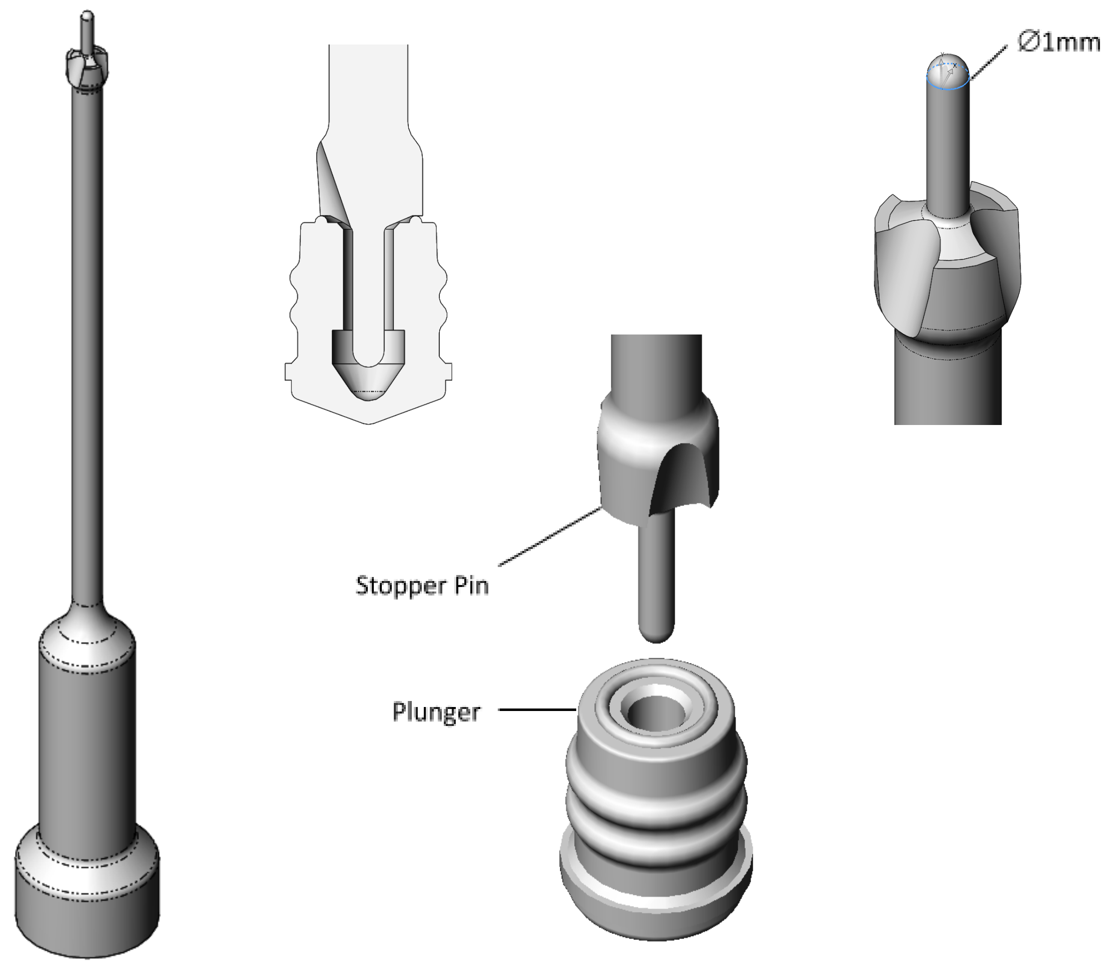
Syringe Plunger Stopper Pin

May 2021



Objective:

The Cytiva machine fills and caps liquid drug product into glass containers, in this case, syringes. A mechanism was designed to insert plungers into the body of the syringes to create a closed system containing the liquid drug product inside. This pin is part of a x100 array, stoppering 100 syringes per press. A 100% successful stoppering every time is required to pass pharmaceutical regulations.

Technical Details:

