Improving the performance of rolling printing machine by monitoring and analyzing mechatronics systems

Haitham Abdel Monem Mostafa Badr
An engineer in the armed forces
Muhammad Ali Metwally
Assistant Professor, Mech. Power Engineering Dept. the Military Technical College
Mohammed Abu Al-Aneen Al-Samnoudi
Professor, Mech. Power Engineering Dept., Faculty of Engineering, Ain Shams University

Abstract:
The research is directed towards the work of modification and development of the poster printing machines that operate with Inkjet by increasing the speed of the poster printing machine without prejudice to the required print quality, which is the main fac- tor in the market Because the quality of printing is the basis for the customer's drive and speed is an important factor for the printing organization in order to save time and provide the largest quantity of production with the highest quality, and through it. it will return to the printing establishment by several factors, namely: Save time by producing the largest quantity in the least time, Providing manpower for the printing establishment, Providing the additional requirements to save electricity and other factors. The purpose of this analysis effect of pressure inside the ink tanks on increasing the print accuracy (print quality) with the printer head steady. , Also to find what is the permissible critical range for increasing the pressure that will increase the speed of printing with permissible accuracy this phenomenon will be validated by Mathematical Model, Coupling of Nozzle Dynamics and Droplet Formation, prediction by CFD modelling and Influence Of Pressure And Media Speed On Printing Quality. It is possible to increase the production process for banner printing by fixing the ma- chine speed at 5 m/h and increasing the pressure with a maximum of 0.38 bar be- cause after that there was a clear defect in the printing process . It can save time and increase production without compromising the quality of the print- ed product. The prediction by CFD modelling was adequately able to predict the formation and development of an ink droplet ejected from the printhead of an inkjet printer. Relationship between the different effect of pressure and the variable speed of the print head and their relationship to the print quality. And we also find that it is possible to reach the maximum degree of printing accuracy after controlling the pressure and speed of the print head.

Keywords:
Nozzle-droplet ejected
Nozzle Dynamics Model
Droplet Formation
Nozzle Dynamics.

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1- Introduction :

The research is directed towards the work of modification and develop- mend of the poster printing machines that operate with Inkjet by increasing the speed of the poster printing machine without prejudice to the required print quality, which is the main factor in the market Because the quality of printing is the basis for the customer's drive and speed is an important factor for the printing organization in order to save time and provide the largest quantity of production with the highest quality, and through it. it will return to the printing establishment by several factors, namely:

1. Save time by producing the largest quantity in the least time. 2- Providing manpower for the printing establishment.
2. Providing the additional requirements to save electricity and other fac- tors.

The purpose of this analysis effect of pressure inside the ink tanks on increasing the print accuracy (print quality) with the printer head steady. , Also to find what is the permissible critical range for increasing the pres- sure that will increase the speed of printing with permissible accuracy this phenomenon will be validated by :

1. Mathematical Model (Droplet Formation Model - Nozzle Dynamics Model) .
2. Coupling of Nozzle Dynamics and Droplet Formation .
3. prediction by CFD modelling .
4. Influence Of Pressure And Media Speed On Printing Quality.

2- Objectives:

The purpose to analyze effect of pressure inside the ink tanks on increasing the print accuracy (print quality) with the printer head steady. to find what is the permissible critical range for increasing the pressure that will increase the speed of printing with permissible accuracy this phenomenon will be validated by :

1- Mathematical Model (Droplet Formation Model - Nozzle Dynamics Model) .
2- Coupling of Nozzle Dynamics and Droplet Formation .
3- production by CFD modeling .

2.1 Mathematical Model

The droplet ejection from inkjet is practically a liquid - air two-phase flow problem , that overwhelmingly include the solution of the navier stock equations for two fluids. But , the viscous force of air might be ignored because of the high liquid - air density ratio and very short time of droplet ejection time . The shear stress along free surface is assume zero. so, only the liquid phase is solved in the droplet formation analysis. Besides, given the high velocity of typical inkjet droplets (10–30 m/s) &The minus- clue measurement of orifice (10–30 s), the Froude number, the proportion of inertia force and gravity, is exceptionally enormous, The Bond number, The proportion of gravity and surface tension , is exceptionally little. In this manner , It could be securely drop the gravity term from the governing conditions of liquid.

2.1.2 Nozzle Dynamics Model

Through the foregoing , It could be found a clear relationship between pressure, speed, and the size of the ink point. The more pressure the greater the size of the ink point, and to compensate for the larger size of the point over what is allowed, increase pressure required to ensure that the ink droplets intentionally overlap and distort the final product , This What will find in fig. (1) and fig (3).

