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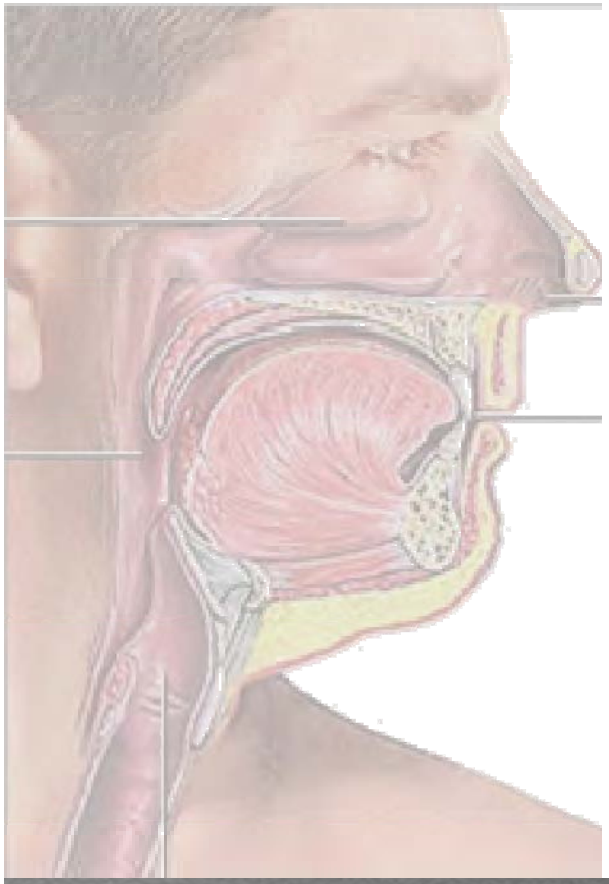
A Value Leader



Cavity Sprayer Flow Optimization for Medical devices Industry

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30th Oct 10

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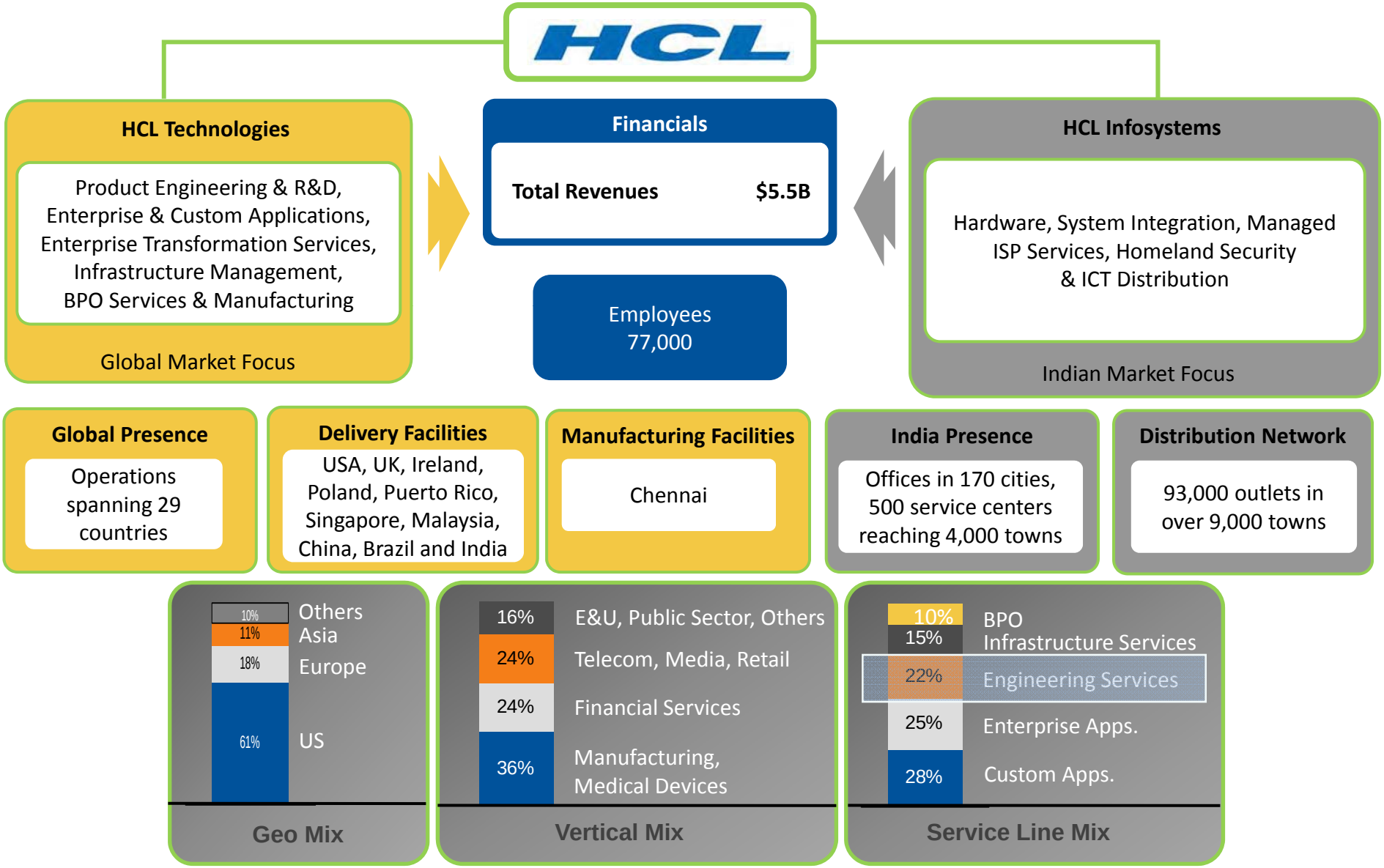
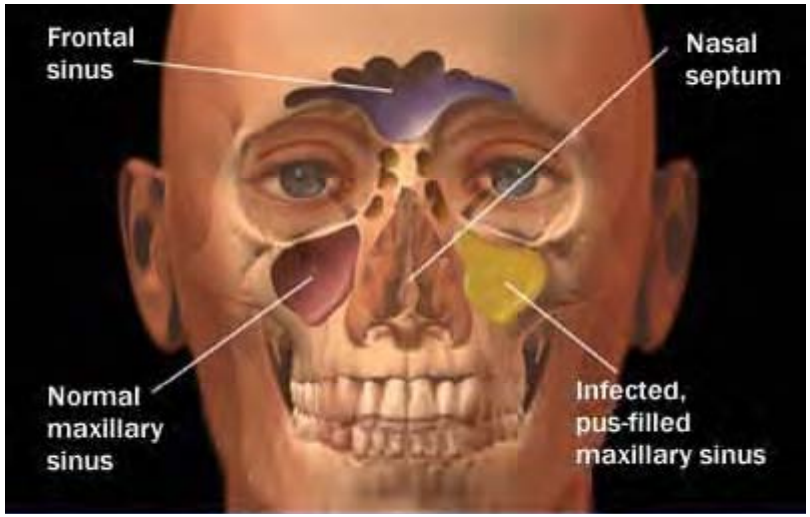