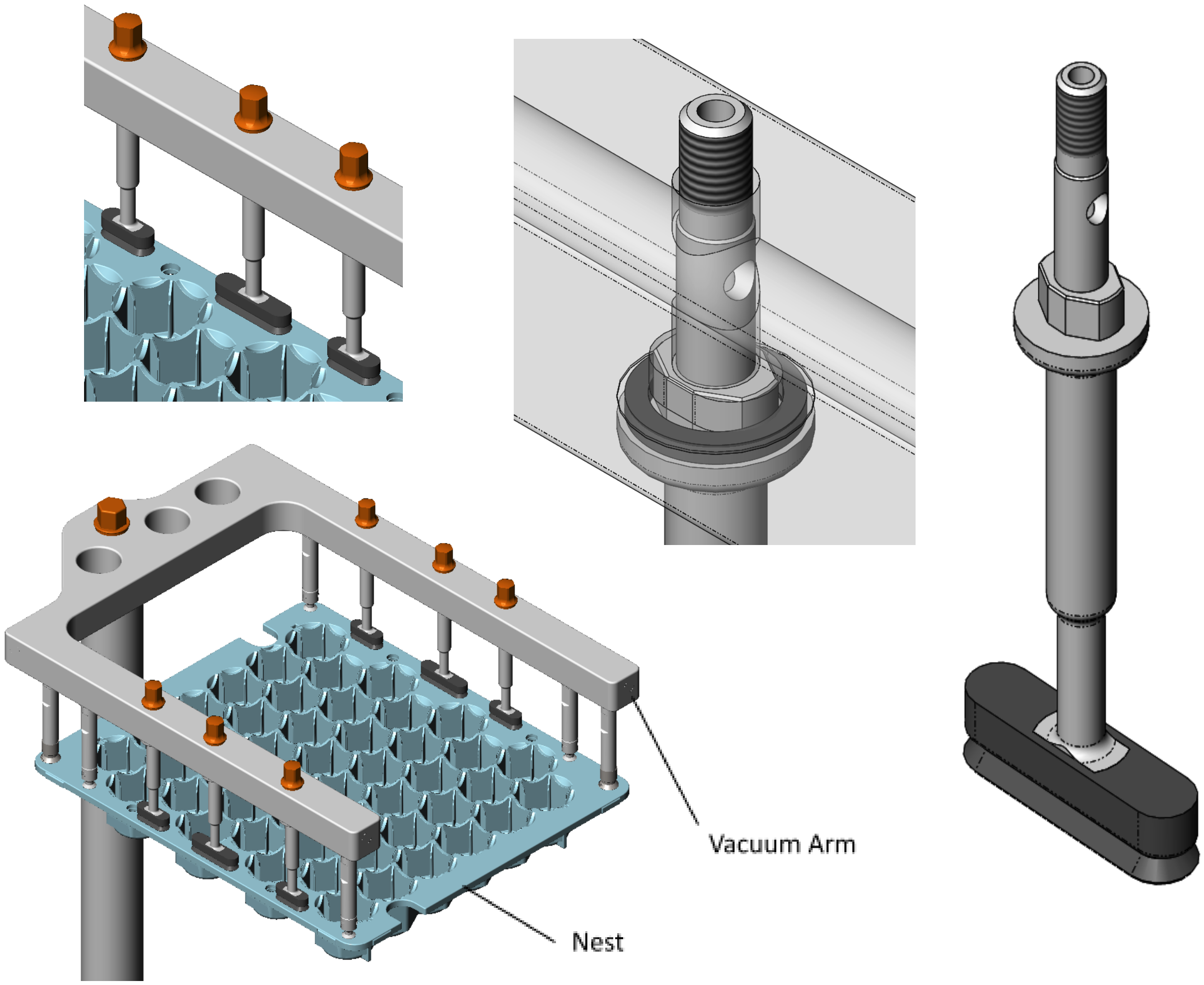
The design challenges facing this project were firstly the size limitations governed by the size of the plunger and corresponding syringe opening and secondly, the stoppering process (inserting the plunger into the syringe) is performed under a partial vacuum which posed some stiction issues during development. This final design is a third generation part after 2 previous iterations. The two initial designs pressed the plunger through contact with the inside bottom of the plunger and failed due to suction upon vacuum release and damage to the plunger respectively. This successful design utilized the shoulder of the plunger with fluted vacuum release channels whilst retaining a partial length cylindrical end from previous designs to prevent the plunger from 'tumbling' before entering the neck of the syringe.

Results/Outcomes:

100% success, no failures observed during any tests. Tool provided to customer and successful test runs were completed May 2021, commercial runs pending pharmaceutical drug approval.

Vacuum Pick and Place Station

January 2021



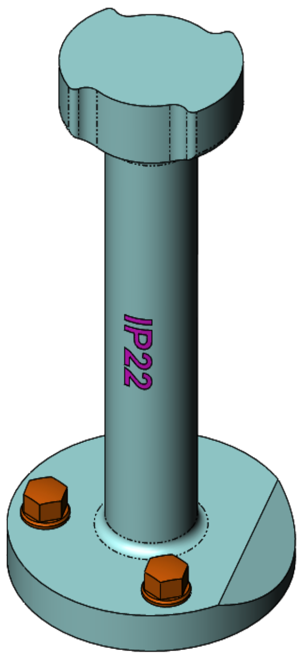
Objective:
Vials are processed by the Cytiva machine in a nested configuration. A nest is an injection molded tray containing a number of vials (between 16 and 100) to be filled and capped during processing. This nest and the accompanying vials must be picked from and placed back into the tub in which they arrive. The design must also conform to the aseptic conditions present inside the isolator.

