EuroEAP Society Challenge 2021

FINAL SUBMISSION FORM

Fill in this form electronically (not manually). Use the following format: Times New Roman, 11pt.

Title of the demo/project:
DE Shaker – Unconfined Fluid Mixing Device

Name of the team leader and his/her affiliation:
Giacomo Sasso (Queen Mary University London – School of Engineering & Material Science)

Email address of the team leader:
giacomo.sasso.job@gmail.com (please CC: g.sasso@qmul.ac.uk)

Name of other team members and their affiliation:
None

Description of the final demo (maximum 3 pages)

This project aims to present a fluid mixing device, whose moving part is made of a double-cone Dielectric Elastomer Actuator. This is formed by two conically-shaped VHB membranes forming a 3D Hyperbole. Each membrane is spray-coated on either side with carbon black-silicone electrodes, forming four independent radial actuation segments. The two conical membranes support a well plate, which can host different fluids. By modulating the activation of the actuation segments, the fluids can be mixed with different dynamics, as a result of different shaking cycles. The well plate's displacement, speed and direction can be tuned via an Arduino-driven, multichannel, HV power supply. The mixing efficiency was optically quantified using a brightness analysis. Compared to a standard mixer, this new device produces a significantly lower amount of heat, simplifying mixing of temperature-sensitive fluids. Furthermore, the controllability of the displacements of the well allows for varying the mixing process. Interestingly, different geometrical mixing patterns can be achieved, enabling spatial modulations of the dynamics of mixing of unconfined fluids. This finding could open up new opportunities to manipulate unconfined fluids, for possibly different applications, such as geometrical structuring of polymer blends, composites, etc.

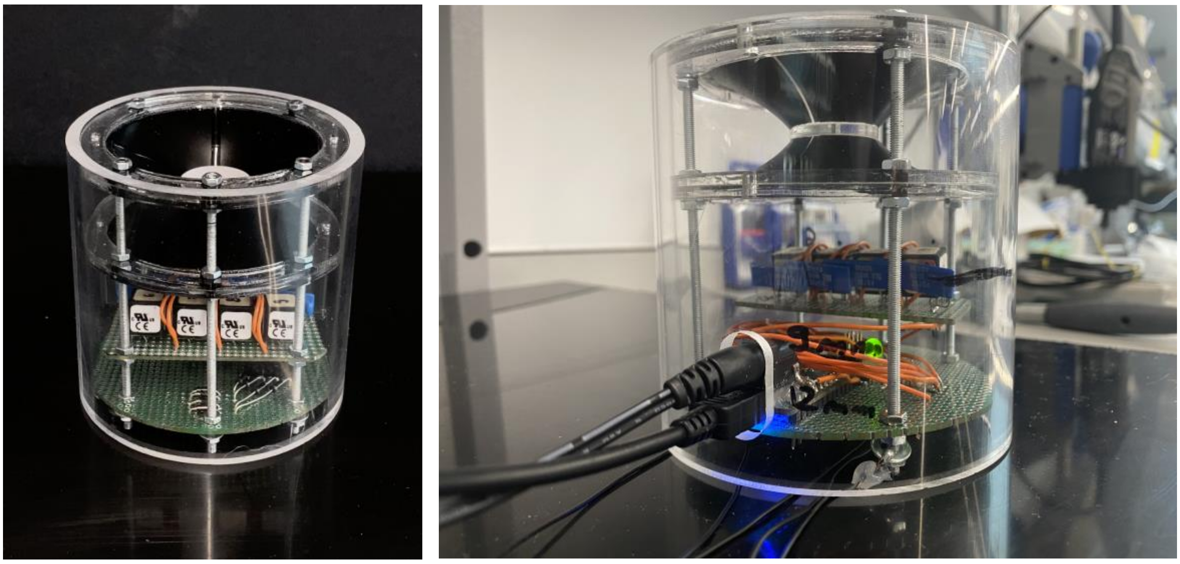

Figure 1. *DE Shaker - Unconfined Fluid Mixing Device.*

A comparison between an active shaked mixing and a passive diffusion process was obtained by placing a drop of glucose-based commercial food colourant at the centre of two well plates (one shaked and the other one static) and by pouring some water in order to completely submerge the central drop.
The DEA-based shaker mixing efficacy was then proved via a brightness-based image analysis. By considering the brightness value (from 0 to 255) of each pixel composing the greyscale analysed image, a custom made MatLab code was developed in order to estimate the temporal variation of the average brightness value over a Region Of Interest (ROI), as indicated in Figure 2 (top). The two mixing processes (shaked and static) were analysed by selecting two ROIs each. The first ROI was selected from a lateral zone of the well plate, where, at the beginning, no colourant was evident. The second ROI was selected from the centre of the well plate, which contained the highest initial concentration of colourant. A full mixing was assumed to be achieved when the average brightness value of the lateral and central ROI became equal. Figure 2 (bottom) shows that over a same amount of time, mixing by DEA-based shaking was able to dissolve the colourant more effectively than mixing by simple passive diffusion.