HCL
HCL Technologies
Product Engineering & R&D, Enterprise & Custom Applications, Enterprise Transformation Services, Infrastructure Management, BPO Services & Manufacturing
Global Market Focus
Financials
Total Revenues $5.5B
Employees 77,000
HCL Infosystems
Hardware, System Integration, Managed ISP Services, Homeland Security & ICT Distribution
Indian Market Focus
Global Presence
Operations spanning 29 countries
Delivery Facilities
USA, UK, Ireland, Poland, Puerto Rico, Singapore, Malaysia, China, Brazil and India
Manufacturing Facilities
Chennai
India Presence
Offices in 170 cities, 500 service centers reaching 4,000 towns
Distribution Network
93,000 outlets in over 9,000 towns
10% Others
11% Asia
18% Europe
61% US
Geo Mix
16% E&U, Public Sector, Others
24% Telecom, Media, Retail
24% Financial Services
36% Manufacturing, Medical Devices
Vertical Mix
10% BPO
15% Infrastructure Services
22% Engineering Services
25% Enterprise Apps.
28% Custom Apps.
Service Line Mix

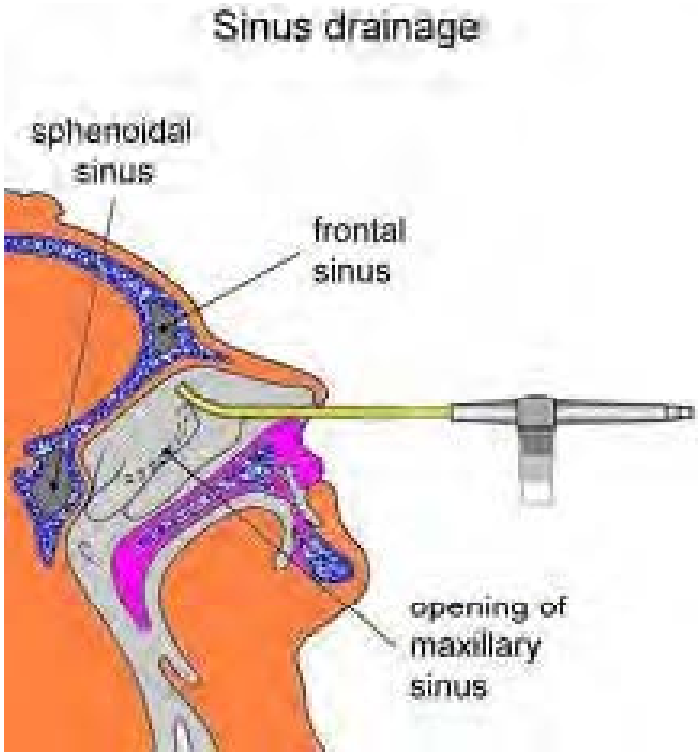
Sinusitis



• Anything that causes a swelling in the nose—an infection or an allergic reaction can affect your sinuses.

