NSSN
NSW Smart Sensing Network

FACT SHEET

WASH REACTOR COMPUTER SIMULATION AND PROCESS OPTIMISATION

2021

RESEARCH UNDERTAKEN BY UNSW AS PART OF THE CRC-P: INCREASED RECYCLING OF PLASTICS BY SENSING AND TREATING LABEL CONTAMINATION

UNSW SYDNEY

LEAD PARTNER

PEGRAS

RESEARCH PARTNERS

UTS

THE UNIVERSITY OF SYDNEY

INDUSTRY PARTNERS

Labelmakers Group Pty Ltd

Dairy Australia

GROUPE LACTALIS

Saputo

Bega The Great Australian Food Company

Wash reactor computer simulation and process optimisation

Laboratory of Process Modelling and Optimization (www.promo.unsw.edu.au) UNSW School of Chemical Engineering

Recycling companies today have problems in recycling HDPE because label adhesive contaminates the feedstock. The current process of HDPE recycling is consistently limited to ~ 25% of re-manufactured HDPE material, due to the current wash process not removing 100% of the contaminating adhesive.

The team at UNSW will contribute by developing a computer model of the current factory wash reactor and chemistry. With the aim of optimising the current ‘black box’ process and testing ‘stretch’ variations for possible large energy cost savings.

How will the success for the sub-project be measured?

Success is being defined by the progress against the agreed quarterly milestones over the 12 month project period. They are integrated with the other partners activities to deliver coordinated outcomes. UNSW is most closely aligned with the University of Sydney to test chemistry and modelling of the real world factory process.

How will you attain the outcomes?

The Laboratory of Process Modelling and Optimization (ProMO) led by Associate Prof. Yansong Shen has an extensive history of direct engagement with the manufacturing industry. The ProMO Lab is equipped with world-leading, unique numerical and experimental techniques for understanding and optimising complex processes; such as the recycling wash reactor processes under investigation.

Numerical simulations and modelling, supported by online data and experiments, have emerged as an indispensable adjunct to traditional investigation methods for design, control, and optimisation of processes, reactors and devices.

How is the project relevant to the recycling challenge?

A clean feedstock of recycled plastic is vital to achieve the APCO 2025 PCR targets for HDPE. The adhesive must be fully removed to match the performance of virgin resin. This project may enable improvements in current recycling processes to achieve this result.

Project impact

To achieve 100% recycled HDPE results UNSW is contributing to the project in the following ways;

An advanced mathematical model is being developed for describing the complex multiphase flow during the adhesive removal process to understand the details of internal phenomena inside the reactors

The mathematical models will be used to test and evaluate new designs and different operational scenarios extensively. A laboratory test rig will be set up for concept proof and model validation

The optimal design and process parameters combination will be finalised. Mathematical modelling supported by laboratory-scale experiments on the test rigs will target re-manufacture of 100% recycled HDPE content

Delivery of a scalable commercial industrial production model: from laboratory-scale proof of concept, to viable industry scale technology demonstration and implementation.

Project achievements

To date, the ProMO laboratory has made significant progress in the model development of the current industry HDPE wash reactor. According to specific operating conditions of the reactor, the process description of input conditions and the 3-dimensional geometry have been defined. This includes the size and shape of the tank, the structure of the internal impeller and blade orientation, as well as the boundary and internal baffles' positions.

As shown in Figure 1, the modelled computational domain has been divided into a set of small zones, i.e., rotating shaft, impellers, and stationary wall with baffles. To achieve rotation simulation, the Sliding Mesh model has been employed at the zone interfaces to calculate the time-accurate solution for rotor-stator interaction. The model relies on 'solving the Reynolds Averaged Navier Stokes (RANS) equations that describe the multiphase flow dynamics.

Initial results are very encouraging with preliminary model outcomes matching the known performance of the reactor in the related areas. The two-phases modelling (gas-liquid and solid-liquid) has visualised some critical internal phenomena (Figure 2), which are difficult to be observed in the actual washing process. Besides, many flow details of liquid and solid velocity distribution can be abstracted and analysed by simulation (Figure 3).

The most recent stage is of three-phase modelling (air-liquid-solid) that considers the addition of HDPE flake into the wash reactor as a gas-solid-liquid system With preliminary results emulating the lighter SG HDPE flakes being drawn down from the liquid surface due to the impeller design and rotational speed.

Next Steps

The next step involves incorporating flow and heat transfer thermodynamics. Noting that each additional step massively increases the computing resource requirements.