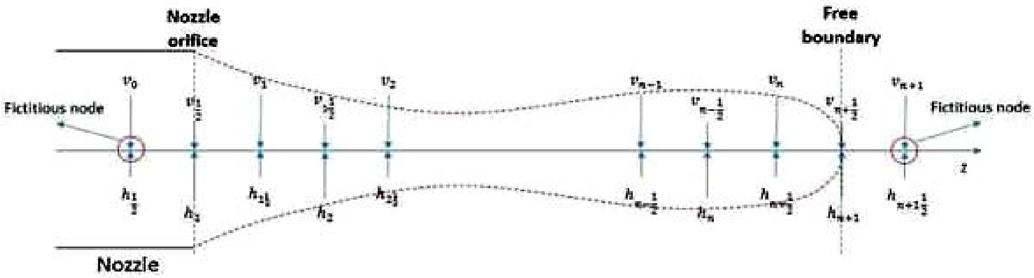

Fig. (1) uniform mesh of droplet formation (droplet connecting to nozzle)

stability, instead of separating the droplet exactly at the point reaching the threshold, create two new ends next to the breakup point and leave a space between them to guarantee a clear partition, as shown in Figure (2).

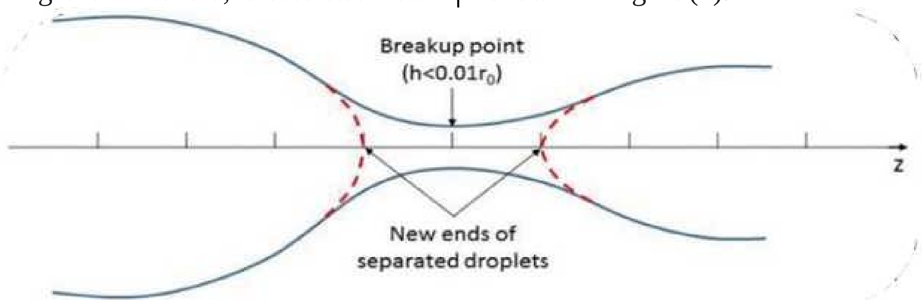

Fig. (2) Relationship between point size and pressure

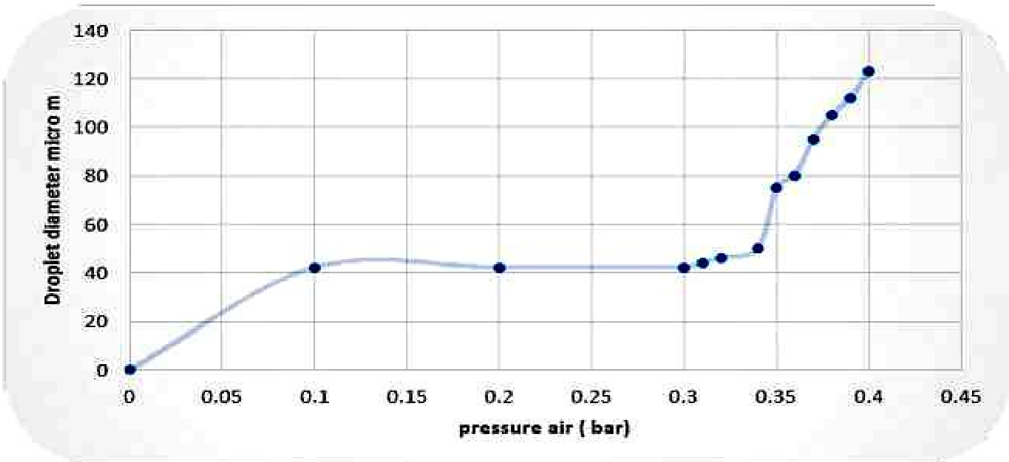

Fig. (3) Relationship between point size and pressure

2-1-3 : Dynamic model results and discussion :

From fig (3) it shows an approximate visualization of the permissible range of the pressure increase, which is between 0.25 to 0.4 bar. After 0.4 bar, there is a large increase in the size of the Droplet Formation, which leads to the sticking of the dots (distortion of the print) and before 0.25 bar there is no noticeable effect on the size of the ink point.

2.1.4 Coupling of Nozzle Dynamics and Droplet Formation :

Meniscus is the interface between the fluid in the nozzle and the ambient air

Fig. (4) and Fig.(5) .

