable of controlling one or more of the above-identified parameters, including ink temperature, substrate temperature, drive voltage, and substrate to ink jet print head distance. These dials would enable a print system user to continuously vary one of the print characteristics, such as ink penetration, from complete penetration up to complete lack of penetration (maximum tactility).

In another embodiment of the invention, a code printer (i.e., a bar code printer) that can accept and print high quality, high density print images on a multitude of labels and other substrates may be provided. The printer would print a text bar code, then automatically read it. If this reading determines that the print image is below optimal quality, then automatic adjustments to the head temperature, paper temperature, drive voltage and head-to-paper distance would be made until the reading becomes acceptable.

Claims

1. A method of jetting hot melt ink from an ink jet print head to a substrate, the substrate (26) having a predefined absorbcency and the ink (24) having a predefined thermal diffusivity, which method includes:
 - giving the ink (24) a selected temperature between 10°C and 200°C , heating the substrate (26) to a selected temperature not below 15°C and not above 50°C , positioning the print head at a selected distance from the substrate (26) between 0.025 mm and 25.4 mm, controlling the print head to effect ejection of the ink (24) at a velocity between 2 meters per second and 60 meters per second, and ejecting ink (24) from the print head toward the substrate,
 - observing the ink (24) which has been jetted onto the substrate (26);
 - varying at least one of the ink temperature, substrate temperature, print head to substrate distance and ink ejection velocity based on the result of the observing step;
 - again ejecting ink (24) from the print head toward the substrate (26), characterised in that heating of the substrate (26) is carried out by monitoring the temperature of the substrate (26) and adjusting the heating of the substrate (26) in response to the monitoring result so as to maintain the substrate (26) at the selected temperature.
2. The method according to claim 1, further comprising the step of: controlling the distance between the print head and the substrate (26) to increase the spread of the dot upon the substrate (26).
3. A method as in claim 1 or claim 2 wherein the predetermined thermal diffusivity is between $0.0022\text{ cm}^2\text{sec}^{-1}$ and $0.00056\text{ cm}^2\text{sec}^{-1}$.
4. A method as in any of claims 1-3 wherein the ink temperature is between 70°C and 150°C .
5. Apparatus for jetting hot melt ink (24) from an ink jet print head to a substrate (26), the substrate (26) having a predefined absorbcency and the ink (24) having a predefined thermal diffusivity, which apparatus includes:
 - means (28, 32) for giving the ink (24) a selected temperature between 10°C and 200°C , means for heating the substrate (26) to a selected temperature not below 15°C and not above 50°C , means for positioning the print head at a selected distance from the substrate between 0.025 mm and 25.4 mm, means for controlling the print head to effect ejection of the ink (24) at a velocity between 2 meters per second and 60 meters per second, characterized in that it further comprises:
 - a system to provide user operatable means for varying at least one of the ink temperature, substrate tem-



hot melt ink of the present invention lies within the range of approximately $0.0010\text{cm}^2\text{sec}^{-1}$ and approximately $0.0006\text{cm}^2\text{sec}^{-1}$.

It has also been determined that the characteristics of the printed image may be affected by surface wetting characteristics. The surface wetting characteristics may be affected by varying the surface tension of the ink and/or the temperature of the ink. Surface wetting characteristics may also be affected by controlling the "critical" surface tension of the substrate.

The present invention is of particular value when printing is to be performed on varying substrates and under varying environmental conditions. For example, the printing system of the present invention may be utilized in a portable bar code printer. Such a printer would be moveable to a position adjacent a conveyor belt, so that the printer could print a bar code label on each of a plurality of boxes or other packaging materials as the materials pass by. It is recognized that the size, shape, structure and other physical attributes of such packaging materials may change frequently. It is also recognized that the operating environment (i.e., temperature, humidity, etc.) of the bar code printer may not be identical for each conveyor belt. It is therefore highly desirable to provide a bar code printer which is capable of adjusting to changing substrate materials as well as changing operating environments, so that bar code labels of uniform quality and durability may be printed. By use of the present invention, a combination of the bar code printing parameters may be controlled so that bar code labels of optimum print quality and durability may be obtained despite changes in the nature of the substrate or the printing environment.

In one embodiment of the present invention, the printing system may include one or more customer adjustable dials capable of controlling one or more of the above-identified parameters, including ink temperature, substrate temperature, drive voltage, and substrate to ink jet print head distance. These dials would enable a print system user to continuously vary one of the print characteristics, such as ink penetration, from complete penetration up to complete lack of penetration (maximum tactility).

