DESIGN AND SIMULATION OF MICROMIXER FOR BLOOD ANALYSIS

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Abstract:

Blood analysis is the most important step aging adults can take to prevent life-threatening diseases. With blood analysis results, we can check the critical changes in our body before they bring about any diseases. Having the proper blood tests can empower us to lead a healthy life. The existing methods used in laboratories for blood analysis brings out results with a colour change for testing concentration which are sometimes not accurate. The proposed system uses a simple measurement method for analysing the blood for haemoglobin using a square splitted reshape micro mixer. The developed system performs mixing operation to estimate the haemoglobin concentration in blood taken from patients. Moreover, the features of the proposed technique and its analysis for determining the haemoglobin level is achieved by using few drops of blood and the time taken for mixing is limited.

Keywords: Square splitted reshape structure, Comsol multiphysics 5.2a, Blood sample.

I. INTRODUCTION

Haemoglobin present in the red blood cells plays a major role in carrying oxygen from the lungs to all the tissues of the body. If the haemoglobin level in blood increases or decreases it causes severe health issues like heart attack, blood cancer, kidney disease. The modern method for determining the haemoglobin count by mixing two solutions with the blood sample brings out results with a colour change or done through machines with stored buffers. In the proposed system, the micro mixer uses only few drops of the blood sample and the time taken for producing the results is also less.

II. EXISTING METHODOLOGY

Blood analysis is a simple and powerful way in improving once health condition, with this analysis one can actually see the biochemical status of human body. Blood test is just a way to confirm a disease or medical problems as it provides massive amount of information about the present status of your health.

Bhaskaran P. [1] proposed a method for haemoglobin analysis by converting hemoglobin to cyanmethemoglobin by the addition of Potassium cyanide and ferricyanide whose absorbance is measured at 540 nm in a photoelectric calorimeter against a standard solution. This method is not used at present because it takes a lot of time to produce the result and due to turbidity it shows variation in the output.

Paddle J. [2] proposed a method for analysis of haemoglobin, the reaction in the microcuvette is a modified azide-methemoglobin reaction. In this Sodium nitrite converts hemoglobin to methemoglobin which, together with sodium azide, gives azide-methemoglobin. The absorbance is measured at two wavelengths (570 nm and 880 nm) in order to compensate for turbidity in the sample. This method is used at present but the major drawback is the disposable cuvettes which makes it expensive.

III. PRINCIPLE AND THEORY

A. Micro mixer

Micro mixers are devices used to mix micron scale fluids and small amounts of reagent in a short period of time. Micro mixers have been commonly utilized in the areas of biotechnical engineering, analytical chemistry, and medical industry because biological processes generally involve complicated chemical reactions that require a useful reactant for mixing of solutions. In this the design and simulation of a new high-performance micro mixer is realized for the effective mixing of reagent with the sample.

IV. DESIGN OF MICROMIXER

A. COMSOL MULTIPHYSICS

Micro mixers can be virtually designed using a powerful 3D and 2D modelling software, COMSOL. It provides the user, the flexibility to model the mixer using a simple 2D user interface. With the help of this software, the performance of the mixer can be studied and analyzed.

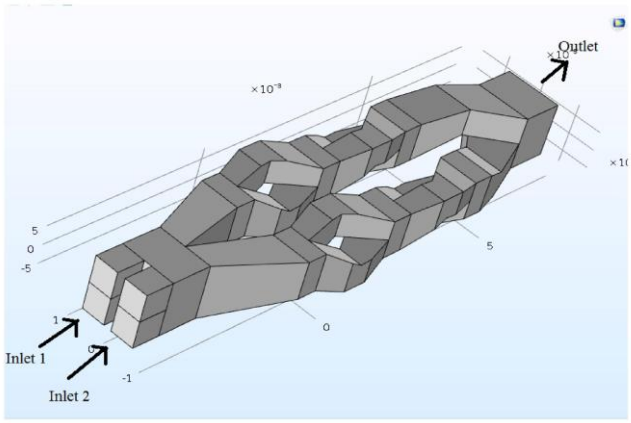

Fig.1: 3D Square splitted reshape micro mixer for mixing of two liquids according to different flow rates.

B. DESIGN CONSIDERATION

The design and simulation (Fig 1: comsol multiphysics 5.2a : model library) of a new high-performance micro mixer via three dimensional (3D) square splitted reshape structures to realize the effective mixing of dilute HCL and the blood sample collected from three different patients for testing the hemoglobin count in their blood is shown. In this the mixing of sample with reagent is achieved by enhancing the diffusion effect between the flow rates of the species. Here the flow has a laminar characteristic, and hence mixing relies mainly on advection effect to increase the contact surface and contact time between the species. The purpose of using a square splitted reshape mixer is due to its asymmetric design and placement of the obstacle. The micro mixer splits the incoming fluid in the direction perpendicular to the interface separating the two fluid layers. After recombining them, the mixer stacks the two flows on top of each other, resulting in four fluid layers. by which the solution, is mixed efficiently. In the proposed channel the mixing efficiency was observed higher when compared to other type of channels.