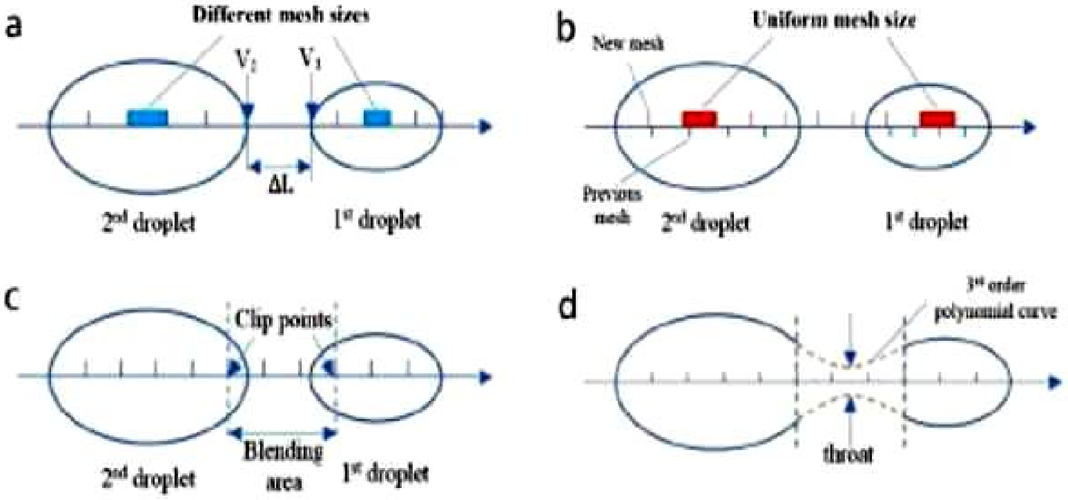

Fig. (4) Strategy of droplet combination:

a. Two moving toward droplet with various work sizes;
b. Re mesh the entire space involved by the combined droplet with a uniform work size;
c. Find cut focuses and mixing territory;
d. A consolidated bead after the remaking of mixing territory.

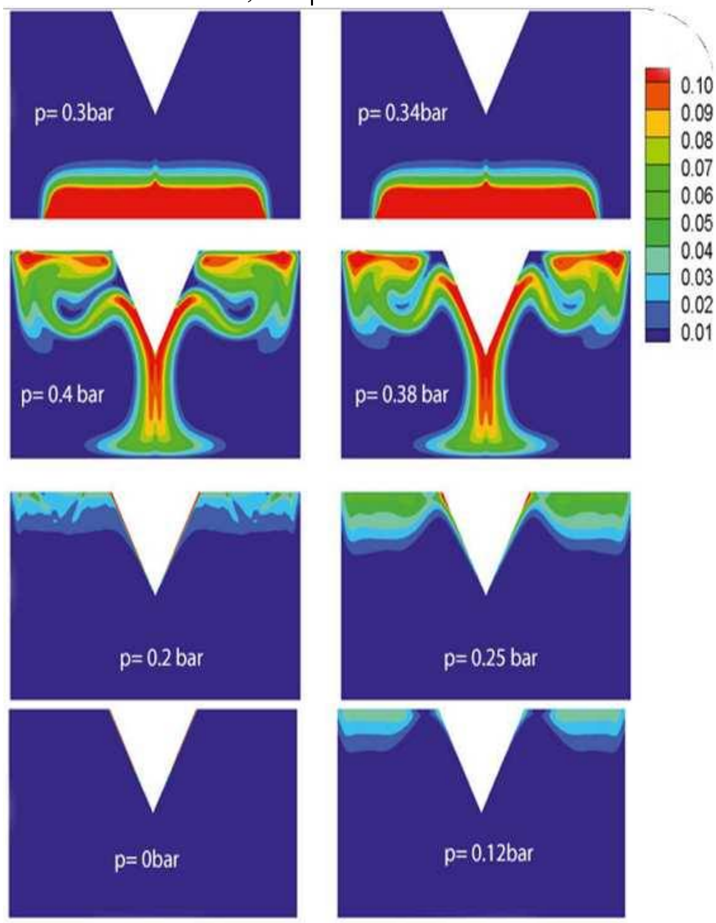

Fig. (5) Point shape during formation with different pressure

From the above, it can be speculated that an approximate numerical solution will be found for the permissible pressure ratio so that the ink point is not deformed .

It has been found that there is a strong and direct relationship between speed, pressure, and the ink point shape. The higher the pressure, the greater the point size and with the increase in speed, it is possible not to compromise the balance between the point and shape size, and we bene- fit from this by increasing the production speed of the machine.

3- Simulation of print head nozzle droplet:

3-1-:Introduction

This solution will provide a simulation of pressure effect on drop ejection from printhead nozzle using CFD . The purpose of this CFD production is to provide guidelines for the transient simulation of drop ejection from the nozzle of the printhead in an inkjet printer. The volume of fluid (VOF) model is used to predict the droplet shape. The time-dependent boundary condition requires a user-defined function (UDF).

