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Research Article

Design Optimization of Blood Diagnosis Chipusing Computational Techniques

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Abstract

The conventional blood testing methods are either expensive or require a large detection time. Whereas other methods based on bio-chip principle have laminar flow in them which reduces the probability of detection of disease. Moreover methods used nowadays for the blood diagnosis require a lot of equipment and so these tests become uneconomical and cumbersome. Therefore an idea is to design and develop portable and inexpensive equipment for the blood diagnosis for the detection of diseases in a short time.The purpose here is to increase the probability of detection of disease. Therefore, few models are analysed to obtain the optimum design for the diagnosis of blood using CFD technique.

Keywords: *Portable , inexpensive, CFD technique.*

1. Introduction

Blood is a constantly circulating fluid providing the body with nutrition, oxygen, and waste removal. Blood is mostly liquid, with numerous cells and proteins suspended in it. The average person has about 5 litres (more than a gallon) of blood. A liquid called plasma makes up about half of the content of blood. Mainly bacteria attacks on plasma. If we can separate plasma in short time, then blood analysis can be done easily.

2. Model of Biochip

Biochips are essentially miniaturized laboratories that can perform hundreds or thousands of simultaneous biochemical reactions. Biochips enable researchers to quickly screen large numbers of biological analysis for a variety of purposes, from disease diagnosis to detection of bioterrorism agent.

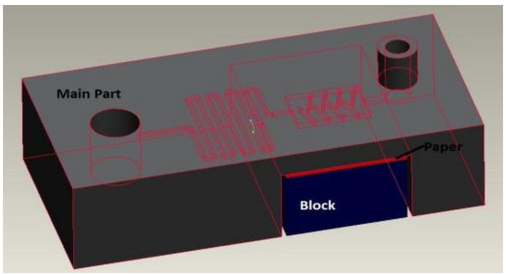

Fig.2.1

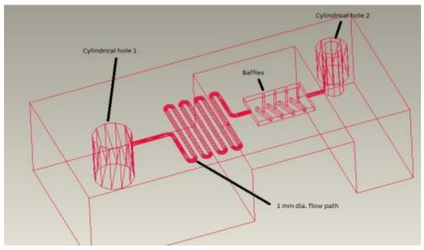

Fig.2.2

2.1 Different flow path cases

By creating certain obstructions in the flow, we will try to have effective utilisation of area of the rectangular trench so that fluid will flow over all the area increasing the probability of detection. Obstructions in the flow of the fluid in the rectangular trench are cylindrical hole, square hole, inclined baffles, straight baffles and straight baffles with square hole.

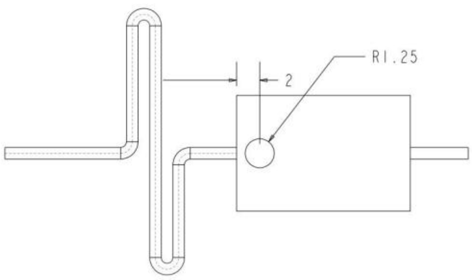

Fig. 2.1.1 Model with circular obstruction

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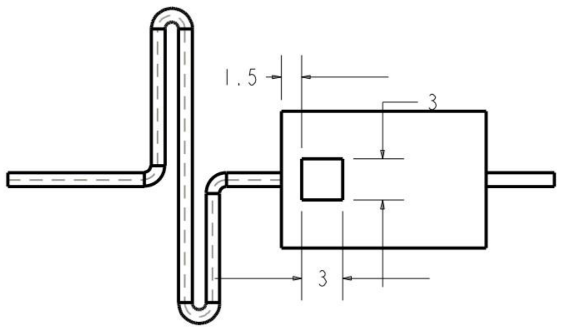

