

Constructional Design for Decontamination of Sputum Specimens for Tuberculosis Culture

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Abstract

This paper provides a proposal model for a medical device that can prepare samples for the purpose of tuberculosis diagnosis using sputum specimens. Conventional methods contain hazards because of the seriousness of the disease and persons infection probability in the laboratory as well as the time spent to prepare each sample individually. The proposed model has a robot arm operates in a completely closed environment to prepare all samples at once, which reduces the total time of the process. All operations controlled by the Programmable Logic Controller (PLC).

Keywords: Tuberculosis ; Robotics; PLC.

1. Introduction

1.1 Overview

Three centuries ago and up to date tuberculosis (TB) is considered one of the most important infectious agent causing human death on both developing and developed countries. The disease responsible for 26% of adult deaths globally. According to World Health Organization (WHO) data, 8 million cases of tuberculosis occur yearly, resulting in 3 million deaths [1,2].

In 2012, an estimated 8.6 million people developed TB and 1.3 million died from the disease (including 320 000 deaths among HIV-positive people).

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In Sub-Saharan Africa, including Sudan, approximately 300 per 100,000 are sickened annually by this disease. Around 110,000 people die of Tuberculosis every year, killing more people in the eastern Mediterranean region than any other major communicable disease [3].

One-3rd of the world population was infected with MTB but only few of them progress to overt disease [4,5]. The disease transmitted through respiratory droplets and causes severe disease that may leads to death. The diagnosis of TB depends on detection of acid fast bacilli from sputum smear stained by Ziehl Neelsen stain or auramin-O fluorescence. A special protocol for decontamination is initially required to decontaminate sputum specimens as such specimens contain large numbers of normal flora that may overgrow the pathogenic species leading to failure of diagnosis. Other reasons for the requirement of decontamination is that the microbe is a slow grower with a generation time of 12 hours or more, this allows the colonies to appear after 2-6 weeks incubation period, leading to exposure to overgrowth with other microorganisms.

The most common and useful protocol is N-acetyl L-cystin – NaOH (NALC-9) which dissolve the mucus of the sputum, destroy the cells and kills the normal flora of the respiratory tract. The protocol has several addition steps and requires several minutes to finish. The protocol includes the addition of an equal amount of NALC-NaOH to the sputum for 20 minutes. The NALC-NaOH was neutralized by phosphate buffer saline (pH 6.8) by filling up the tube, and the mixture was centrifuged at 3000 RPM for 20 minutes. The supernatant was decanted and the deposit was re-suspended with 1 ml phosphate buffer saline [6].

1.2 Rationale and justification

The addition and decanting of solution in the NALC-NaOH method may leads to laboratory hazards of getting infected or spreading up the bacilli to the surrounding environment and/or the close contact personnel. This elicits the need for an air close system to process the sputum samples, biological safety cabinet number 2 and well trained laboratory technologist. For that reason we think about a machine able to process the sputum samples automatically with minor hazard of contamination.

2. Methods

The idea of working for the proposed system is as follows:

- Samples of Sputum will be labeled and equal amount of freshly prepared NALC-NaOH will be added before starting the machine.
- The tubes, then placed in the tube hole in the machine – each two tubes should face each other to prepare equilibrium.
- The tubes, then mixed by the device after closing the upper lid with gentle rotation left and right for 20 minutes.
- The tubes will stopped and placed facing the sucking tubes and the tubes will be filled by the buffer and the arm will placed away from the tubes.

