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THE 'PERFECT' MIXING MACHINE

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Abstract: In the past few years the Machine and Product Design Institute of the University of Miskolc took part in an international project, called HeiBus (http://www.heibus.eu/). As a part of this project student groups had to work on different real-life problems that were given by companies like Valeo, Robert Bosch, Festool etc. The real-life problem this paper is about was given by the Festool. The task was to design a machine that helps to make the 'perfect' mix. This paper is about the idea and about the developing process. In the task inscription, there was only one statement: 'Develop the perfect mixing machine'. There were no restrictions about size, price and application, everything was up to the student team, but it was obvious that it had to be marketable.

Keywords: *smart system, mixing machine, 3D modelling, modularity*

1. BRAINSTORMING

At the beginning of the project there was an intensive week in Esslingen, Germany, where the participants took place on several programs for better understanding the task and to get to know the team members better.

There were presentations hold by university lecturers and representatives of the Festool company. We visited the company and some work sites, where a direct interaction with the consumers could be established and it was a very useful way to see what is actually needed in real life.

After we got acquainted with the challenge we had to face in the next ten and a half weeks, we got some time to talk to each other, speak our minds and put together a mock-up of our idea, in order to have something that we could discuss with the supervisors from the universities and with the professionals from the company. Our main principle for the whole process of development was modularity. We all agreed on that we should think about a quite complex machine, that can satisfy all the diverse needs of the costumers (painters, construction workers etc.). On the other hand, to keep the price low we designed modules for different functions and each module could be bought separately to fulfil the given function.

The following functions and parts were the initial idea of our concept. Nevertheless, it would have been developed and improved during the rest of the project. Some of them were refused, following the supervisor's advice, and other have been remained in the final concept of our project.

1.1. Smart system

The aim was to move automatically the tool of the mixing device on the mathematically optimized orbit and for the perfect period, calculated by the computer and dependent what are the mixing components. By this system the workers' physical health is also conserved, as nowadays used manual mixing machines often cause backpain for their users, due to company representatives. A display and a microcontroller form the smart system incorporated in our machine.

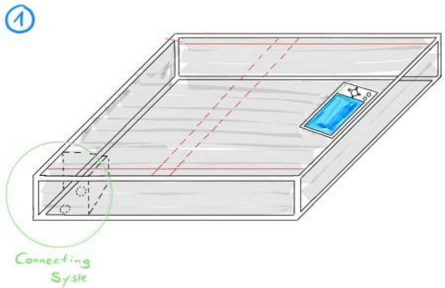

Figure 1. X-Y coordinate automatic system

1.2. Scale

The aim was to help the workers to make the perfect mix by telling them how much to put from each ingredient into the mixture.

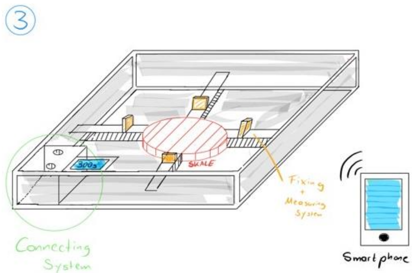

Figure 2. Scale

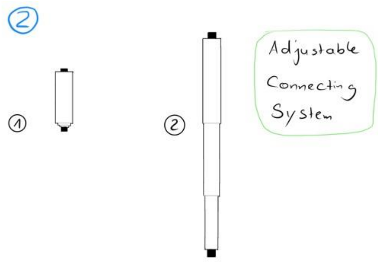

Figure 3. Connecting system

1.3. Connecting system

The conceptual design phase, in comparison with the other steps of the whole design process is barely supported by computer. The research intends to fill this gap [4], [5]. The most important aspect is to help brainstorming with an easy-to-use application on mobile devices. In the first phase of the research, the aim is that the students use the application in their own individual tasks in design methodology lessons and build concepts based on their individual ideas. A further goal is to create a version of the application that is capable of generating all the possible solution variants from functional subassemblies selected by the user and then reducing the large number of solutions based on the user-defined rule set, according to the theory in chapter 2 of this paper. The goal was to connect the upper side (axles and microcontroller) to the underside (scale) with a removable connection system to ensure stability and to be able to adjust the operating height to the workers working on it.

1.4. Cleaning system

Talking to the costumers made us to realize what a huge issue is to clean the tools and it takes surprisingly a lot of time. We found it really important to deal with this problem and to find a solution for it.