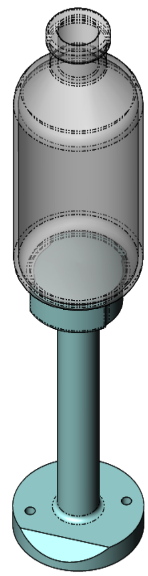
Technical Details:
The design utilized suction cups engaging with the small amount of available space on the outer edges of the top surface of the nest. Vacuum lines were drilled down the center of each vacuum post and down the length of each arm ending in a barbed fitting with tubing running to a venturi vacuum system. Each post with an oval suction cup uses a boss feature to fit into a slotted section in the arm, locking them rotationally to align the long axis of the suction cups with the edge of the nest. The top surface of the locking boss was used as a hard stop to ensure optimal compression of the square cross section o-ring achieving a sanitary seal. The crossflow holes in the top section of each of these posts can be seen in the transparent view. Air flow and post strength were weighted as competitive mechanisms in optimizing the size of this cross hole. Posts with a circular suction cup are essentially a redacted version of the oval cup posts and simply thread into the arm.

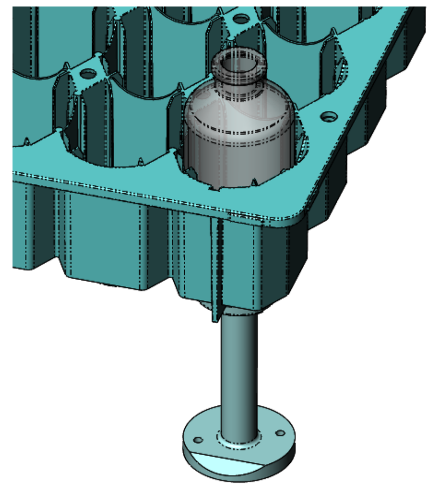
Results/Outcomes:
The system was able to repeatedly pick and place the nest to and from the tub with a 2.1 FOS with respect to lifting capacity relative to filled nest weight. Design was used as the new benchmark for systems to follow.

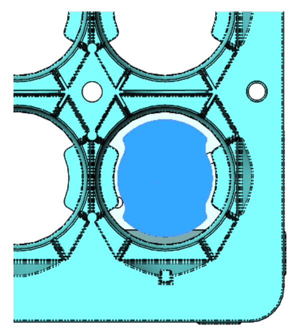
Fill Volume Verification Post

March 2020









Objective:

During the filling process (when liquid drug product dispensed into vials) inside the Cytiva machine, some or all vials are checked as per recipe parameters to confirm the fill volume conforms to specifications. To achieve this, a post mounted to a scale was used to raise a single vial and isolate it from the nest. The vial weight is tared, filled, weighed and returned to the nest after measurement. A successful design isolates the chosen vial from the nest and allows the scale to read stable and accurate tare and filled values.

Technical Details:

Several iterations were tested to fulfill these design requirements, however in the end the best approach was simplicity. Posts were tested with top surfaces that partially mimicked the underside surface of the vial to aid in centering each vial on the post, however a simple flat top post proved to be the most effective. The different designs were 3D printed for testing before the final post shown above was machined from PEEK which disallowed conductivity issues from interfering with the scale. It is a simple turned part with a milled top surface that mimics the opening in the bottom of the nest. The top surface of the post extends out to the foot of the vial (the contact surface of a vial while resting upright on a flat surface) while considering a complex tolerance stack up including robot arm repeatability to disallow any contact with the nest itself.

Results/Outcomes:

After successful testing, post was handed to customer and has been used for commercial fills since 2018.

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Models for the bead mobility technique: A droplet-based viscometer

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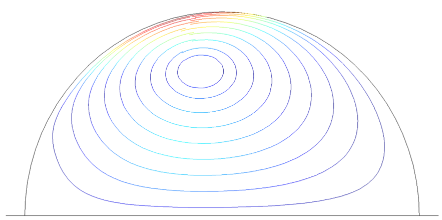
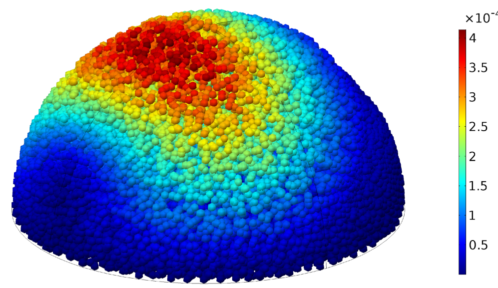