In another embodiment of the invention, a code printer (i.e., a bar code printer) that can accept and print high quality, high density print images on a multitude of labels and other substrates may be provided. The printer would print a text bar code, then automatically read it. If this reading determines that the print image is below optimal quality, then automatic adjustments to the head temperature, paper temperature, drive voltage and head-to-paper distance would be made until the reading becomes acceptable.

Claims

1. A method of jetting hot melt ink from an ink jet print head to a substrate, the substrate (26) having a predefined absorbency and the ink (24) having a predefined thermal diffusivity, which method includes:
 - giving the ink (24) a selected temperature between 10°C and 200°C , heating the substrate (26) to a selected temperature not below 15°C and not above 50°C , positioning the print head at a selected distance from the substrate (26) between 0.025 mm and 25.4 mm, controlling the print head to effect ejection of the ink (24) at a velocity between 2 meters per second and 60 meters per second, and ejecting ink (24) from the print head toward the substrate, observing the ink (24) which has been jetted onto the substrate (26);
 - varying at least one of the ink temperature, substrate temperature, print head to substrate distance and ink ejection velocity based on the result of the observing step;
 - again ejecting ink (24) from the print head toward the substrate (26), characterised in that heating of the substrate (26) is carried out by monitoring the temperature of the substrate (26) and adjusting the heating of the substrate (26) in response to the monitoring result so as to maintain the substrate (26) at the selected temperature.
2. The method according to claim 1, further comprising the step of: controlling the distance between the print head and the substrate (26) to increase the spread of the dot upon the substrate (26).
3. A method as in claim 1 or claim 2 wherein the predetermined thermal diffusivity is between $0.0022\text{ cm}^2\text{sec}^{-1}$ and $0.00056\text{ cm}^2\text{sec}^{-1}$.
4. A method as in any of claims 1-3 wherein the ink temperature is between 70°C and 150°C .
5. Apparatus for jetting hot melt ink (24) from an ink jet print head to a substrate (26), the substrate (26) having a predefined absorbency and the ink (24) having a predefined thermal diffusivity, which apparatus includes:
 - means (28, 32) for giving the ink (24) a selected temperature between 10°C and 200°C , means for heating the substrate (26) to a selected temperature not below 15°C and not above 50°C , means for positioning the print head at a selected distance from the substrate between 0.025 mm and 25.4 mm, means for controlling the print head to effect ejection of the ink (24) at a velocity between 2 meters per second and 60 meters per second, characterized in that it further comprises:
 - a system to provide user operatable means for varying at least one of the ink temperature, substrate tem-

perature, print head to substrate distance and ink ejection velocity; and means to monitor the temperature of the substrate (26), said means co-operating with the means for heating the substrate (26) to maintain the substrate at the selected temperature.

- 5 6. A method of jetting hot melt ink from an ink jet print head to a substrate, the substrate (26) having a predefined absorbency and the ink (24) having a predefined thermal diffusivity, which method includes:
 giving the ink (24) a selected temperature between 10°C and 200°C, heating the substrate (26) to a selected temperature, positioning the print head at a selected distance from the substrate (26), controlling the print head to effect ejection of the ink (24) at a selected velocity, and ejecting ink (24) from the print head toward the substrate,
 10 observing the ink (24) which has been jetted onto the substrate (26);
 varying at least one of the ink temperature, substrate temperature, print head to substrate distance and ink ejection velocity based on the result of the observing step;
 again ejecting ink (24) from the print head toward the substrate (26), characterised in that heating of the substrate (26) is carried out by monitoring the temperature of the substrate (26) and adjusting the heating of the substrate (26) in response to the monitoring result so as to maintain the substrate (26) at the selected temperature.
- 15 7. Apparatus for jetting hot melt ink (24) from an ink jet print head to a substrate (26), the substrate (26) having a predefined absorbency and the ink (24) having a predefined thermal diffusivity, which apparatus includes:
 means (28,32) for giving the ink (24) a selected temperature between 10°C and 200°C, means for heating the substrate (26) to a selected temperature, means for positioning the print head at a selected distance from the substrate, means for controlling the print head to effect ejection of the ink (24) at a selected velocity, characterized in that it further comprises:
 means to monitor the temperature of the substrate (26), said means cooperating with the means for heating the substrate (26) to maintain the substrate at the selected temperature.
- 20 8. Apparatus according to claim 7, characterised in that a system provides user operatable dials for varying at least one of the ink temperature, substrate temperature, print head to substrate distance and ink ejection velocity.