Fig.2.1.2 Model with square obstruction

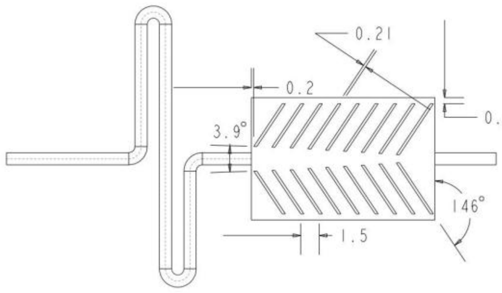

Fig.2.1.3 Model with inclined baffles

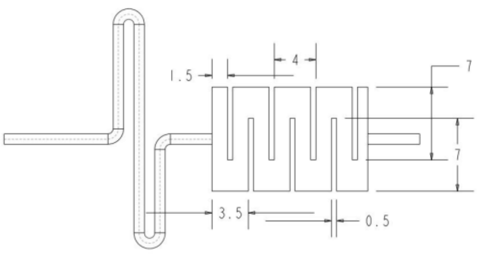

Fig.2.1.4 Model with straight baffles

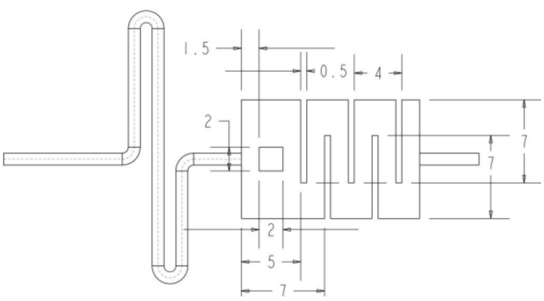

Fig.2.1.5 Model with square obstruction and straight baffles

3. CFD Analysis

CFD analysis for the velocity contours, turbulence intensity contours, path lines for this concept design is carried out. Selected boundary conditions are atmospheric pressure is applied at the inlet and outlet is set for suction pressure.