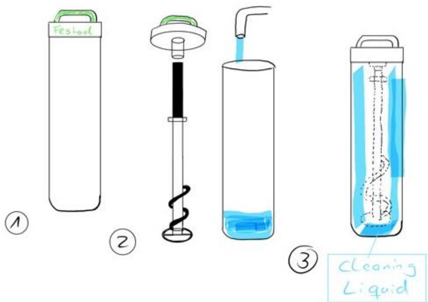

Figure 4. Cleaning system

Figure 5. Transportable device

Being aware of that most of the costumers work on-site, which means a lot of daily travel to them, transportability is crucial for them, so we kept that in mind during developing.

Figure 6. Our mock-up

2. Finalizing the concept

After the intensive week came ten weeks when continued the work individually and had weekly meetings to discuss and distribute the tasks and to talk about that we have done during that week. At the beginning, we had to finalize our concept considering the valuable pieces of information that we have received after the presentation of our mock up and that we gathered during a market research. We decided that we will not focus on the fully-automated mixing system because it might be too unpractical, too expensive and less flexible/mobile for our customers in their daily workplace.

Instead, we started designing a tripod manual mixing machine, based on the Collomix RMX's (Collomix RMX [10. 10. 2018], https://www.dalhoff.de/werkzeuge/zubehoer-fuer-elektromaschinen/ruehrkoerbe/collomix-ruehrstaender-rmx-gewicht-17-kg-abmessung-45-5x118-mm.html?utmid=nex) improved idea. Our solution was planned to be less expensive, more mobile and was meant to be complemented by useful additional modules can be seen later.

Figure 7. Collomix RMX

Keeping in mind our first idea during the intensive week, we've continued developing more ideas to improve some flaws in our design. There will be four main components, intended to work separately, but they are better if the set is complete, specially the first three ones, because the last one – the cleaning system – is a standalone useful accessory. Otherwise we create special accessories for all of our products.

- Scale: weighs the mix.
- Tripod: holds the mixer.
- The HMI: shows the GUI (Graphical User Interface) easier than a smartphone.

3. Scale

This is one of the main components, as it is needed to achieve a perfect mix: it weighs the different materials in real-time in order to calculate the fraction of every material depending on temperature, humidity, area or volume needed (to improve efficiency). Industrial grade scales are very robust and water/dust resistant; therefore, this is a must in our idea. Most of them only have a display, but expensive ones have other wired, industrial and real-time connections, for example Profibus, Profinet, Ethernet IP, RS85 or RS232.

Those were good examples for connections in precise machines. A simpler and smaller display (e.g. 7-segment one) would be required in order to have an easy functionality. If we want to give advice to the user about the mix, we will need a stable connection with the smart system. This system can help the user with the needed quantities of water/liquids/component and warn them to stop when it has reached the perfect amount. It's very useful, for example, when the worker is using a water hose to fill the bucket. Moreover, it weighs the bucket first and then in every stage of the process: adding components is completely guided from an easy-to-use GUI (Graphical User Interface).

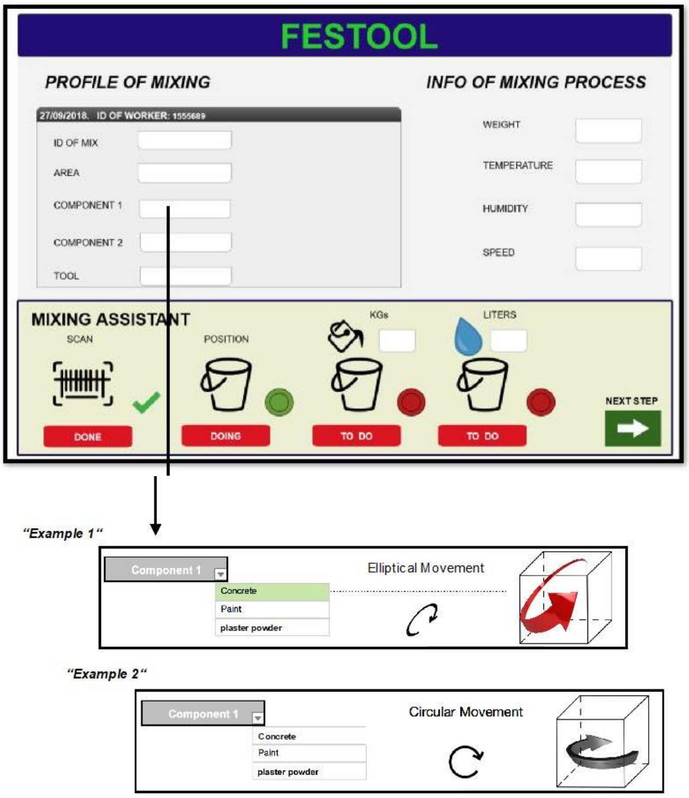

Figure 8. One possibility for the GUI, either in smartphone or display

However, the connection has to be wireless as a wire can be damaged and requires time to be mounted. We have decided to be wireless, even on the power supply side.

