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MECHANICAL CLASH DETECTION SYSTEM APPLIED FOR MEDICAL DEVICES MANIPULATORS

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Abstract
The present paper purpose is to propose a new type of clash detection system which can be used in medical analyzers. Most of the types of analyzers used in the medical world have a variety of mechanisms which are fulfilling different tasks in order to achieve the cycles of the medical analysis. A common type of mechanism used for this purpose is the sampling arm, which on many of the analyzers can be a two joints manipulator, one linear vertical joint and a second one being a rotational joint.

Keywords: Manipulator – Clash Detection – Medical Analyzer

1.Introduction
Manipulators and mechanisms are widely used in the medical clinical chemistry and immunoassay analyzers. This kind of devices are basically automated machines comprising of a multitude machine cycles steps which needs to be achieved by having small mechanisms inside the analyzer. These mechanisms are used for different type of steps in the machine cycles.

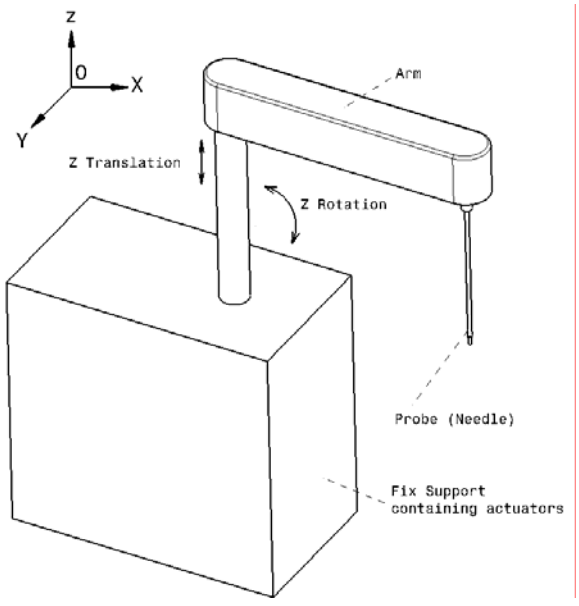

Fig 1. Sampling arm[1]

The cycles of the medical analyzer depend on the type of investigation that is made. The present paper treats only a certain type of these mechanisms, which is called regularly “Sampling Arm”. A simple 3D generic representation of a sampling arm is shown bellow in figure 1. It comprises of a fixed support in a shape of a box, which contains the actuators for the two degrees off freedom, one linear degree of freedom on Z axis and one rotary degree of freedom also on Z axis. The element pointed as being “Arm” in figure 1 contains the electronic and mechanical systems which can comprise of sensors and the fluidic circuit. The main task of a sampling arm in a medical analyzer is to take a certain mass of reagent, other chemical substances or sample fluid which is analyzed and dispose it into different standard recipients in order to achieve the cycle needed for doing a certain analysis for the sample. For this task, the arm two degrees of freedom described above and shown in figure 1 are used. The needle is connected to a fully automated syringe which is controlling the mass of fluid to be collected or disposed by the sampling arm. In some designs the needle can be bent in order to get an easier access to the fluidic system hose which can go through the sampling arm vertical cylinder shown in figure one (the cylinder being a hollow shaft); in other designs the needle can be straight and the hose from the fluidic system longer to be able to be connected to the probe[2] (needle). A bent probe like described can be seen in figure 2. The overall height

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of the probe can vary, but generally in most of the machines it can be in within the range of 100 to 200 mm.

Fig 2. Probe (needle)

2.Actual vertical clash detection system

The probe seen in figure 2 is doing a lot of traveling during all the steps of the machine cycles. During these steps, there is a risk of clash between the probe and possible objects accidentally placed in the probe path. Due to the fact that these machines are often subject of interaction with human operators in the laboratories, a clash between the probe and a human operator is also a risk.

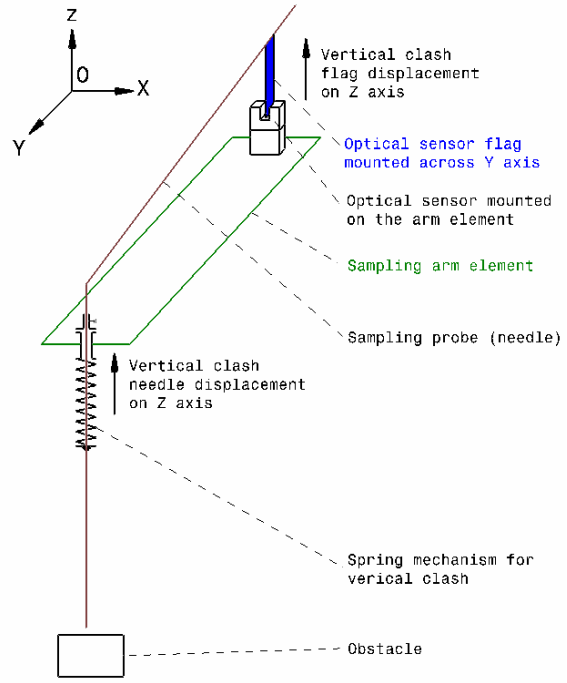

Fig 3. Existing vertical clash detection

To overcome these possible events, these arms are usually fitted with a vertical clash detection system, like the one presented in figure 3.