3-2- computational domain set up:

The problem to be solved in this CFD production is shown in fig (3.7).To capture the capillary effect on the ejected ink, the surface tension and prescription of the wetting angle will be specified. The surface inside the nozzle is neutrally wettable , while the surface surrounding the nozzle orifice is non- wettable .

At time zero, ink fills the nozzle, while the rest of the domain is filled with air. Both fluids are assumed to be at rest. To initiate the ejection, the ink velocity at the inlet boundary suddenly rises from 0 to 3.58 m/s and drops according to a cosine law.

A user-defined subroutine is shown in the Appendix A. After 10 microseconds , the velocity returns to zero. The calculation is run for 30 microseconds overall, i.e., three times the duration of the initial impulse. Gravity is not included in the simulation. Due to the axial symmetry of the problem a 2D model is used. The computation mesh consists of 24,600 cells. The domain consists of two regions: an ink chamber and an air chamber.The ink chamber dimensions are summarized in the following table (1) .

Table (1) The ink chamber dimensions

Ink chamber Cylindrical region: radius (mm) Ink	$15 * 10^{-4}$
Ink chamber Cylindrical region: length (mm) Ink	$10^{-3} * 5$
(Ink chamber Tapered region: final radius (mm	$10^{-4} * 9$
(Ink chamber Tapered region: length (mm	$10^{-3} * 5$
(Air chamber: radius (mm	$10^{-3} * 3$
(Air chamber: length (mm	$10^{-3} * 28$

As the dimensions are small , CFD is used with double precision. The primary phase is air and the secondary phase is water-liquid. Patching is required to fill the ink chamber with the secondary phase.

1. Copy the files (inkjet . mesh , inlet1.c, and udfconfig.h) to your working folder.
2. Use CFD Launcher to start the 2D version.
3. Enable Double-Precision in the Options list.
4. Click the UDF Compiler tab and ensure that the Setup Compilation Environment for UDF is enabled.

3-2- Drop ejection without effect of pressure:

First, data entry without the effect is the fear of the normal situation of the print head .