Finally, our scale has to fulfil the following requirements: portability, lightweight if possible, robust, IP 67 (maximum in dusty-wet environments), range up to 100 kg or less, it really depends on the application for the mixer, battery powered: lithium, wireless connection: for example Bluetooth 4.0, low-consumption (8 or 32 bit) microcontroller that can handle wireless connections, a little 7-segment display to check the weight and LEDS to update the battery level status.

This is feasible, but we need an enterprise to develop/modify current industrial scales to include lithium batteries, Bluetooth 4.0 as it has low consumption profiles, very stable connections (if the devices are nearer than 10 meters); and a little display.

3.1. Database

As mentioned above, the scale is a great help, but not the best option to achieve a perfect mix yet. That is why we have developed a smart system for the whole process. Obviously, it needs a display or a screen. The best option is using our integrated display directly on the tripod, but if the scale has to work in its own, a smartphone can be used. Here is a simple example to explain how it works:

A painter wants to paint a determined area. In our app (smartphone or display) he/she selects the size of the surface he/she wants to cover. Then, he/she has three choices:

- Scan the barcode with the camera integrated in the display,
- Scan the barcode with his/her smartphone app,
- Choose the paint already set in the app previously or from his/her own catalogue.

The system, keeping in mind the temperature and humidity with cheap sensors located in the scale, calculates the perfect quantity of each component. Beside quantity, the system also calculates the mixing time –another crucial parameter of mixing. The next step is placing the empty bucket on the scale. After that, the scale already knows the weight of the bucket. The painter pours the different components and either the display or the smartphone warns (with sound) when the calculated volume is near.

Finally, the worker can mix using a FESTOOL mixer or from any other brands. If he/her uses a FESTOOL mixer, the app can advise him/her which tool is the best one from his/her repertory and check it with RFID sticker located in the tool and a RFID scanner located in the display.

This database will improve over time, using Machine Learning Techniques and recording the user's different mixes, helping him to do the whole process faster and better.

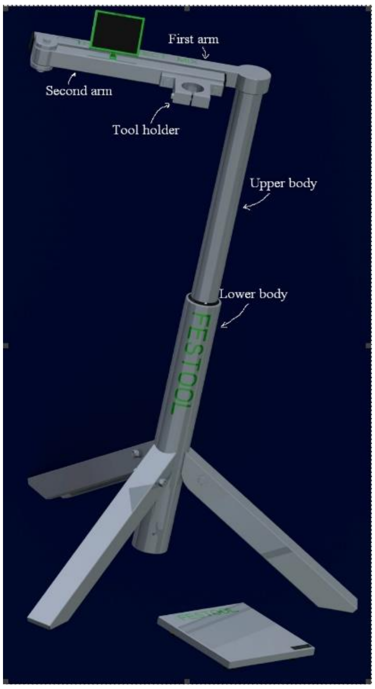

Figure 9. The tripod

4. Tripod

While designing our tripod, our main goal was to provide an affordable solution to anybody. To achieve this, we needed our system to be fully adjustable and cheap to produce. The gas spring provides a range of motion that spreads from 700 to 1,200 millimetres, thus making it ergonomic for workers at any height. The production costs are kept down by using as few welded connections as possible and keeping the design simple. Furthermore, the tripod is sold in an unassembled state, the buyer can assemble it in a few easy steps. This way we can keep boxing and transport costs as low as possible and it even makes it easier to keep the system clean.

The heart of the tripod is a gas spring seen on the top of *Figure 10*, that provides a constant pressure force that keeps the upper part of our system lifted, supports the weight of any attached power tool, and enables rotation. The section view of the spring can be seen on the bottom of *Figure 10*.