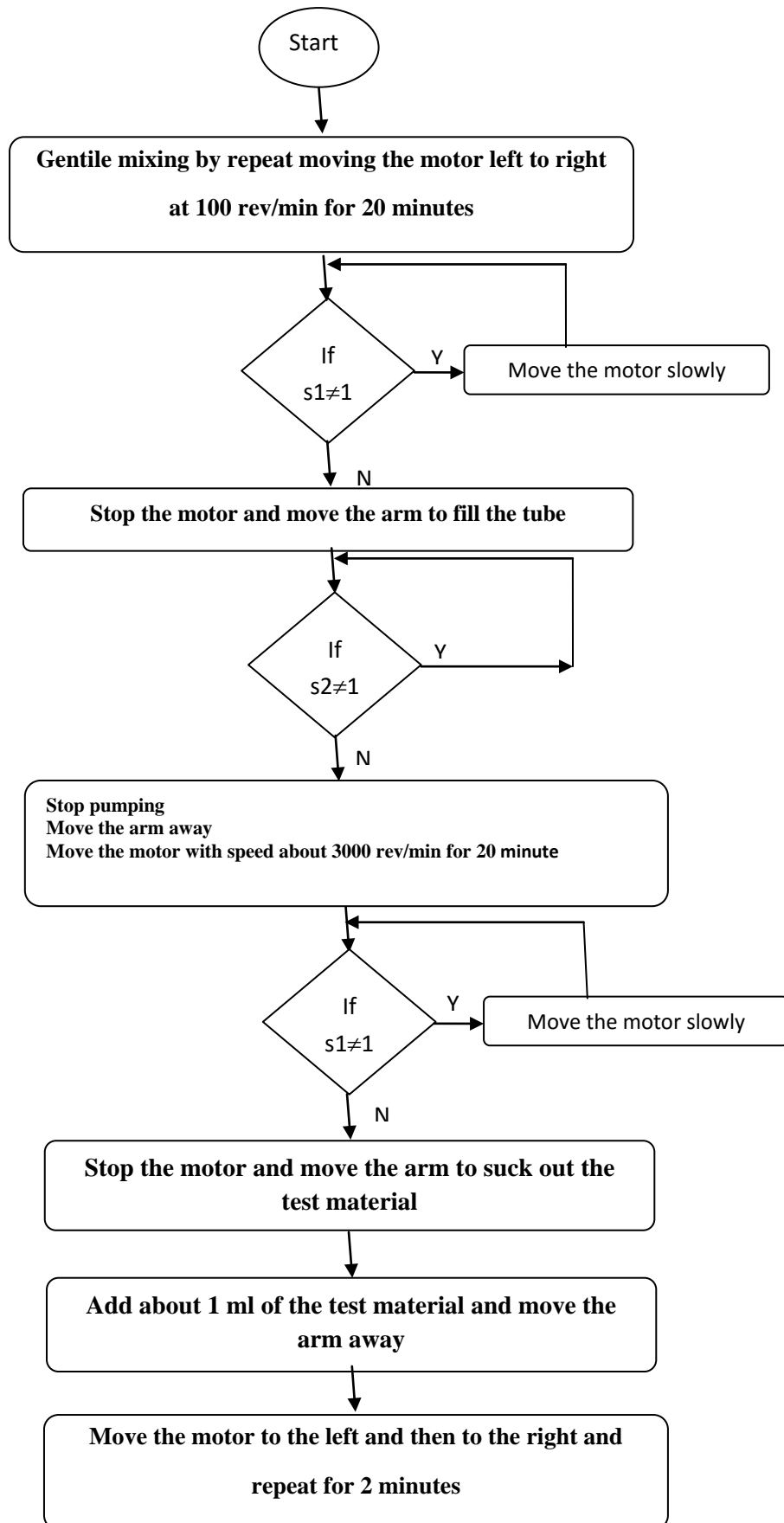


Figure (1): The System Flowchart

- The tubes will centrifuge at 3000 RPM for 20 minutes and the machine will stopped and placed facing the sucking tubes.
- The supernatant will sucked out to the draining container, leaving about 0.5 ml in the deposit.
- 1 ml buffer will be added to each tube and mixed with gentle rotation left and right for 1 minute Figure 1 explains the flow chart for the proposed system

3. System Design

Figure 2 shows the system component.

