Application for a TSM-DTC funded PhD studentship

Please complete this form electronically
and submit to Lilian Wanjohi (l.wanjohi@imperial.ac.uk)
by Friday January 8, 2010

1st supervisor
Name: Maria Charalambides
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2nd supervisor
Name: Gordon Williams
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3rd supervisor (optional)
Name: Peter D. Lee
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Please complete the following:

1. Project title:
Micro-mechanical Model Development for Potato Tubers

2. Project abstract (≤ 200 words please and please add 1 or 2 key references)

Potato tubers have a cellular structure; each parenchyma cell is about 150 to 250 mm, water-filled and with thin flexible cellulose cell walls held together by hemi-cellulose. A large number of starch granules and also contained within these cells. It is important to be able to predict the mechanical response of this complex structure to external loads during processes such as cutting or slicing. It is proposed to conduct an investigation with the aim of producing a predictive micromechanical model based on the micro-structure's geometry. This model will be an essential step towards optimising the cutting operation in terms of minimising wastage and damage in the potato's micro-structure (hence reduce and control starch wash-out). As potato tubers are often cut in thin slices (for crisps), the slice thickness is comparable to the cell dimensions. This necessitates the development of a micromechanics model.

A Finite Element Analysis (FEA) model of the cutting process will be developed. Either sections of the microstructure or a Representative Volume Element (RVE) will need to be generated in the model. Typical geometries of the micro-structure will be obtained through imaging studies including X-Ray Micro Tomography (XMT). This information will provide the three-dimensional geometry of the cellular architecture which will be generated in finite element models.

3. What is the multi-scale nature of the project? (≤ 100 words please)

At the macro scale, the important process parameters include the blade geometry (e.g. tip radius, wedge angle), the cutting rate and the orientation of the cut in relation to the potato's cellular size/structure. At the micro-scale, the material parameters include the geometry of the microstructure, the cell wall deformation and fracture properties, the turgor pressure of the cell and the adhesion between cell walls. The effect of the loading rate on the cell wall properties as well as the cell wall interface needs to be taken into account in the model. The cutting rate will also affect possible fluid flow out of the cell.

4. How do the expertises of the supervisors complement each other? (≤ 100 words please)

Dr Charalambides's research is centred on mechanical modeling and characterisation of complex materials, i.e. materials with inherent complex material behaviour, (e.g. non linear viscoelasticity), complex geometries in their microstructure and/or more than one phase. She specialises in soft solids such as foods and hydrogels. Prof Williams has worked on the derivation of analytical models for determining energy release rates from cutting forces which will be very useful for this work. Prof Lee develops novel in situ observation techniques for assessing morphological changes at a micron scale using techniques such as microtomogrpahy.

5. Is there a self-contained 12-week MSc project that would usefully initiate this PhD project? (If the answer is no the project will not be offered as an MSc project)

Yes. The MSc student could set up preliminary material models based on information in literature. This will only be concerned with deformation of potato tubers, not the cutting/fracture aspect of the project.

References

[1] Gamonpilas, C., Charalambides, M.N., Williams, J.G., "Determination of large deformation and fracture behaviour of starch gels from conventional and wire cutting experiments", J Mater Sci 44, (2009), 4976–4986.
[2] J. R., Poologasundarampillai, G., Atwood R. C., Bernard, D., Lee, P. D., "Non-Destructive Quantitative 3D Analysis for the Optimisation of Tissue Scaffolds", Biomaterials 28(7):1404-1413, 2007.