3.1 Pressure Plots

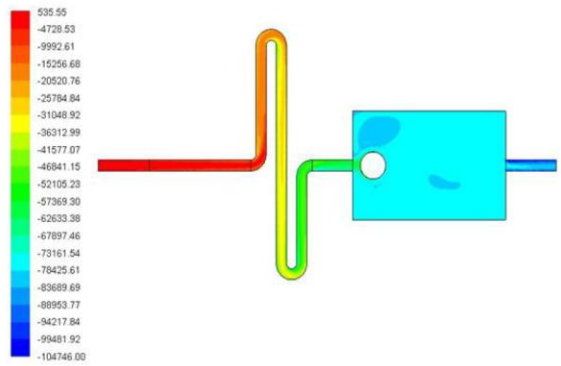

Fig.3.1.1 Model with circular obstruction

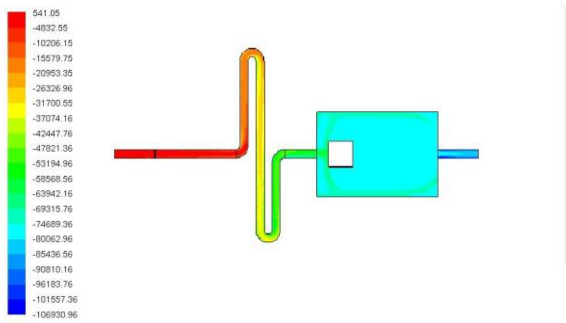

Fig.3.1.2 Model with square obstruction

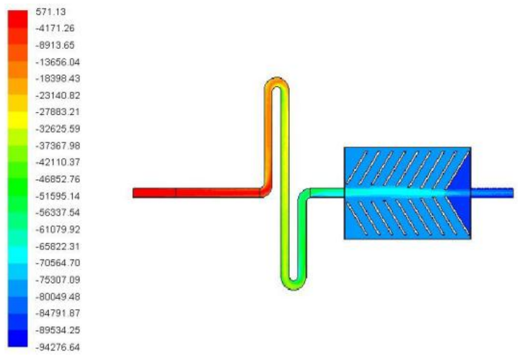

Fig.3.1.3 Model with inclined baffles

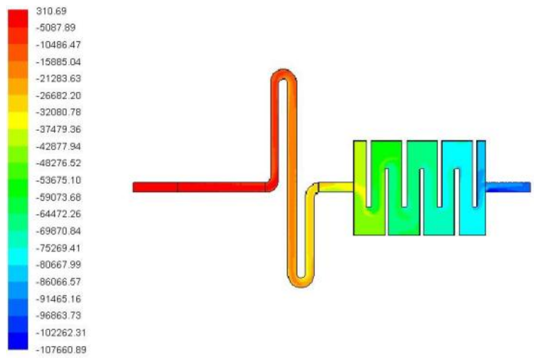

Fig. 3.1.4 Model with straight baffles

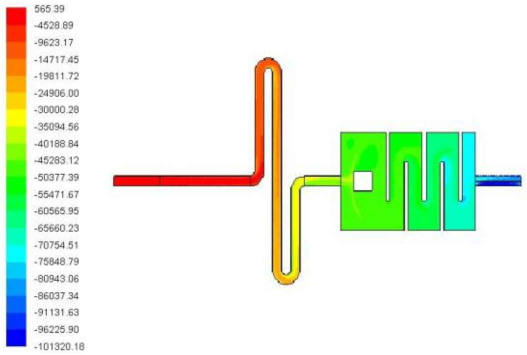

Fig. 3.1.5 Model with square obstruction and straight baffles

3.2 Velocity Contours

Velocity contours for above designs are,

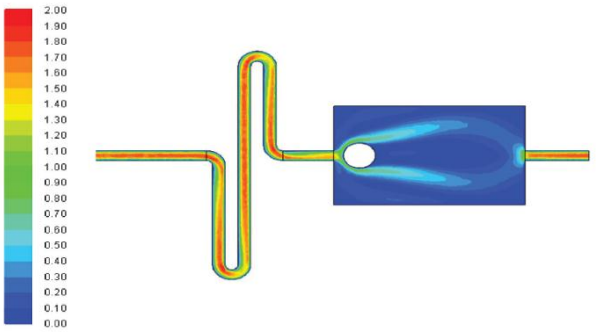

Fig. 3.2.1 Model with circular obstruction

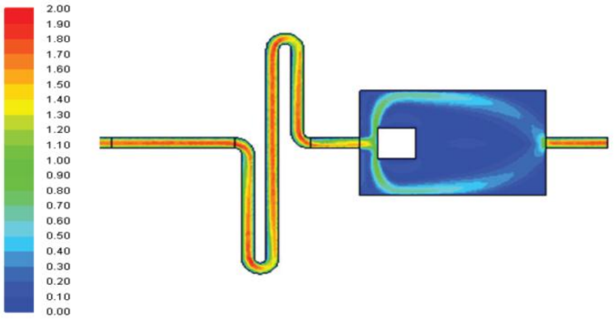

Fig. 3.2.2 Model with square obstruction

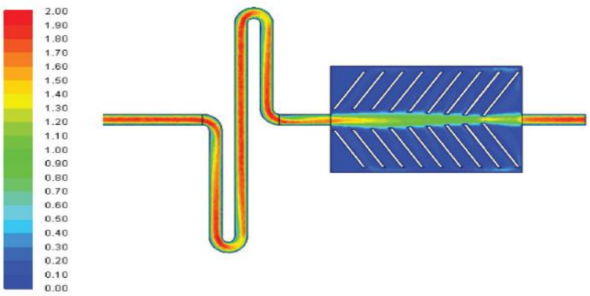

Fig. 3.2.3 Model with inclined baffles

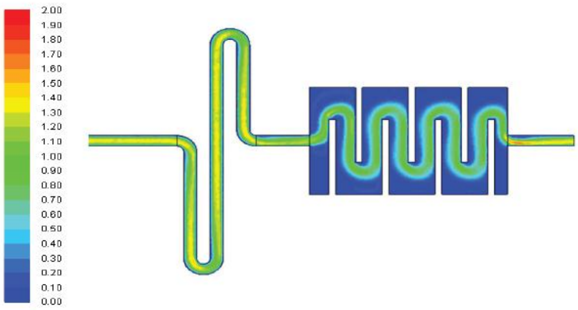

Fig.3.2.4 Model with straight baffles

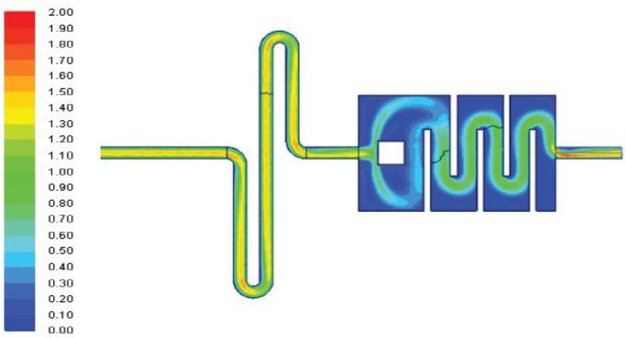

Fig.3.2.5 Model with square obstruction and straight baffles

Table 1 Velocity at rectangular inlet

Designs	Velocity at Rectangular entry (m/s)
Circle	1.234
Square	1.232
Inclined baffles	1.226
Straight baffles	0.959
Square and straight baffles	1.040