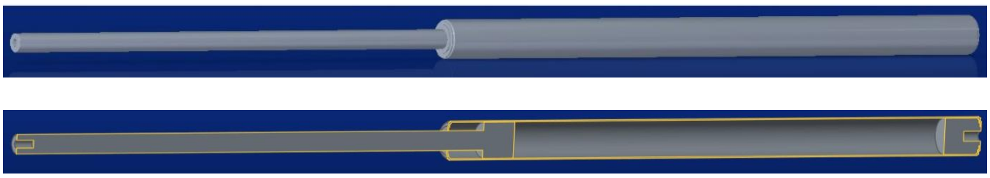

Figure 10. Gas spring

The gas spring is supported by an outer body, section view can be seen in *Figure 11*, that helps with bearing the weight of upper part, provides an easy rotating sliding surface, and keeps the dirt out with a rubber seal. Both the upper and the lower body are connected with end screws.

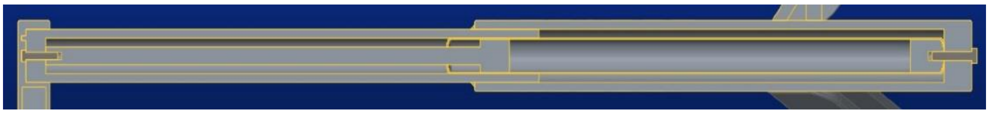

Figure 11. Outer body

The legs are held in place with the highlighted part seen in *Figure 12*, which is welded to the lower body. The screws allow them to rotate. In an open position they perfectly fit the lower body, so they stand still. While closed, the screws and mother screws provide enough support to keep them from wiggling.

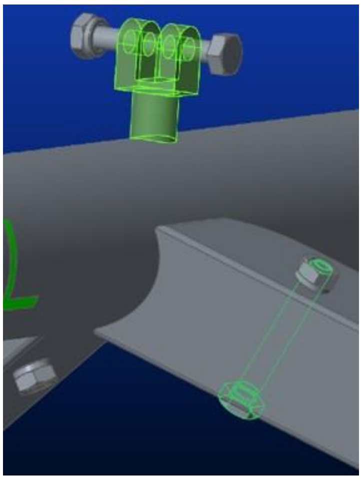

Figure 12. Leg holder

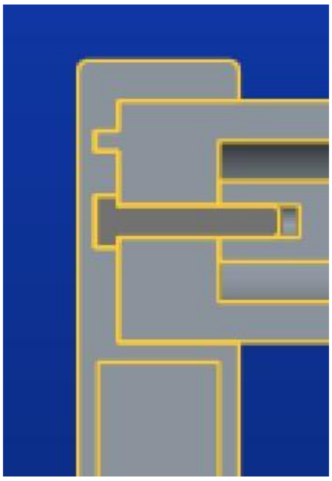

Figure 13. Upper connector

The first arm is connected to the upper body and is held in position by a positioning rod and a magnet, as it can be seen in *Figure 13*. The magnet provides enough force to keep the system together, while it is easy to detach and is not sensible to dirt.
To provide a wider range of motion, another rotation axis was needed too, it can be seen in *Figure 14*. The highlighted rotating arm can be locked in closed position with the pin, highlighted with red. The screen is held by a regular screen holder, which is connected by a screw and a positioning rod. The power tool can be inserted on the holder seen on the lower right part of the picture and can be fixed by tightening the end screw.

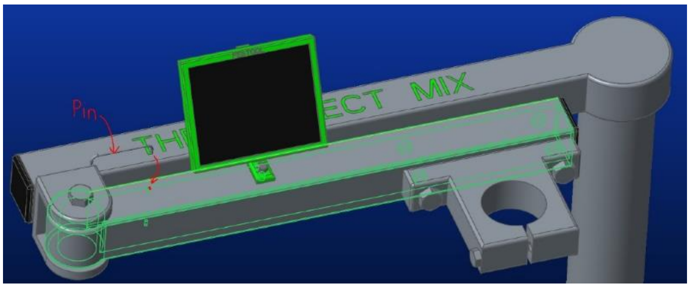

Figure 14. Upper part

The upper body has two machined slots on its bottom, as seen in *Figure 15*. With the help of these and two screws connecting to them, the tripod can be locked in a closed position by pushing it down and rotating it clockwise. Then the gas spring pushes it back up, creating a shape connection, and holding it closed.