Patentansprüche

- 30 1. Ein Verfahren zum Ausstoßen heißschmelzender Tinte aus einem Tintenstrahldruckkopf auf ein Substrat, wobei das Substrat (26) ein vorbestimmtes Absorptionsvermögen besitzt und die Tinte (24) ein vorbestimmtes Temperaturausbreitungsvermögen besitzt, wobei das Verfahren enthält:
 Bringen der Tinte (24) auf eine gewählte Temperatur zwischen 10° C und 200° C; Heizen des Substrats (26)
 35 auf eine gewählte Temperatur nicht unter 15° C und nicht über 50° C; Positionieren des Druckkopfs in einem gewählten Abstand von dem Substrat (26) zwischen 0,025 mm und 25,4 mm; Steuern des Druckkopfs, um ein Ausstoßen der Tinte (24) mit einer Geschwindigkeit zwischen 2 m/s und 60 m/s zu bewirken; und Ausstoßen von Tinte (24) aus dem Druckkopf in Richtung des Substrats;
 Beobachten der Tinte (24), die auf das Substrat (26) ausgestoßen worden ist;
 40 Variieren von mindestens einer der Größen Tintentemperatur, Substrattemperatur, Druckkopf-zu-Substrat-Abstand und Tintenausstoßgeschwindigkeit basierend auf dem Ergebnis des Beobachtungsschritts;
 erneutes Ausstoßen von Tinte (24) aus dem Druckkopf in Richtung des Substrats (26), dadurch gekennzeichnet, daß das Heizen des Substrats (26) durchgeführt wird durch Überwachen der Temperatur des Substrats (26) und Einstellen der Beheizung des Substrats (26) als Reaktion auf das Überwachungsergebnis, um das Substrat (26) auf der gewählten Temperatur zu halten.
- 45 2. Das Verfahren gemäß Anspruch 1, das desweiteren den Schritt umfaßt: Steuern des Abstands zwischen dem Druckkopf und dem Substrat (26), um die Ausbreitung des Punktes auf dem Substrat (26) zu vergrößern.
- 50 3. Ein Verfahren gemäß Anspruch 1 oder 2, bei dem das vorbestimmte Temperaturausbreitungsvermögen zwischen 0,0022 cm²/s und 0,00056 cm²/s beträgt.
4. Ein Verfahren gemäß einem der Ansprüche 1 bis 3, bei dem die Tintentemperatur zwischen 70° C und 150° C liegt.
- 55 5. Vorrichtung zum Ausstoßen heißschmelzender Tinte (24) aus einem Tintenstrahldruckkopf auf ein Substrat (26), wobei das Substrat (26) ein vorbestimmtes Absorptionsvermögen besitzt und die Tinte (24) ein vorbestimmtes Wärmeausbreitungsvermögen besitzt, wobei die Vorrichtung enthält:
 Einrichtung (28, 32), um die Tinte (24) auf eine gewählte Temperatur zwischen 10° C und 200° C zu bringen;
 Einrichtung zum Heizen des Substrats (26) auf eine gewählte Temperatur nicht unter 15° C und nicht über 50° C;



Einrichtung zur Positionierung des Druckkopfs in einem gewählten Abstand von dem Substrat zwischen 0,025 mm und 25,4 mm; Einrichtung zum Steuern des Druckkopfs, um ein Ausstoßen der Tinte (24) mit einer Geschwindigkeit zwischen 2 m/s und 60 m/s zu bewirken;

dadurch gekennzeichnet, daß sie desweiteren umfaßt:

- 5 ein System, um Benutzerbedienungseinrichtungen zur Varrierung von mindestens einer der Größen Tintentemperatur, Substrattemperatur, Druckkopf-zu-Substrat-Abstand und Tintenausstoßgeschwindigkeit zur Verfügung zu stellen; und eine Einrichtung, zum Überwachen der Temperatur des Substrats (26), wobei diese Einrichtung mit der Einrichtung zum Heizen des Substrats (26) zusammenwirkt, um das Substrat auf der gewählten Temperatur zu halten.