V. RESULTS AND SIMULATION

The results are simulated by using few drops of dilute HCL in inlet 1 and blood sample in inlet 2, making it to flow inside the channel by using an external mechanism, ie. velocity flow rate as 2 µl ,5 µl, 10 µl into the square splitted reshape micro mixer. When solution enters the channel it gets splitted due to some obstacles present inside the mixer and then it gets recombined, and the output is realized.

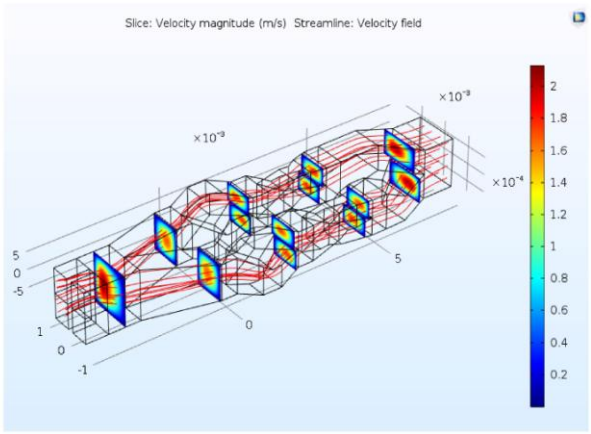

Fig 2: Slice velocity after mixing of dil HCL with blood sample

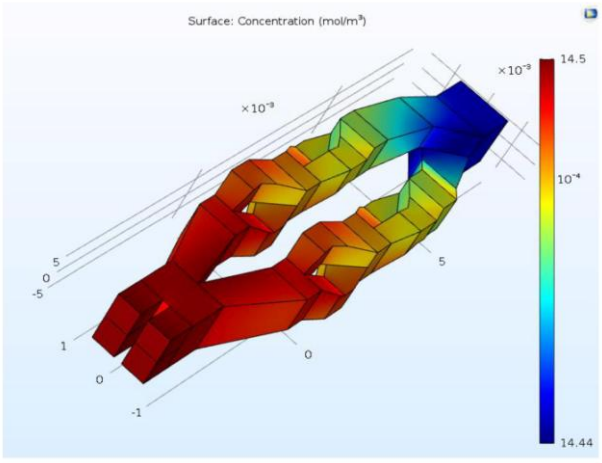

Fig 3: (A) Normal

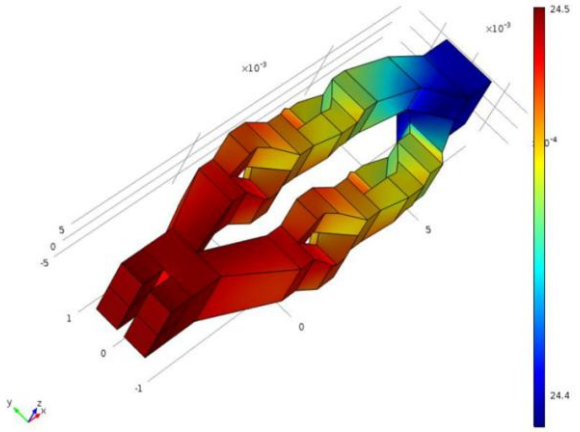

Fig 4: (B) Polycythemia

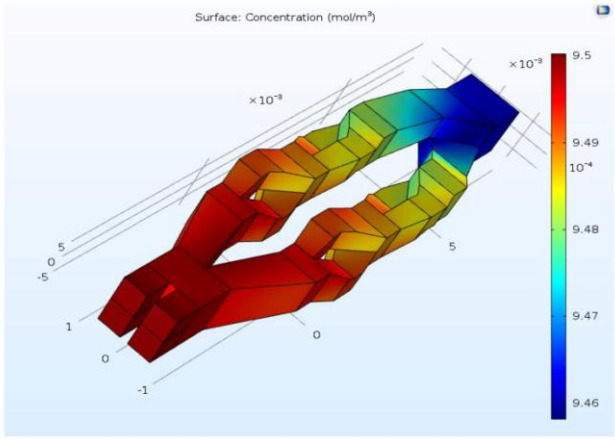

Fig 5: (C) Anaemia

Table 1**:** Comparison of concentration obtained from laboratory procedures and micro mixer simulation

Condition	Standard Range	Laboratory values	Values from Micro mixer simulation
Normal	(13-17mol/m^3)	13	14.5
Anaemia	(>10 mol/m3)	9	9.5
Polycythemia	(< 20 mol/m3)	24	24.5

This proposed method proves to be more accurate when compared with the results taken in clinical laboratories. The output is realized based on the rate of concentration, the patient's condition are categorized as, patients with haemoglobin rate ranging from **(13 to 17 mol/m3)** as normal, patients with haemoglobin rate (**>10 mol/m3)** as anaemia, and patients with haemoglobin rate **(< 20 mol/m3)** as polycythemia.

VI. CONCLUSION

The micromixer for the measurement of haemoglobin is designed and the patients are categorized according to the range as normal, anaemia and polycythemia. The analysis of this design is compared with the concentrations values taken from the laboratory and found to be accurate .The total time taken for performing these analyses is only few seconds.

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