3.3. Plot of Velocity Vector

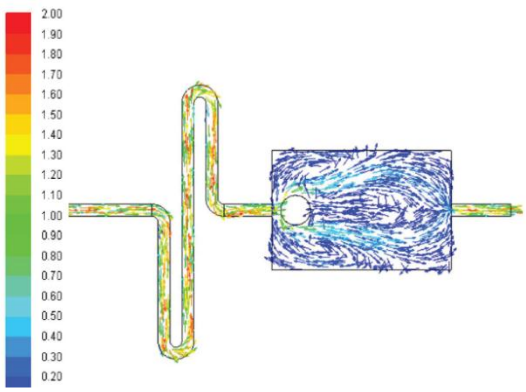

Fig. 3.3.1 Model with circular obstruction

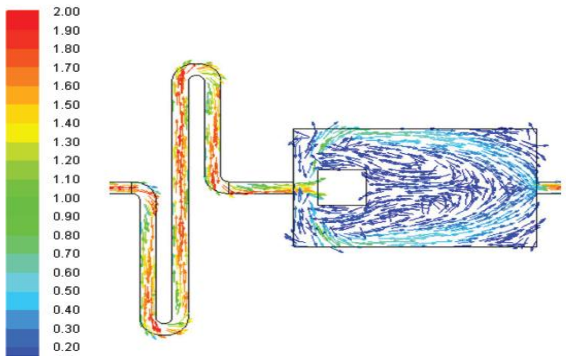

Fig.3.3.2 Model with square obstruction

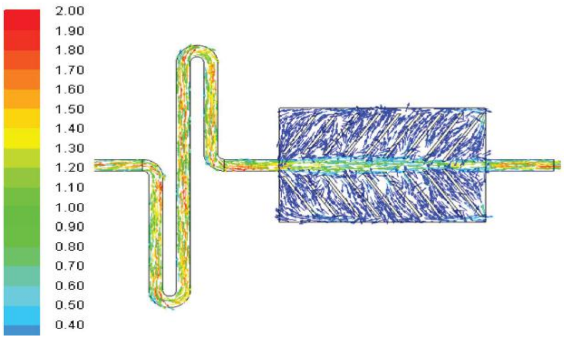

Fig 3.3.3 Model with inclined baffles

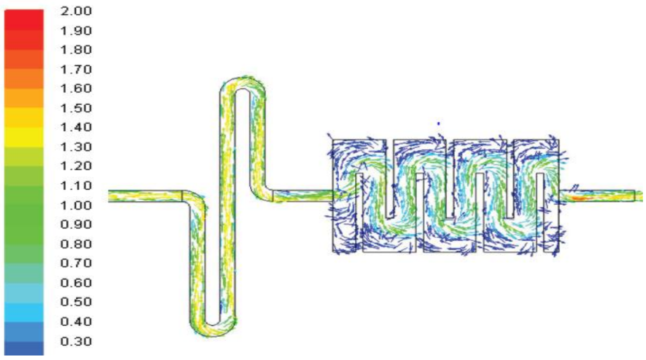

Fig. 3.3.4 Model with straight baffles

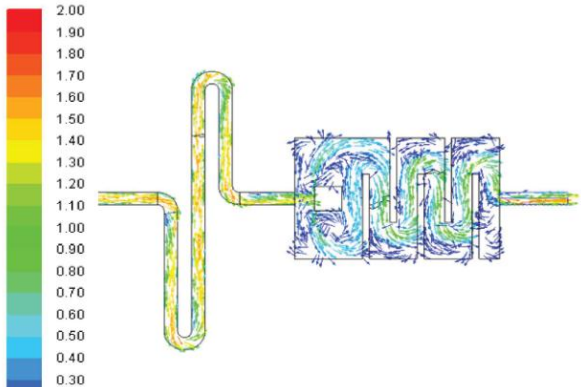

Fig. 3.3.5 Model with square obstruction and straight baffles

3.4 Plotof Turbulence Intensity (TI)

In the present design due to necessity of mixing TI is important plot

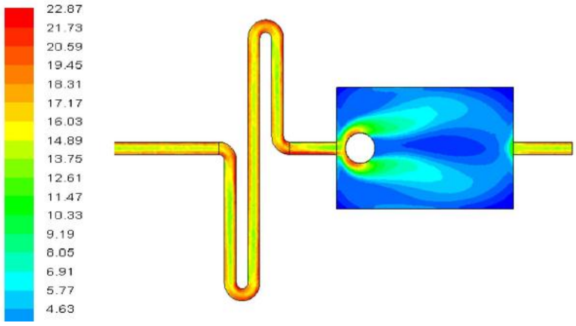

Fig.3.4.1 Model with circular obstruction

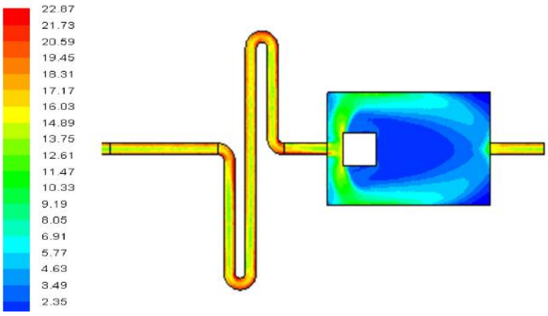

Fig.3.4.2 Model with square obstruction

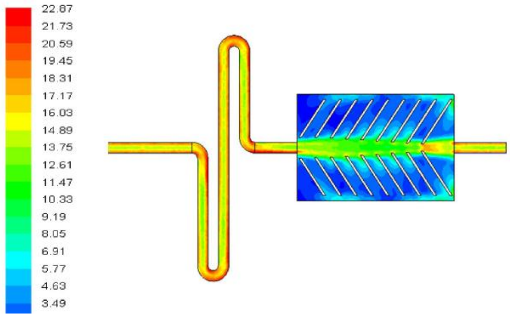

Fig. 3.4.3 Model with inclined baffles

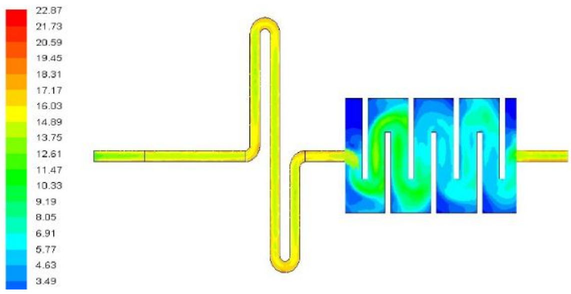

Fig 3.4.4 Model with straight baffles

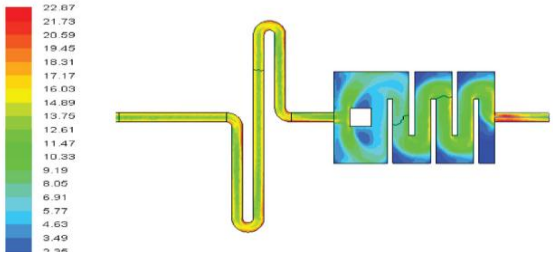

Fig. 3.4.5 Model with square obstruction and straight baffles

Table 2 Turbulence at rectangular inlet

Design	Turbulence intensity
Circle	5.791
Square	6.245
Inclined baffles	5.132
Straight baffles	4.876
Square and straight baffles	6.487

4. Manufactured Model

1. First we manufactured channels by glass blowing fabrication method. For this we selected glass tube of 3mm Inner Diameter and 5mm Outer Diameter. With the help of LPG and O2 we heated the tube and bent it to the shape shown above. This part is made up of borosilicate glass (3.3 expansion). This material ensures no reaction with the blood.
2. Inlet and outlet part are also made up of borosilicate glass (3.3 expansion). They are manufactured by glass blowing technique.
3. After manufacturing channels, inlet, outlet we did annealing by heating the part to temp. of 6000 C by slow heating and slow cooling in the furnace itself.
4. Now the next part is to manufacture rectangular trench. We manufactured it to the scale of 1:3 as shown above. For this we manufactured baffles and rectangular trench separately. We assembled it together with the help of glue. This part ismade of Acrylic material.

Conclusion

After doing the initial analysis by using CFD techniques for the different obstruction patterns in the flow path, we reached the conclusion that, the obstruction of the straight baffles having 90^0 angle and without gap gives good results for this project. The velocity is minimum for the straight baffle model and to have proper reaction the velocity should be minimum. Hence the straight baffle model satisfies this aim. The reason behind this is the model has lesser velocity of plasma at the rectangular inlet andhas lesser turbulence intensity than all other models. Lesser the turbulence intensity greater is the Reynold's number.

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