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6. Ein Verfahren zum Ausstoßen heißschmelzender Tinte aus einem Tintenspritzdruckkopf auf ein Substrat, wobei das Substrat (26) ein vorbestimmtes Absorptionsvermögen besitzt und die Tinte (24) ein vorbestimmtes Temperaturausbreitungsvermögen besitzt, wobei das Verfahren enthält:

15 Bringen der Tinte (24) auf eine gewählte Temperatur zwischen 10° C und 200° C; Heizen des Substrats (26) auf eine gewählte Temperatur; Positionieren des Druckkopfs in einem gewählten Abstand von dem Substrat (26); Steuern des Druckkopfs, um ein Ausstoßen der Tinte (24) mit einer gewählten Geschwindigkeit zu bewirken; und Ausstoßen von Tinte (24) aus dem Druckkopf in Richtung des Substrats;

Beobachten der Tinte (24), die auf das Substrat (26) ausgestoßen worden ist;

20 Variieren von mindestens einer der Größen Tintentemperatur, Substrattemperatur, Druckkopf-zu-Substrat-Abstand und Tintenausstoßgeschwindigkeit basierend auf dem Ergebnis des Beobachtungsschritts;

erneutes Ausstoßen von Tinte (24) aus dem Druckkopf in Richtung des Substrats (26), dadurch gekennzeichnet, daß das Heizen des Substrats (26) durchgeführt wird, durch Überwachen der Temperatur des Substrats (26) und Einstellen der Beheizung des Substrats (26) als Reaktion auf das Überwachungsergebnis, um das Substrat (26) auf der gewählten Temperatur zu halten.

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7. Vorrichtung zum Ausstoßen heißschmelzender Tinte (24) aus einem Tintenstrahldruckkopf auf ein Substrat (26), wobei das Substrat (26) ein vorbestimmtes Absorptionsvermögen besitzt und die Tinte (24) ein vorbestimmtes Temperaturausbreitungsvermögen besitzt, wobei die Vorrichtung enthält:

30 Einrichtung (28, 32), um die Tinte (24) auf eine gewählte Temperatur zwischen 10° C und 200° C zu bringen; Einrichtung zum Heizen des Substrats (26) auf eine gewählte Temperatur; Einrichtung zum Positionieren des Druckkopfs in einem gewählten Abstand von dem Substrat; Einrichtung zum Steuern des Druckkopfs, um ein Ausstoßen der Tinte (24) mit einer gewählten Geschwindigkeit zu bewirken, dadurch gekennzeichnet, daß sie desweiteren umfaßt;

35 eine Einrichtung zum Überwachen der Temperatur des Substrats (26), wobei diese Einrichtung mit der Einrichtung zum Heizen des Substrats (26) zusammenwirkt, um das Substrat auf der gewählten Temperatur zu halten.

8. Apparat gemäß Anspruch 7, dadurch gekennzeichnet, daß ein System von außen zugängliche benutzerbedienbare Wähleinrichtungen zur Varrierung von mindestens einer der Größen Tintentemperatur, Substrattemperatur, Druckkopf-zu-Substrat-Abstand und Tintenausstoßgeschwindigkeit zur Verfügung stellt.

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Revendications

1. Procédé pour projeter de l'encre fondue à chaud par une tête d'impression à jet d'encre sur un substrat, le substrat (26) possédant une capacité d'absorption prédéfinie et l'encre (24) possédant une diffusité thermique prédéfinie, lequel procédé consiste à :

45 amener l'encre (24) à une température sélectionnée entre 10°C et 200°C, chauffer le substrat (26) à une température sélectionnée non inférieure à 15°C et non supérieure à 50°C, positionner la tête d'impression à une distance sélectionnée du substrat (26) entre 0,025 mm et 25,4 mm, commander la tête d'impression pour obtenir l'éjection de l'encre (24) à une vitesse comprise entre 2 mètres par seconde et 60 mètres par seconde, et éjecter l'encre (24) depuis la tête d'impression en direction du substrat,

50 observer l'encre (24) qui a été projetée sur le substrat (26);

modifier au moins la température de l'encre et/ou la température du substrat et/ou la distance entre la tête d'impression et le substrat et/ou la vitesse d'éjection sur la base du résultat de l'étape d'observation;

éjecter à nouveau de l'encre (24) de la tête d'impression en direction du substrat (26),

55 caractérisé en ce que le chauffage du substrat (26) est exécuté au moyen du contrôle de la température du substrat (26) et de l'ajustement du chauffage du substrat (26) en réponse au résultat contrôlé de manière à maintenir le substrat (26) à la température sélectionnée.