Study Parameter	Parameter Range	Apex Velocity Min $[ms^{-1}]$	Apex Velocity Max $[ms^{-1}]$	Apex Velocity $\frac{Max}{Min}$	Max Surface Velocity Min $[ms^{-1}]$	Max Surface Velocity Max $[ms^{-1}]$	Max Surface Velocity $\frac{Max}{Min}$
Viscosity	(1-1000)Pas	3.31E-7	2.67E-5	808	4.39E-7	3.39E-4	773
Contact Angle B	(50-110)°	5.40E-5	5.75E-4	10.6	6.26E-5	7.70E-4	12.3
Radius	(1-2.5)mm	1.01E-4	2.67E-4	2.64	1.15E-4	3.39E-4	2.96
Drafting	-	1.59E-4	3.03E-4	1.91	1.66E-4	3.96E-4	2.39
Contact Angle A	(50-110)°	1.55E-4	2.67E-4	1.72	2.03E-4	3.39E-4	1.67
Surface Tension	(0.01-0.13)Nm^{-1}	2.54E-4	3.27E-4	1.28	3.25E-4	3.75E-4	1.16

Objective:

A novel technique was developed to measure the viscosity of liquid atmospheric particles. The viscosity of these particles has a profound effect on global climate models through their influence as cloud condensation nuclei. The technique places droplets of the liquid seeded with tracer particles into a flow chamber and observes the circulation of the tracer beads inside the droplet. The viscosity of the droplet is proportional to the speed of the bead recirculation inside the droplet. The experiment however was subject to large uncertainties. This thesis sought to utilize knowledge of flow dynamics alongside CFD modeling to investigate potential contributions to the errors seen and hence improve the results of this useful technique.

Technical Details:

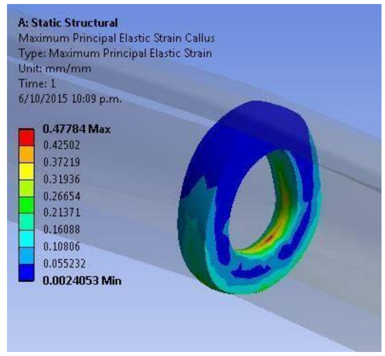
A complex model was developed using COMSOL in conjunction with supervisor Dr M. Sellier to simulate the experiment. This model was used, in conjunction with an analytical model, to explore the effect of potential errors in the experiment through parametric studies. The streamline and tracer particle images above show the flow pattern of fluid inside the droplet. The final table weights the investigated error sources in terms of their negative contribution to experimental uncertainty.

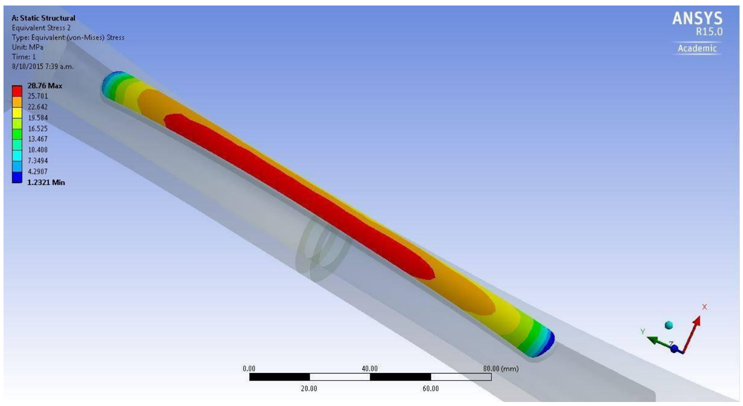
Results/Outcomes:

The results of the thesis were provided to the experimental group facilitating a vast improvement in measurements. The improvements have been passed to research groups aiding in the accuracy of global climate models with respect to cloud formation and its effect on the Earth's albedo.

Femoral Fracture Analysis

September 2015





Objective:

As part of a Biomedical elective course at the University of Canterbury, the design of a fracture plate was designed and optimized to aid the healing of a fractured femur.

Technical Details:

The bone was received as a 3D scan model and repaired using SolidWorks surfacing techniques before transferring to ANSYS for FEA analysis. Forces were applied to the bone simulating a steady walking motion including relevant muscle, ligaments and tendon attachments. Parametric studies were used to analyze the effect of plate width, height and length and screw trajectory on bone healing. The challenge was to minimize stress shielding of the bone (disallowing excessive bone mass loss due to resorption) whilst also minimizing the strain seen by the healing callus to facilitate bone growth. The former aspect of stress shielding becomes a large factor if the plate is to be left in place after healing.

Results/Outcomes:

Course assignment only, outputs were reviewed by professor however the data was not linked to any real world experiments.