The physics of dishwashers: first steps for developing a model to analyse automatic dishwashers (ADW) behaviour.

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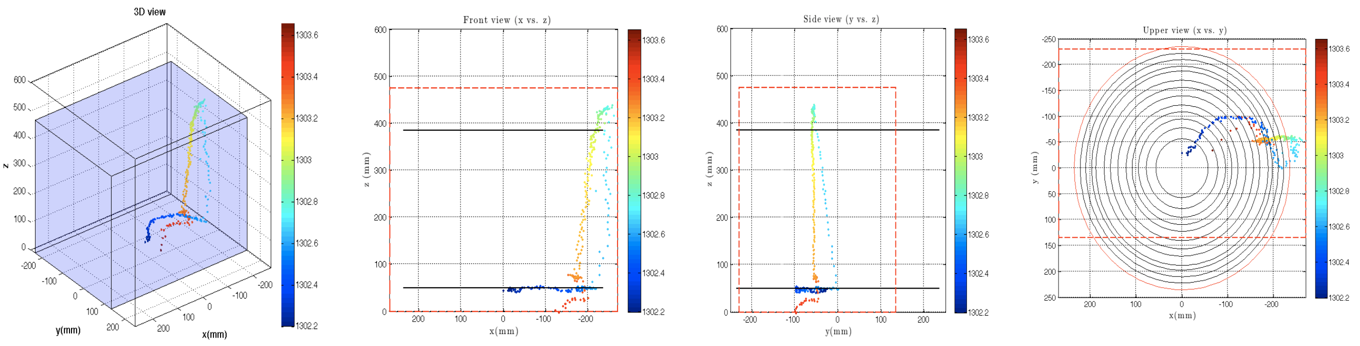
Existing research on the cleaning phenomena in household appliances such as dishwashers is scarce. Relevant work has focused on the cleaning of industrial scale equipment. Nonetheless, as the environmental impact of domestic appliances is important, more work will be required in order to understand ways of maximising cleaning efficiency. Surveys have shown that on average, a household dishwasher consumes about 268 kWh per year, with water consumption generally between 15 and 30 litres per cycle, depending on the age and the quality of the equipment[1].

As in most types of cleaning, there is a synergy between physical and chemical phenomena. Physical cleaning is brought about by the water jets inside the dishwasher and chemical cleaning by the type of detergent used. A combination of both is often required as overall cleaning is dependant on the interaction between these two phenomena. This work will focus on studying the physical processes occurring inside the equipment and will aim at understanding the full-scale cleaning process by means of analysis of the forces that are generated whilst the dishwasher is running. One of the techniques that is going to be used to quantify the flow of the water jets is Positron Emitting Particle Tracking (PEPT)[2].

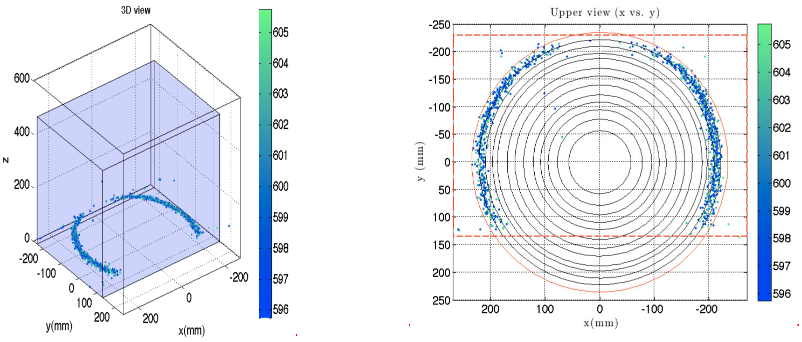
By using PEPT, it was possible to obtain particle paths in a commercially available dishwasher (Miele G 1222 SC). These reveal patterns of the dishwasher behaviour. For instance, a jet coming out of the lower spray in shown in Fig 1.:



(a) (b) (c) (d)

Figure 1. Jet from the bottom spray. Limits of the axes are dishwasher limits. Blue box and red dotted line represent PEPT camera field. Black lines and circles belong to the paths of the jet holes on the bottom spray. a) 3D; b) Front view; c) Side view; d) Upper view.