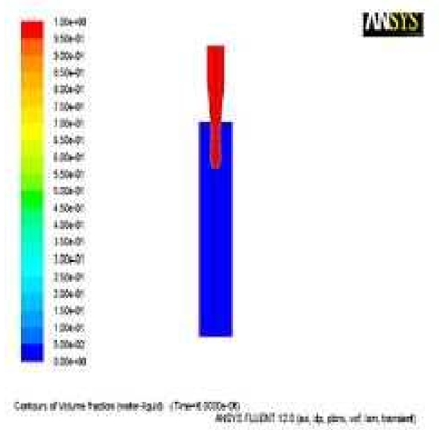

Fig. (6) Contours of water Volume Fraction After 6 µs

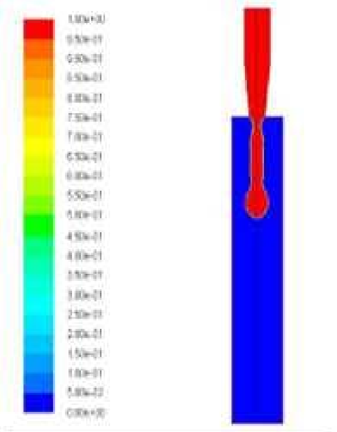

Fig. (7) Contours of water-liquid Vol- ume Fraction After 12 µs

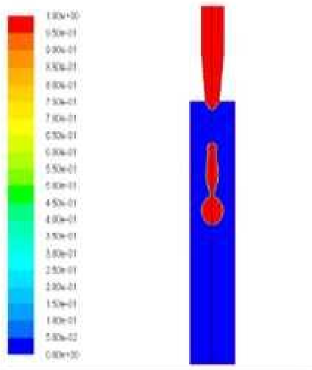

Fig.(8)Contoursofwater-liquid VolumeFractionAfter18µs

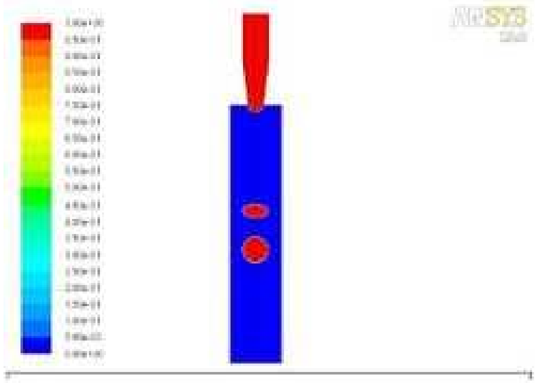

Fig. (9) Contours of water-liquid Vol- ume Fraction After 24µs

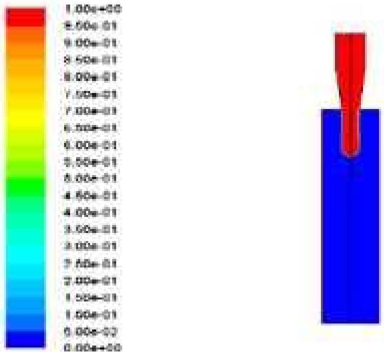

Fig.(10)Contoursofwater-liquid VolumeFractionAfter30µs

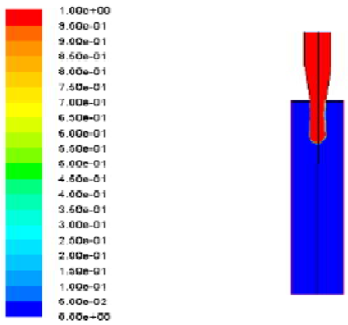

Fig.(11)Contoursofwater-liquid VolumeFractionAfter6µs

fromfig.(10)and(11)Inkpointsformnaturallywithout adhesion or overlap be- tween the points and some of them, especially after they have completely fallen off. It gives us an initial visualization in the form of droppinginkpointswithoutany external influence.

3-2-1. <u>Drop ejection with effect of pressure :</u>

Repeat the above with a change in the pressure value and study the Drop Ejection from a Printhead Nozzle.

<u>The pressure value at 0.32 bar :</u>

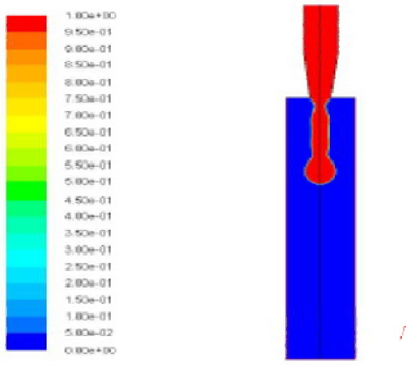

Fig. (12) Contours of water-liquid Volume Fraction After 12 µs

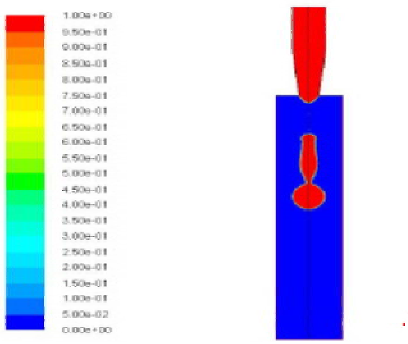

Fig.(13)Contoursofwater-liquid VolumeFraction After 18 µs

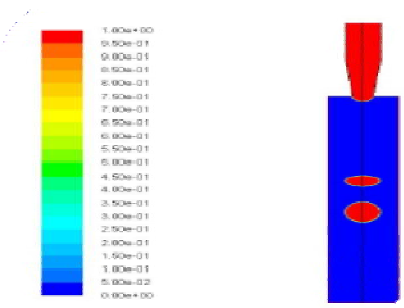

Fig. (14) Contours of water-liquid Volume FractionAfter24µs

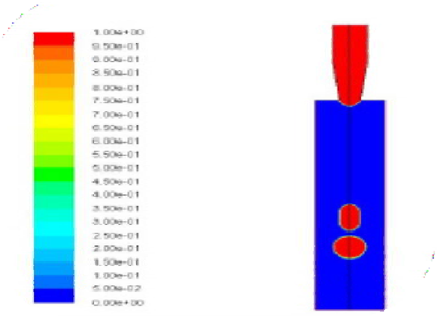

Fig. (15) Contours of water-liquid Volume FractionAfter30µs

The pressure value at 0.34 bar :

