Dishwasher Modelling: Using PEPT technique to visualise water motion inside an Automatic Dishwasher.

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The cleaning processes occurring inside an automatic dishwasher (ADW) is not a phenomena currently well known. A detailed study of the characteristics of an ADW is necessary to build the in-depth knowledge to fully understand the wash process. Thus, the main objective of this research is to create a model that could describe these main parameters, avoiding the currently laborious and full-scale experiments within an ADW.

Four areas can be considered as critical for the whole system: dishwasher design and operation parameters, dishwasher load and type, types of soils[1][2] and detergent formulation.

Among the dishwasher parameters, water distribution plays a very important role when analysing the performance of the system. Water is the key element that links all the parameters together, as it is responsible for influencing the total cleaning time, via shear stresses produced by direct impact of the water jets, transportation of the chemistry onto the soil, dissolution processes in certain type of soils, removal of low adhesive soils after penetration of chemistry…

The University of Birmingham has available a technique called Positron Emission Particle Tracking[3][4] (PEPT) which enables high-speed detection of a radioactively labelled particle in three-dimensional opaque systems ("black box" problem). The technique was applied to a commercially available dishwasher, where a single radioactive particle was introduced into the system while different wash cycles were run. The following set-ups were considered for these experiments:

TEST	1	2	3	4	5
PUMP SPEED	High	Medium	Low	High	Low
LOAD / NO LOAD	No load	No load	With load	With load	With load
DETERGENT / NO DETERGENT	No detergent	No detergent	No detergent	With detergent	With detergent

Table 1. Summary of experimental considerations.

An initial look at the data allows to distinguish between different sequences in the water motion: movement inside the spray arm, ejection and downfall after impact. This latter step can also happen in three different ways: free falling, downfall over the walls or downfall over the crockery.

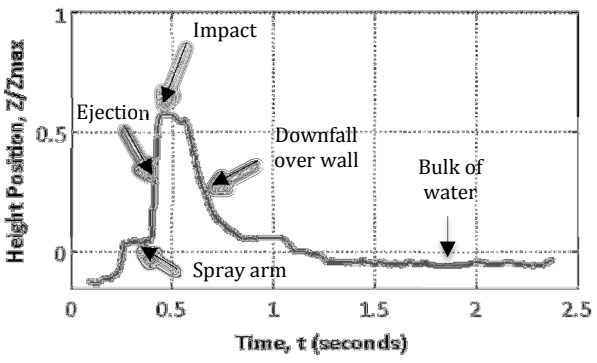
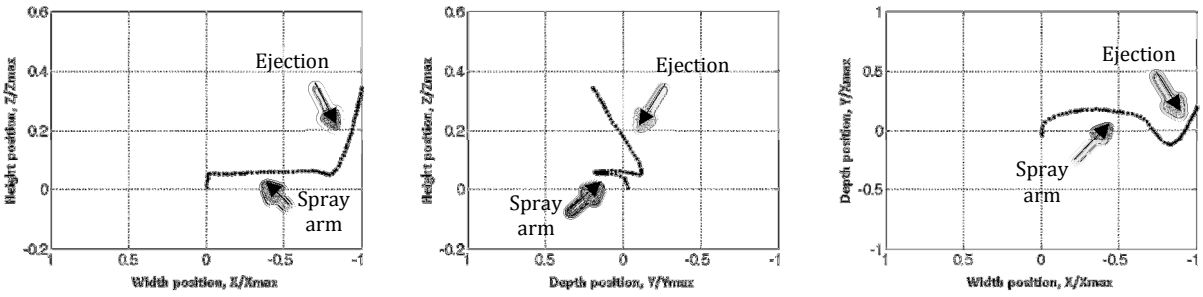


Figure 1. Typical movement sequence of water inside a dishwasher.

Velocities and accelerations can be assigned to every tracer location and therefore distributions obtained. By applying either Lagrangian or Eulerian analysis, colormap plots can be build and different areas in the dishwasher characterised. Also, data has shown that jets paths are straight, with no effect of the rotation of the spray arm on their trajectories. This means angular component of the velocity can be disregarded with respect to the vertical and radial components.



A B C

Figure 2. Example of straight path on a water jet. No curvature observed on trajectory.
A – Front view; B – Side view; C – Upper view

Ongoing work is focused on building a model based on first principle equations to analyse the influence of dishwasher´s design factors and to predict jet patterns. Also PEPT data has been used to validate data generated through CFD. The idea of implementing and using these models would lead to saving both in experimental time and costs.

References

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