Improving the SmartCompounders Total Parenteral Nutrition automatic compounder

Smartcompounders is a small company from Enschede that has developed a machine that can automatically fill IV bags that are used for chemo treatments. The main customers of SmartCompounders are from foreign countries like Germany, Italy and even Israel. They also have a prototype TPN (Total Parenteral Nutrition) compounder which is a new machine that fills IV bags with a collection of nutrients. The first iteration of the design has been done and a prototype has been made, they now need to improve it and make it suitable to sell. The design consists of 14 tubes that connect to the bags containing the nutrients, these tubes are used to suck in the nutrients, this is done by closing all the tubes except for the one that is needed. This design is tested and it is working but the company is left with some questions and some ideas on how to improve the design. The report starts with analysing the process of TPN compounding and the existing prototype and design. The aim of this project is therefore to further complete the product in a way that makes it more usable for the staff in the pharmacy to work more reliably and to do their job with ease.

Total parental nutrition is a medical treatment that is used when patients are not capable anymore to use their gastronomical system and digesting food. To ensure they still get all the nutrients they need to survive they will be injected straight into the bloodstream. This is done by pumping the TPN mixture straight into the subclavian vein via a catheter as seen in figure 1.

The mixture consists of nutrients that do not need to be digested anymore and are the direct nutrients the body needs to stay fed and survive. Examples of nutrients used are:

- Amino acids
- Carbohydrates (e.g. Glucose, Dextrose)
- Electrolytes (e.g. potassium, calcium, chloride)
- Lipids (e.g. fats)
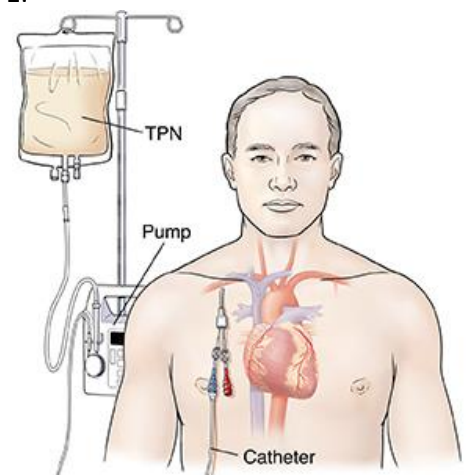- Minerals
- Proteins
- Vitamins
- Insulin
- Water

Figure 1 - TPN injection diagram [5]

This mixture needs to be mixed and put in an IV bag for use. This process is very time consuming and labour intensive and on top of that, it should be done in a cleanroom wearing suits. This is why automatic compounders like the one in this project are developed.

When starting the project the compounder did not have a rack to store the containers yet, which can be seen in figure 2. The rack was something that still had to be added to the machine. When the machine was evaluated and some previous tests were analysed, some problems and things to improve were found. Also, some tests were done to confirm problems or to see if something may be a problem. This started with removing a wiggle in the peristaltic pump and so making it more reliable. After that, the following improvements were found and addressed in the report; The

Figure 2 - The compounder at the start of the project

simplification of the tubing that is used by the machine to function, the reorganization of the valves to fit the new tubing with new parts to improve the accuracy of the machine, the clips that hold down the tubes are improved, and the pump tubes now are secured in place and shorter and in general and some of the parts were made more resilient to breakage. Also, there was looked at the software side of the machine and what could be improved on this part. The prototype has been fitted with some new parts and some first tests are done to ensure the new parts only influenced the compounder in a good way.

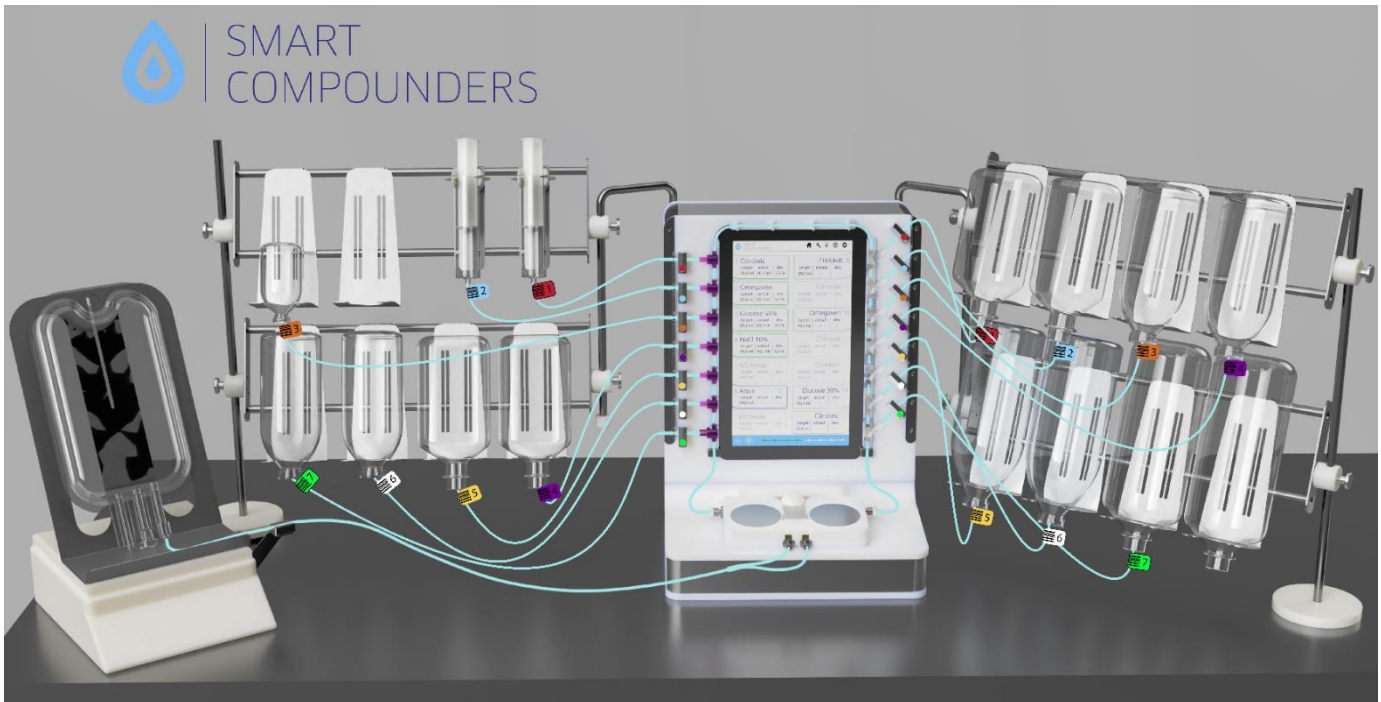The newly designed racks and the new design of the compounder can be viewed in figure 3.

Figure 3 - Final design of the setup

The racks are made in such a way that the containers can be stored easily and the setup gives the user a kind of cockpit view of the machine and the containers that are connected to it. The movable racks ensure the containers are within reach and can be moved again to make space. The colour-coded labelling system makes it easy for users to see if they connect the right input to the right bottles. Even if a user tries to connect a bottle to the wrong input, the scanner that scans the bottle in combination with the input will not let the user go further in the process and so stopping the user from making a mistake that can have bad consequences for the patient if the bag is used.

In general, the changes made to the compounder improved its accuracy, speed, usability and reliability. Therefore it is now a more finished product with a prototype that has been adapted to the changes and is ready to be tested in a more real user scenario with real medications and nutrients.