2. Procédé selon la revendication 1, comprenant en outre les étapes consistant à : commander la distance entre la tête d'impression et le substrat (26) pour augmenter l'étalement du point sur le substrat (26).
3. Procédé selon la revendication 1 ou 2, selon lequel la diffusibilité thermique prédéterminée est comprise entre $0,0022 \text{ cm}^2\text{s}^{-1}$ et $0,00056 \text{ cm}^2\text{s}^{-1}$.
4. Procédé selon l'une quelconque des revendications 1-3, selon lequel la température de la lampe est comprise entre 70°C et 150°C .
5. Dispositif pour projeter de l'encre fondue à chaud (24) par une tête d'impression à jet d'encre sur un substrat, le substrat (26) possédant une capacité d'absorption prédéfinie et l'encre, (24) possédant une diffusité thermique prédéfinie, lequel dispositif contient :
 - des moyens (28,32) pour amener l'encre (24) à une température sélectionnée entre 20°C et 200°C ; des moyens pour chauffer le substrat (26) à une température sélectionnée non inférieure à 15°C et non supérieure à 50°C , des moyens pour positionner la tête d'impression à une distance sélectionnée du substrat comprise entre $0,025 \text{ mm}$ et $25,4 \text{ mm}$, des moyens pour commander la tête d'impression pour exécuter l'éjection de l'encre (24) à une vitesse comprise entre 2 mètres par seconde et 60 mètres par seconde, caractérisé en ce qu'il comprend en outre :
 - un système pour fournir des moyens pouvant être actionnés par l'utilisateur pour modifier au moins la température de l'encre et/ou la température du substrat et/ou la distance entre la tête d'impression et le substrat et/ou la vitesse d'éjection de l'encre; et des moyens pour contrôler la température du substrat (26), lesdits moyens coopérant avec les moyens servant à chauffer le substrat (26) pour maintenir le substrat à la température sélectionnée.
6. Procédé pour, projeter de l'encre fondue à chaud par une tête d'impression à jet d'encre sur un substrat, le substrat (26) possédant une capacité d'absorption prédéfinie et l'encre (24) possédant une diffusité thermique prédéfinie, lequel procédé consiste à :
 - amener l'encre (24) à une température sélectionnée entre 10°C et 200°C , chauffer le substrat (26) à une température sélectionnée, positionner la tête d'impression à une distance sélectionnée du substrat (26), commander la tête d'impression pour obtenir l'éjection de l'encre (24) à une vitesse sélectionnée, et éjecter l'encre (24) depuis la tête d'impression en direction du substrat,
 - observer l'encre (24) qui a été projetée sur le substrat (26);
 - modifier au moins la température de l'encre et/ou la température du substrat et/ou la distance entre la tête d'impression et le substrat et/ou la vitesse d'éjection sur la base du résultat de l'étape d'observation;
 - éjecter à nouveau de l'encre (24) de la tête d'impression en direction du substrat (26),
 - caractérisé en ce que le chauffage du substrat (26) est exécuté au moyen du contrôle de la température du substrat (26) et de l'ajustement du chauffage du substrat (26) en réponse au résultat contrôlé de manière à maintenir le substrat (26) à la température sélectionnée.
7. Dispositif pour projeter de l'encre fondue à chaud (24) par une tête d'impression à jet d'encre sur un substrat, le substrat (26) possédant une capacité d'absorption prédéfinie et l'encre (24) possédant une diffusité thermique prédéfinie, lequel dispositif contient :
 - des moyens (28,32) pour amener l'encre (24) à une température sélectionnée entre 10°C et 200°C ; des moyens pour chauffer le substrat (26) à une température sélectionnée, des moyens pour positionner la tête d'impression à une distance sélectionnée par rapport au substrat, des moyens pour commander la tête d'impression pour exécuter l'éjection de l'encre (24) à une vitesse sélectionnée,
 - caractérisé en ce qu'il comprend en outre :
 - des moyens pour contrôler la température du substrat (26); lesdits moyens coopérant avec les moyens de chauffage du substrat (26) pour maintenir le substrat à la température sélectionnée.
8. Dispositif selon la revendication 7, caractérisé en ce qu'un système comporte des cadrans accessibles de l'extérieur et pouvant être actionnés par l'utilisateur pour modifier au moins la température de l'encre et/ou la température du substrat et/ou la distance entre la tête d'impression et le substrat et/ou la vitesse d'éjection de l'encre.