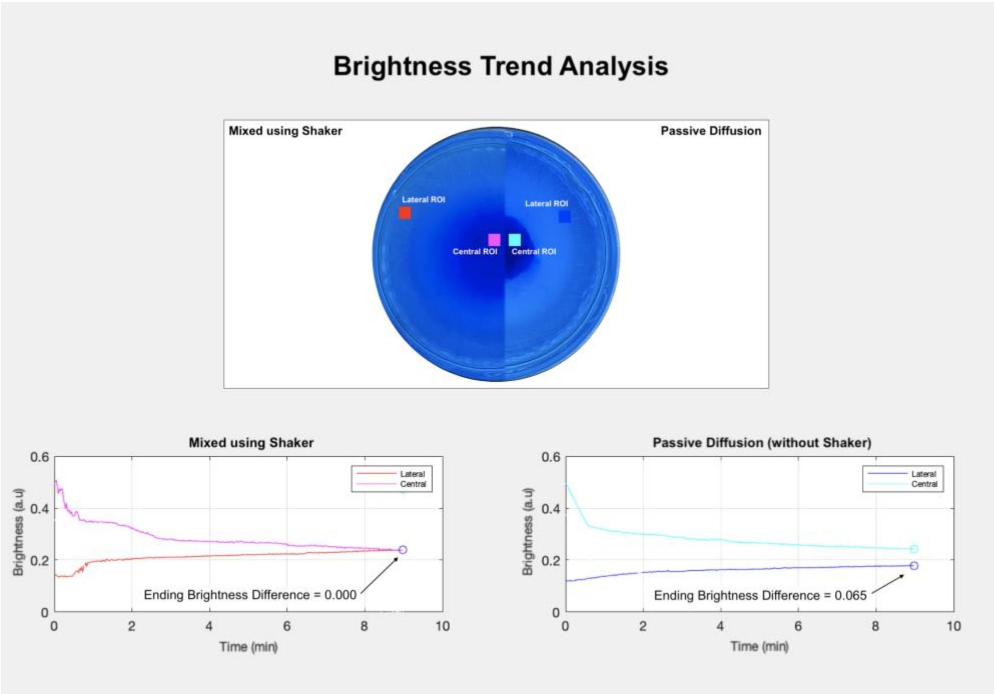

***Figure 2.** Brightness Trend Analysis.*

In order to prove that the DEA-based device effectively produces less heat than a conventional shaker, it was compared with a commercial shaker (Orbital Shaker 1000 by VWR) which is frequently used in cell and chemistry labs.
Heat production is a key issue when a temperature-controlled environment is required, for example in incubators used for cell experiments. Incubators, made out of a heated adiabatic chamber, can keep a constant temperature of 37°C, necessary for living cells to survive. When the shaker is activated inside the oven, heat produced by the brushless motor can challenge the temperature control. In order to measure the produced heat, the DEA-based shaker and commercial one, were separately tested over 4 hours in an incubator with the heating system turned off, so as to measure the temperature rise due to the operation of the shaker inside an adiabatic chamber.
The temperature was monitored using a thermocouple (Figure 3) dipped into a water filled well plate.

Figure 3. *Traceable Thermocouple (VWR).*

Starting from room temperature, each shaker was operated with the same rotational speed (RPM). Considering that the expected main heat source of the DEA device was the High Voltage power supply, the device was tested in two conditions differing for the location of the electronics: inside or outside the chamber (in the latter case thing high voltage leads were arranged through the incubator door sealing). Figure 4 shows the variation of temperature as a function of time for the different cases. As evident the conventional shaker produced a significantly higher temperature rise relative to the DEA-based shaker. As expected, for the DEA-driven device most of the heat was generated by the electronics, as shown by the larger increase when the latter was located inside the chamber.

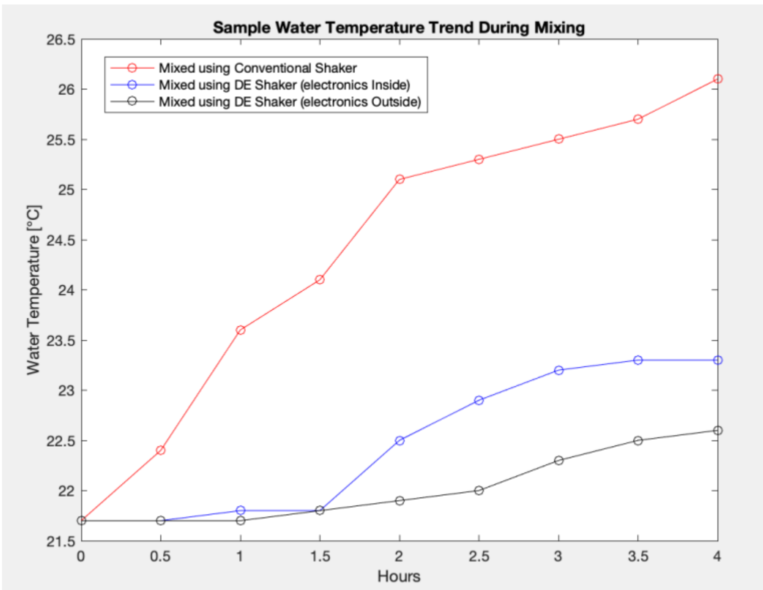

Figure 4. *Sample water temperature trend during mixing GRAPH.*

Link to download a video file of the demo.
https://www.dropbox.com/s/wk6l5enjjpg6jz7/DE%20Shaker%20-%20Unconfined%20Mixing%20Device%20%28Giacomo%20Sasso%29.mp4?dl=0

Alternative Link (WeTransfer link active till Friday 4th June 2021):
https://we.tl/t-IjSgJMx73m

SIGNATURE OF THE TEAM LEADER

Giacomo Sasso

SUBMSSION
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