The system presented will be a bent probe system, although implementation of such a vertical clash system is possible also with a straight probe. The main elements of the system are first of all the probe. In case of a vertical clash, the probe will be the mechanical component to be in direct contact with the object placed on its vertical path like shown in figure 3. In the same figure we can observe a spring mechanism witch is attached to the probe in such a manner that the probe will slide upwards and the spring will take the load in the event of a vertical clash with the object. Also, on the part called "Sampling arm element" we have fixed a optical sensor. A "flag" is fixed on the bent probe in the optical sensor area. We call a flag a small strip of any material which can have two positions:

- if the flag is covering the area between the transmitter and the receiver in the optical sensor, which accordingly with the digital electronics, the software will se it as a non-clash situation
- if the flag is not covering the area between the transmitter and the receiver in the optical sensor, it means that the probe clashed with the object and the probe went upwards, which accordingly with the digital electronics, the software will se it as a clash situation and retract the arm upwards.

3.Proposed new vertical – lateral clash detection system

The system presented in figure 3 is generally used in many medical analyzers. It can be made with a bent needle but also with a straight one. The present paper will approach an example of clash system that is using a bent probe. The proposed system is a system not just for vertical clash, but also for lateral clash detection. It's using the same principle for vertical clash like the system presented as already being in use. The proposed design has the advantage of using the same optical sensor for vertical and lateral clash detection. A schematic of it can be seen in figure 4. The differences are that the flag going into the optical sensor has been rotated with 90 degrees and the sampling arm element has been split into two elements: "back arm element" and "front arm element". The two elements are now joined by a "Twisting joint spring mechanism" presented in details in figure 5. This mechanism had to be detailed in a separated figure in order to avoid confusion in figure 4 because of too many elements added on a small area of the schematic representation.

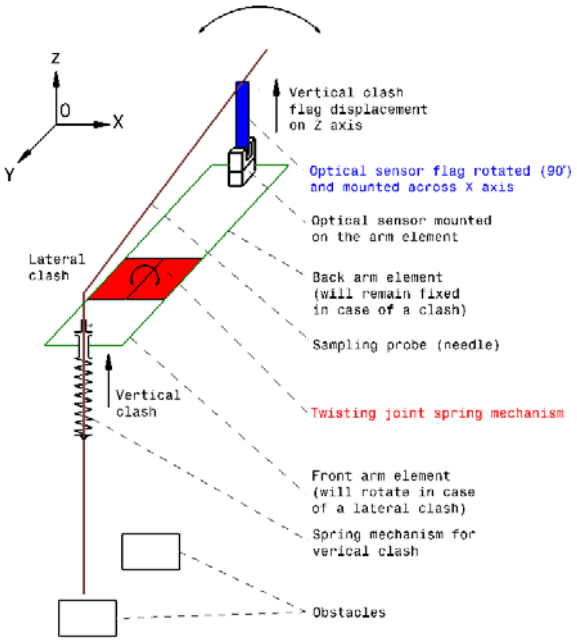

Fig 4. Proposed lateral – vertical clash detection

In case of a vertical or a lateral clash, the control software of the sampling arm will retract the arm upwards. In this way the probe will be protected also from lateral clashes, being mounted on the flexible system presented in figure 5, which is basically a twisting flexible joint comprising of two springs and a locking mechanism[3]. The locking mechanism will always ensure that after the clash recovery, the horizontal position of the front arm element will be aligned with the position of the back arm element. Another important advantage of lateral clash detection is that the event can be included in the command software of the machine, which will allow recovery and continuity of the machine cycle.
Lacking of such a system would mean that the clash will not be detected, and the sampling arm might not reach the desired positions for dispensing/acquiring the fluids, thing with can lead to a total compromise of the analysis done at the time, in this way the result being corrupted.

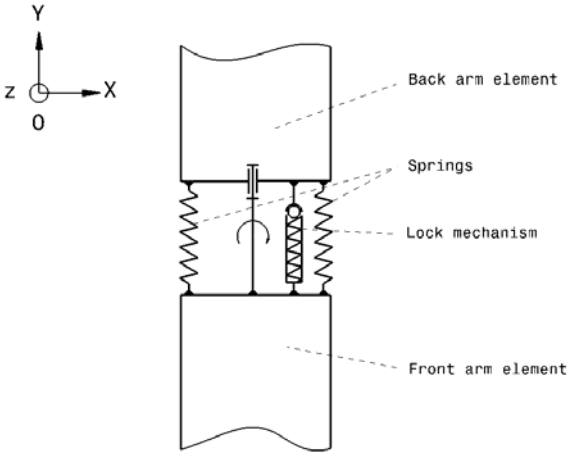

Fig 5. Proposed mechanical twisting joint

4.Acknowledgment

I would like to express my great appreciation and respect for my friend and colleague Dipl. Eng. Cristian Butoi, for sharing his vast experience and knowledge in the field of medical devices during the period when we were work colleagues.

5.References

1- www.clinchem.org - Clinical Chemistry is the leading forum for peer-reviewed, original research on innovative practices in today's clinical laboratory.
2 - www.tecan.com – Components section, refer to Cavro Probes as an example
3 - www.vlier.com – refer to Ball Plungers section for examples