Introduction
Bags or pouches made from film or paper are a familiar form of protective packaging. The paper or film from which these packages are made is manufactured as a flat sheet of uniform width and stored on a roll. For dry free flowing materials the vertical form-fill-seal packaging machine is the most commonly used for transforming the flat sheet into bags. The single web of film or paper is fed over a forming shoulder that guides the material from the flat roll to a tubular shape around the product feed tube. The edges of the film are overlapped and are either heat sealed or glued to form a tube into which the product to be packaged can be dropped in measured quantities. The tube of packaging material is then cross-sealed to form a sealed bag. The final seal also forms the bottom seal of the next bag. This basic approach has been adapted to produce a variety of different packs. These include packs with flat bottoms and tetrahedral tea bags.

The Research
The ongoing research program focuses on the crucial element of the the form/fill/seal packaging machine – the forming shoulder. This component guides the packaging material from the flat sheet into a tube from which the bags are formed. An understanding of the geometry of these shoulders has been developed and the possible geometries mapped. It is through this knowledge that the matching of materials to suitable shoulder designs can be accomplished.

The model
A parameterised model based on the mathematics of differential geometry has been developed. The shoulder is part of a family of surfaces called ruled surfaces. A successful shoulder should guide the material from the flat to the tube shape without stretching, tearing or wrinkling the material. These constraints upon the shoulder define an envelope with in which lies all the possible shoulder designs. The model generates shoulder designs for a given set of parameters. The height, the radius, the back angle, the front angle, and the included angle of the flat plane.

This model was used to explore the bounds of the solution space, as not all combinations of the parameters will result in a viable shoulder.

The parametric model was developed for the specific purpose of modelling the solution space. The designs generated by this model have been also used to test and validate other mathematical models that seek to replicate the force and tracking properties that are important to the successful matching of material to machine. The model has also been used to develop forming shoulder designs for a variety of different tube shapes including those based on squares and triangles.