Close collaboration with all the project partners, led by PEGRAS has enabled rapid progress in spite of the COVID-19 impact.

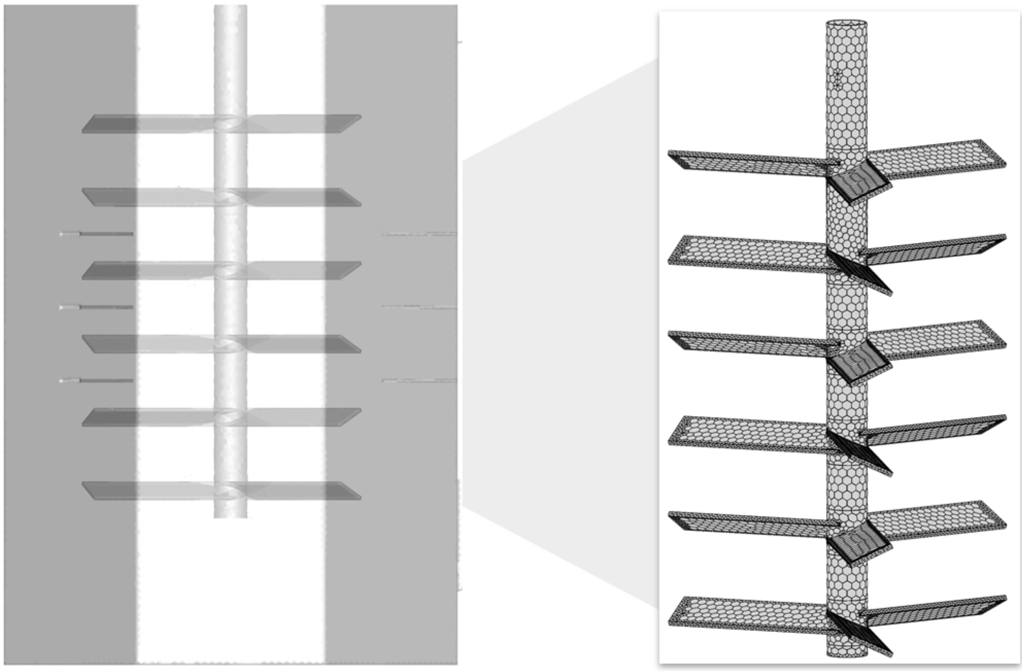
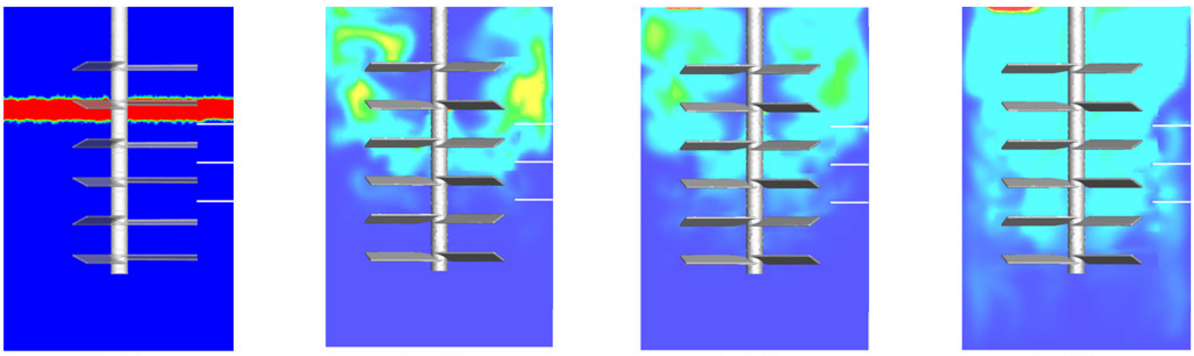