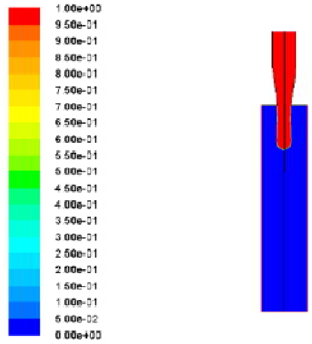

Fig. (16) Contours of water-liquid Volume Fraction After 6 μs

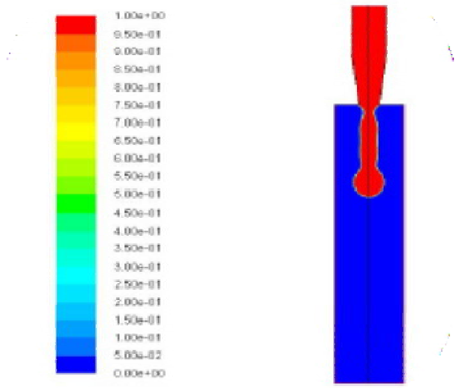

Fig. (17) Contours of water-liquid Volume Fraction After 12 μs

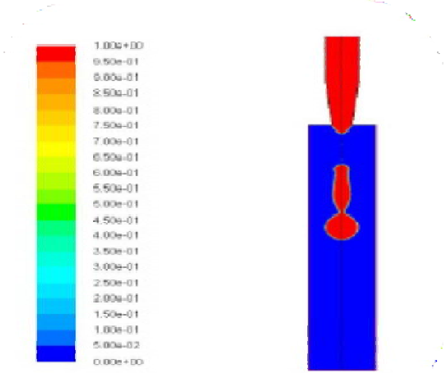

Fig. (18) Contours of water-liquid Volume Fraction After 18 μs

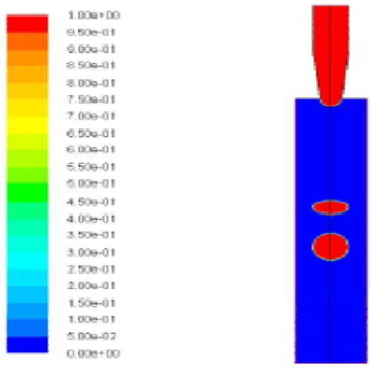

Fig. (19) Contours of water-liquid Volume Fraction After 24 μs

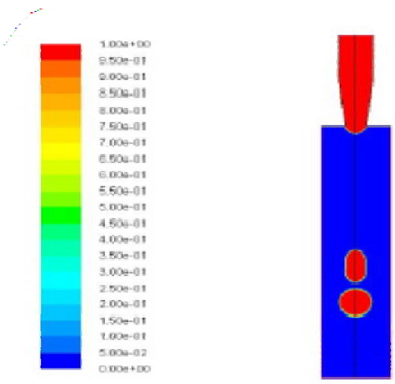

Fig. (20) Contours of water-liquid VolumeFractionAfter30μs

The pressure value at 0.38 bar :