Figure 15. Upper body connecting slot

5. HMI

5.1. Microcomputer

A small and affordable computer: the Rasberry Pi 3 Model B+. It is the latest product in the Raspberry Pi 3 range. Specifications (https://www.raspberrypi.org):

- Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz,
- 1GB LPDDR2 SDRAM,
- 2.4 GHz and 5 GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE,
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps),
- Extended 40-pin GPIO header,
- Full-size HDMI,
- 4 USB 2.0 ports,
- CSI camera port for connecting a Raspberry Pi camera,
- DSI display port for connecting a Raspberry Pi touchscreen display,

– 4-pole stereo output and composite video port,
– Micro SD port for loading your operating system and storing data,
– 5V/2.5A DC power input,
– Power-over-Ethernet (PoE) support (requires separate PoE HAT).

Figure 16. Rasberry Pi 3 Model B+

Figure 17. Chosen display

5.2. Display

This 7” touchscreen monitor for Raspberry Pi gives us the possibility to create our smart system device for our mixing machine. The 800 × 480 display is easily connectable to our system, which also gives the opportunity for a quick change if needed. The screen is big enough to be easily visible for the workers, so they don’t have to stop doing their job to look at it, they will be able to see everything in a glance. The smart system will provide all the necessary data to make the perfect mix and will be interactive for the workers. It could be like ‘Siri’ of Apple or ‘Cortana’ of Windows. Our device will be connected to the IoT by simply having an internet connection, so we will be able to transform data into information in real time. That will be extended by the machine learning concept, which makes the system even smarter. The smart system will represent step by step all the way the necessary data to make the perfect mix.

5.3. Camera

We have chosen the Raspberry Pi Camera Board v2 that is a high quality 8-megapixel Sony IMX219 image sensor custom designed add-on board for Raspberry Pi, featuring a fixed focus lens. It is capable of 3280 × 2464-pixel static images and also supports 1080p30, 720p60, and 640 × 480p90 video.

Figure 18. Rasberry Pi camera

Figure 19. RFID reader

5.4. RFID reader

The RFID reader reads out the tools on which an adhesive RFID tag is attached. If the right tool has been selected to match the selected program, the user will be informed by audio signal.

6. CLEANING SYSTEM

The main idea of our cleaning system is to keep the tools with the stucked mixed material wet during the day – working hours plus travelling from the working site – so cleaning the tools at ‘home’ becomes much easier and faster. In order to keep the tools wet, it should be put in a tube filled with water or with a solution that does not let the mixed material dry and does not harm the tool.

Figure 20. Cleaning tubes

It has a longer lower part, in which comes the cleaning solution and the tool. It is supposed to be made of a clear/glass like material – hardened plastic: durable, no cracks, so the worker can see the type of the tools in the tubes without having to open them and check each time a tool is changed. It is connected to its cover with the screw thread. That makes the connection strong and able to lock hermetically, so with the hole on the top the tubes can be hung up or either laid. In addition, the tools are connected to the cover with the same connector as the mixing tools do with the mixing machine. This greatly increases the removal of the tools immensely.

7. ACCESSORIES

7.1. Rack

The rack is built up from 5 parts, but this takes quite a lot of space and besides being inconvenient to set up it also consumes quite a lot of time, but a perfect choice for the home workshop.

Figure 21. Rack

7.2. Holder to go

In most cases there is no need for many tools at the job sites, 3 of them are enough. This holder is built up from 3 parts to make it easier and faster to assemble or disassemble, takes less space and it is more massive then the first one. We suggest this holder for the job sites as it is easy to transport and does not take a lot of space.

Figure 22. Holder to go

Figure 23.

Figure 24. The case

7.3. Case

Storing the tubes in the case is the most evident solution, if somebody buys the case for the tripod. No extra parts, no extra weight, easy to carry.

8. Conclusion

I am glad to have the opportunity to participate in this program. I gained experiences from different fields, that I can apply either in my studies, everyday life and at my job. Going through chronologically, I have improved my organizing skills during preparing for the program – finding a way to get to Esslingen, booking room, etc. During the intensive week, my communication has improved quite a lot. It became more and more easier to express myself, to talk about my ideas in the way, that my colleagues can understand what I am talking about. My English got better, new, special words came up, that I have learnt. My listening skills have also improved, as I have been talking to a lot of people, from different countries and the 10 weeks of ‘home work’ and skype meetings helped a lot, in order to improve myself. I experienced what it is like to work hard together in a project to achieve our common goal and I really enjoyed it!

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