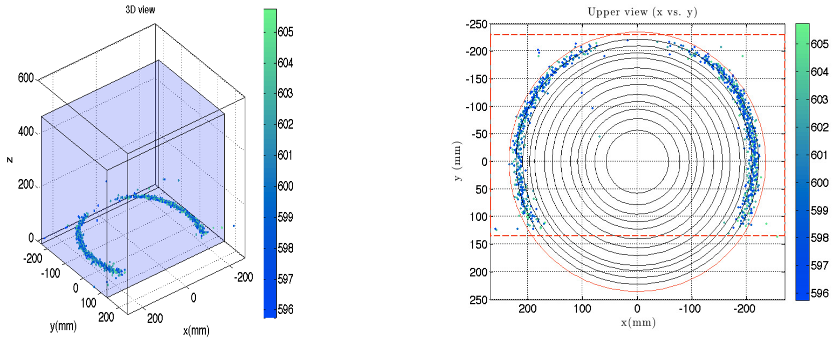
It was not uncommon for the radioactive particle to get "stuck" in the spray, and then rotate at the same velocity as the spray arm.



~~(a)~~ ~~(b)~~

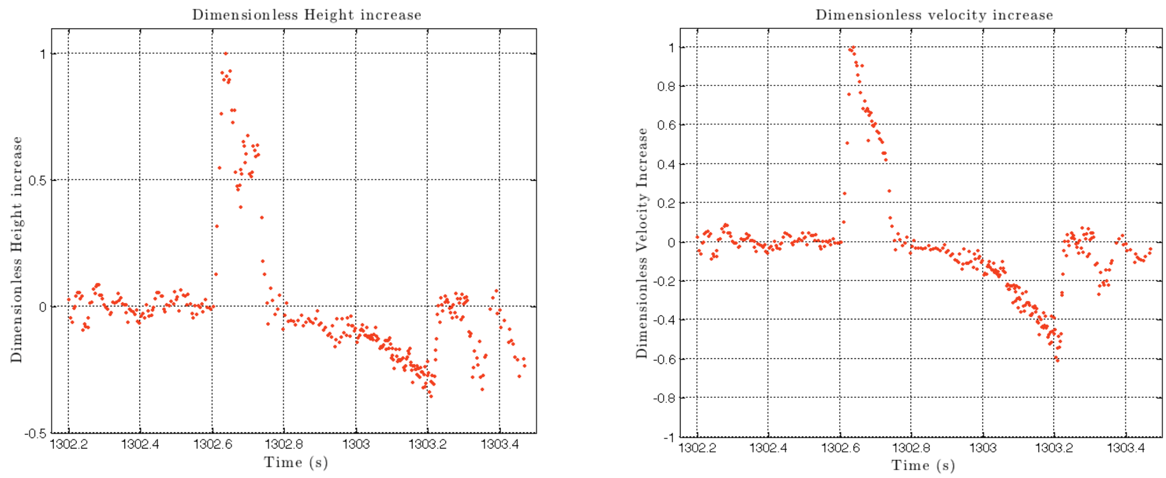
~~**Figure 2**. Representation of data from the particle turning in~~rotating with ~~the spray. Limits of the axes are dishwasher limits. Blue box and red dotted line represents PEPT camera field. Black lines and circles belong to~~ paths of the jet holes on ~~the bottom spray 's holes paths. a) 3D; b) Upper view.~~

Height and velocity of the water jets were



(a) (b)

Figure 2. Representation of data from the particle rotating with the spray. Limits of the axes are dishwasher limits. Blue box and red dotted line represent PEPT camera field. Black lines and circles belong to paths of the jet holes on the bottom spray. a) 3D; b) Upper view.



(a) (b)

Figure 3. Analysis of particle path. a) Dimensionless height increase; b) Dimensionless velocity increase.

estimated using particle paths in Fig.1. In Fig.3 one can see that the tracer accelerates as it goes through the jet and then decelerates as an effect of gravity. Eventually, negative velocities were estimated during the fall.

Finally, further understanding of the physical cleaning phenomena may be possible through small-scale decoupled measurement techniques, such as: micromanipulation[3] and fluid dynamic gauging[4],[5]. Both of these techniques allow measurement of the force required to remove a soil from a surface and also to determine the type of soil that it is attached to it.

References

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