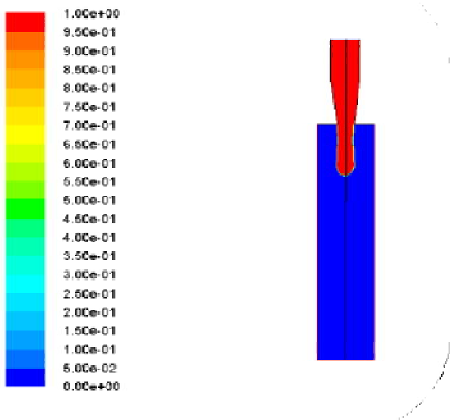

Fig. (21) Contours of water-liquid Volume Fraction After 6 μs

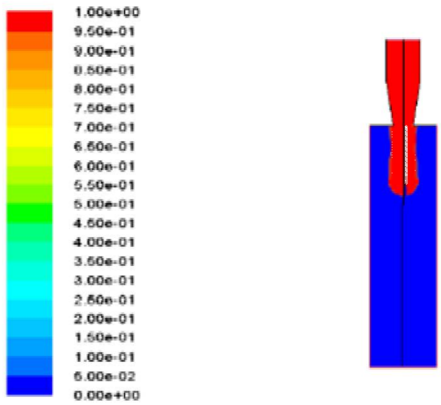

Fig. (22) Contours of water-liquid Volume Fraction After 12 μs

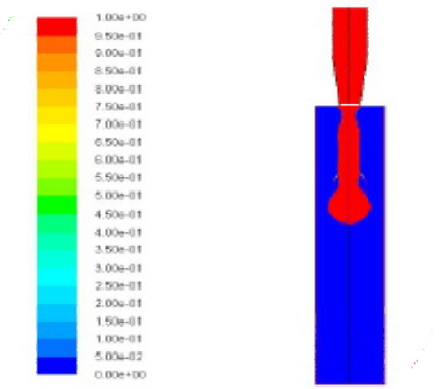

Fig. (23 Contours of water-liquid Vol- ume Fraction After 18 µs

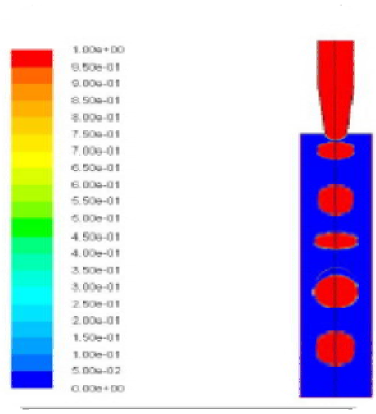

Fig. (24) Contours of water-liquid Volume Fraction After 24 µs

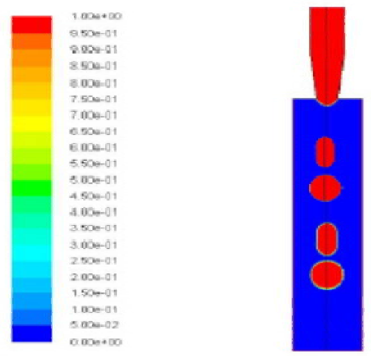

Fig. (25) Contours of water-liquid Volume Fraction After 30 µs

The pressure value at 0.4 bar :

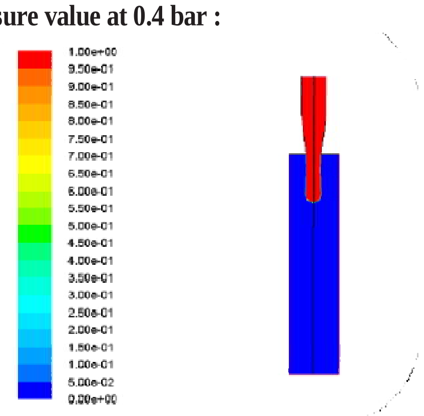

Fig. (26) Contours of water-liquid Volume Fraction After 6 µs

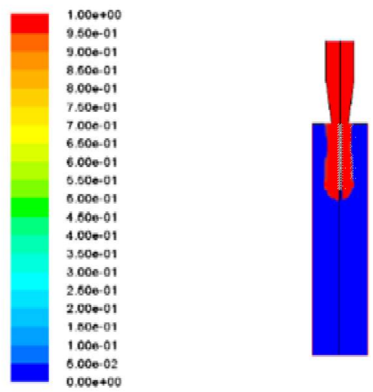

Fig.(27) Contours of water-liquid Volume Fraction After 12 µs

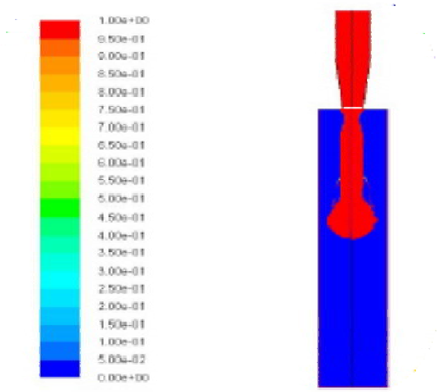

Fig. (28) Contours of water-liquid Volume Fraction After 18 µs

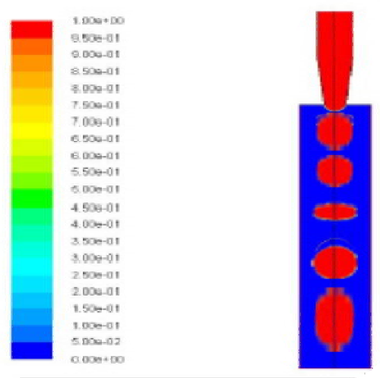

Fig. (29) Contours of water-liquid Volume Fraction After 24 µs

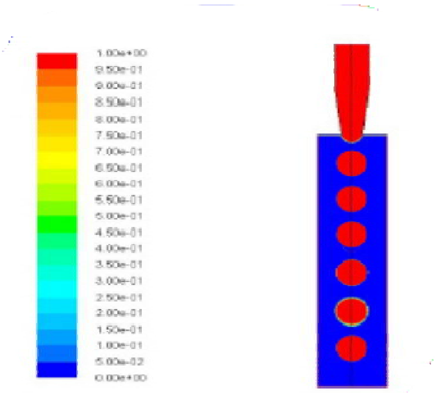

Fig.(30)Contoursofwater-liquid VolumeFractionAfter30µs

3-2-2. : Fluid flow model result discussion :

Ink points are formed increasingly as the pressure increases, with the possibility of adhesion or interference between the points and each other when the pressure increases to 0.4 bar, especially after it has completely fallen off.

A preliminary visualization of the dropping of the droplets is given when the externally affected pressure increases.

The production by CFD modeling was adequately able to predict the for- motion and development of an ink droplet ejected from the printhead of an inkjet printer.