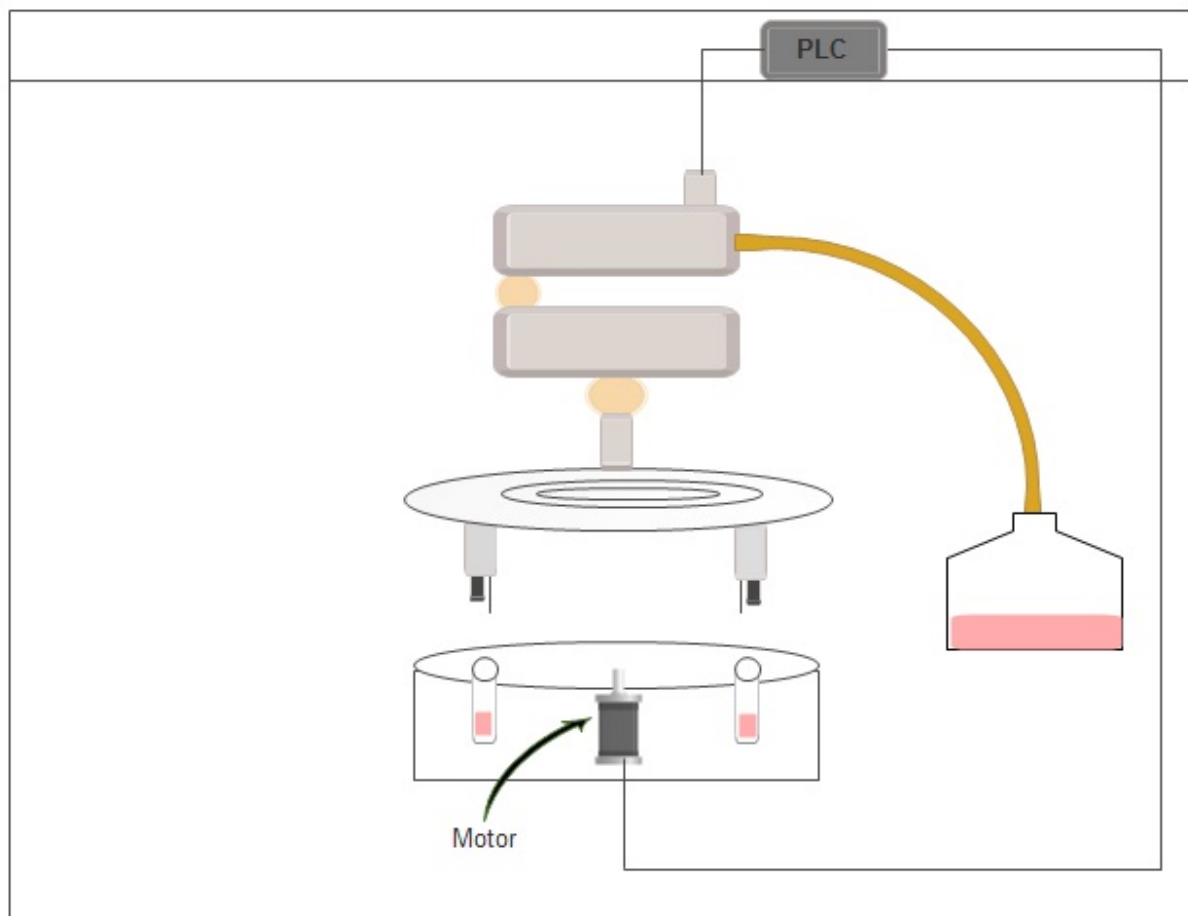


Figure 2: The Proposed System

All the system component will placed in glass container to avoid the air pollution. The robot arm has three degrees of freedom (DOF). It moves up and down, left and right for adding and sucking the liquids used in the test. The system also contains level and position sensors to detect the level of the liquieds inside the tubes and to determine its current positions. The PLC will control the whole process.

4. Conclusion

The development and automation of the laboratory devices and equipments always contribute to improve the

quality of the testing and the prevention from the risk of rapid spread of the disease. The model proposed here saves the time and protects the laboratory doctors from tuberculosis. Also it contributes to the environment protection from the pollution.

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