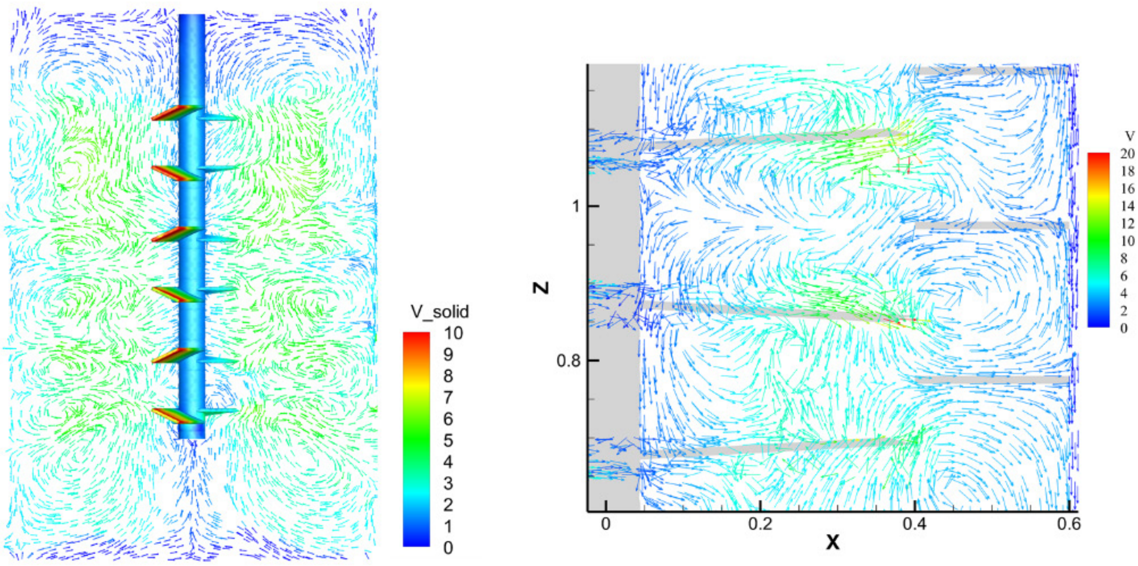
Figure 1

The draw down process of HDPE flakes in the solid-liquid system



t=0s t=10s t=15s t=50s

Figure 2



Solid velocity vector Local solid velocity vector

Figure 3

Figure 4

Key take away

The most recent stage is of three-phase modelling (air-liquid-solid) that considers the addition of HDPE flakes (Figure 4) into the wash reactor as a gas-solid-liquid system. With preliminary results emulating the lighter SG HDPE flakes being drawn down from the liquid surface due to the impeller design and rotational speed.

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A detailed prototype machine has been developed, due for construction and testing in Q1 2021.

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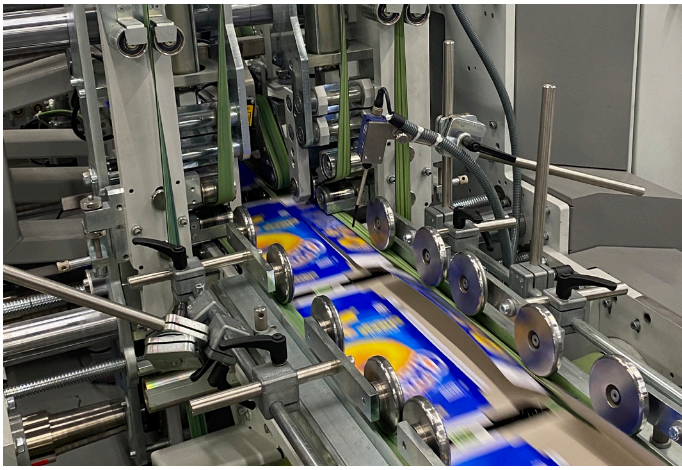
Industry Partners

The project's industry partners are making an investment in the future by funding this research to the tune of nearly $1.5 Million.

Labelmakers started back in 1987 printing self-adhesive labels, and grew to become Australasia's largest and most innovative label supplier. Packaging has changed considerably over the last three decades and they have developed solutions that have responded to the changing needs of our customers. Self-adhesive labels are now just one of six core labelling products. Labelmakers are supporting this project as part of their commitment to exploring opportunities that expand our business to continue to grow our offerings to our customers while remaining competitive in a global market and looking at ways to further reduce our carbon footprint.



PEGRAS Asia Pacific, is a technical solution consulting company based in NSW. For seneral years they have been collaborating with the NSSN and many industry partners to solve real world problems.

With a network of consultants in Australia, Europe and Asia, PEGRAS has provided solutions for various companies, including Audi, BioOil, Continental, Siemens, and TOYO.

Building on immense background knowledge of print and packaging, their business focus includes developing solutions for the Circular Economy needs of plastic recycling. PEGRAS developed the initial proof of concept chemistry that has evolved into this CRC-P project and provides a chemical and engineering lead.

To find more about the project out how the NSSN can help solve your challenges in other areas, please contact Dr Don McCallum at 0433 496 778 or don.mccallum@nssn.org.au

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