It is possible to increase the production process for banner printing by fixing the machine speed at 5 m/h and increasing the pressure with a maximum of 0.4 bar because after that there was a clear defect in the printing process It can save time and increase production without compromising the quality of the printedproduct.

4- Experiment work:

Increasing the production process by increasing the speed without the difference in printing quality.

The experiment has been done on the Roland Poster Printing Machine , on two (banner-vinyl) materials, and the machine will be printed at three speeds as follows:

Table (2) relation between speed and Print precision

No speed	Speed m/h	Print precision
The first speed	5 m/h	360 dot/ inch
The second speed	2.5 m/h	720 dot/ inch
The third speed	1.25 m/h	1440 dot/ inch

Raisingtheprintqualityonthespecifiedmaterials andraisingthespeed by increasing the pressure in the ink tanks, which leads to an increase in the impulsive ink on the print head.

4-1-1 :The first experiment:

Try the machine at three speeds with the machine without any outside effect the speed of the machine was confirmed by printing 1 square meter of banner, and the print quality was measured by the density measuring equipment.

4-1-2 :The second experiment:

Fixing the machine speed to 2.5 m/h with increasing pressure gradual- ly on the ink tanks, while measuring the accuracy of printing by means of measuring the ink density.

experiment results :

It is possible to increase the production process for banner printing by fixing the machine speed at 2.5 m/h and increasing the pressure with a maximum of 0.34 bar because after that there was a clear defect in the printing process.

It can save time and increase production without compromising the quality of the printed product.

4-1-3 :The third experiment

Fixing the machine speed to 5 m/h with increasing pressure gradually on the ink tanks, while measuring the accuracy of printing by means of measuring the ink density.

experiment results :

It is possible to increase the production process for banner printing by fixing the machine speed at 5 m/h and increasing the pressure with a maximum of 0.38 bar because after that there was a clear defect in the printing process.

It can save time and increase production without compromising the quality of the printed product.

The production by CFD modeling was adequately able to predict the formation and development of an ink

droplet ejected from the printhead of an inkjet printer.

From the following drawing, we find an overlapping relationship between the different effect of pressure and the variable speed of the print head

and their relationship to the print quality.

And we also find that it is possible to reach the maximum degree of printing accuracy after controlling the pressure and speed of the print head. The following fig (30) chart illustrates The relationship between variable pressure and variable speed and their relationship to print quality.

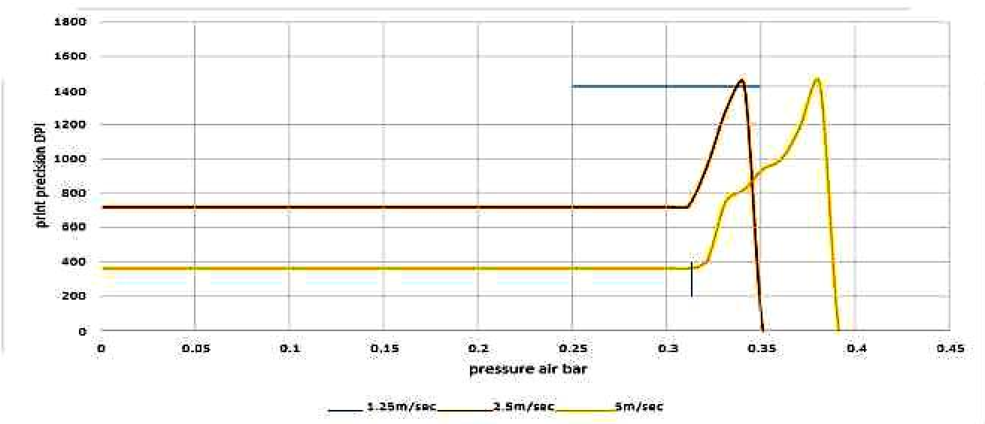

Fig. (30) The relationship between variable pressure and variable speed and their relationship to print quality

5- Conclusions:

Producing the largest quantity with the highest quality, and through that, it will return to the printing establishment by several factors, such as; Save time by producing the largest amount in the least time. Providing manpower for the printing establishment . Providing the additional requirements of providing electricity and other factors .

From all this, it will benefit the establishment with the enormous benefit and the ability to compete in the market at the lowest prices without affecting the profit margin.

In conjunction with the current findings, it is recommended that future works may be performed to:

1. It is possible to take care of developing the print head by relationship between pressure and print speed and reaching a balance that does not affect the print quality.
2. Increasing the speed of digital printing machines without disturbing the print quality.
3. Working to improve the quality of the printing products.
4. Using different types of printing materials.
5. Attention to saving time by increasing the machine speeds, which al- lows to increase production and reduce economic costs of operation.

6- REFERENCES

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