• Air trapped within a blocked sinus, along with pus or other secretions may cause pressure or vacuum on the sinus wall that can cause the intense pain of a sinus attack.

Surgical Treatment

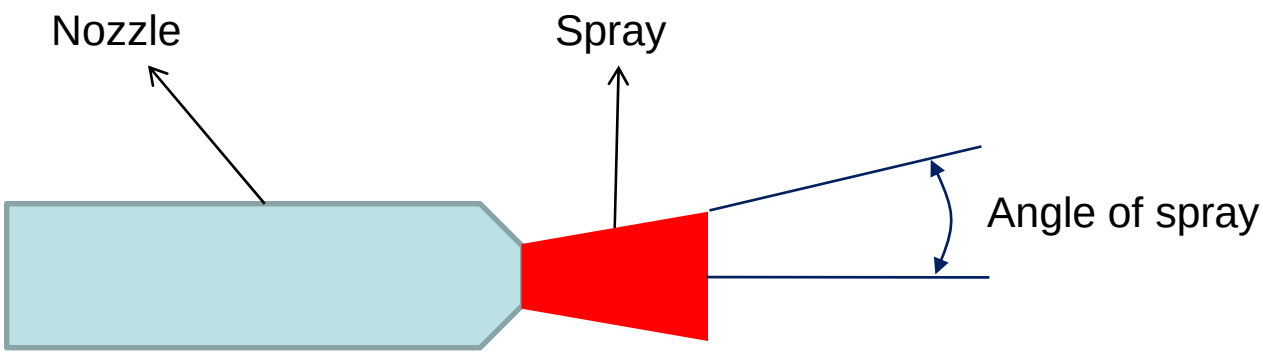


Surgery has three phases;

- Reducing blockage of the nasal passages by enlarging the natural opening of the sinuses.
- Draining and cleaning the sinuses.
- Spray-coating an antibiotic polymer to prevent further infection.

All these phases are intrusive and painful.

Objective



• The objective of the work was to reduce the intrusiveness of the third phase, spray-coating the sinuses.

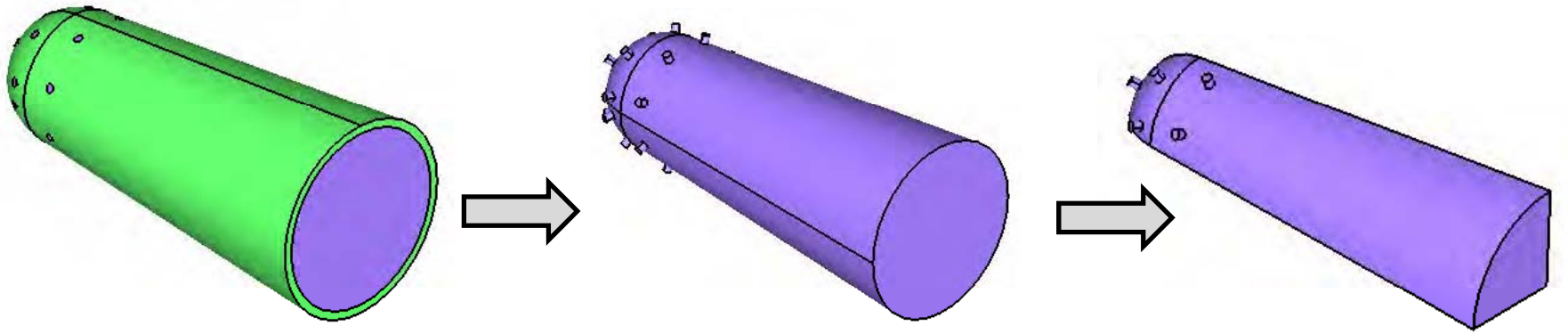
• A multi-hole nozzle was designed to be effective in optimally spreading the medicinal coat while being least intrusive.

• goal of the FEA was to maximize the effectiveness of the multi-hole nozzle by varying a set of parameters and narrowing down to an optimal solution using DoE.

Analysis methodology

- Analysis has been carried out in COMSOL.
- Linear tetrahedral elements have been used to mesh the model.

Nozzle | Fluid part | Quarter symmetry model

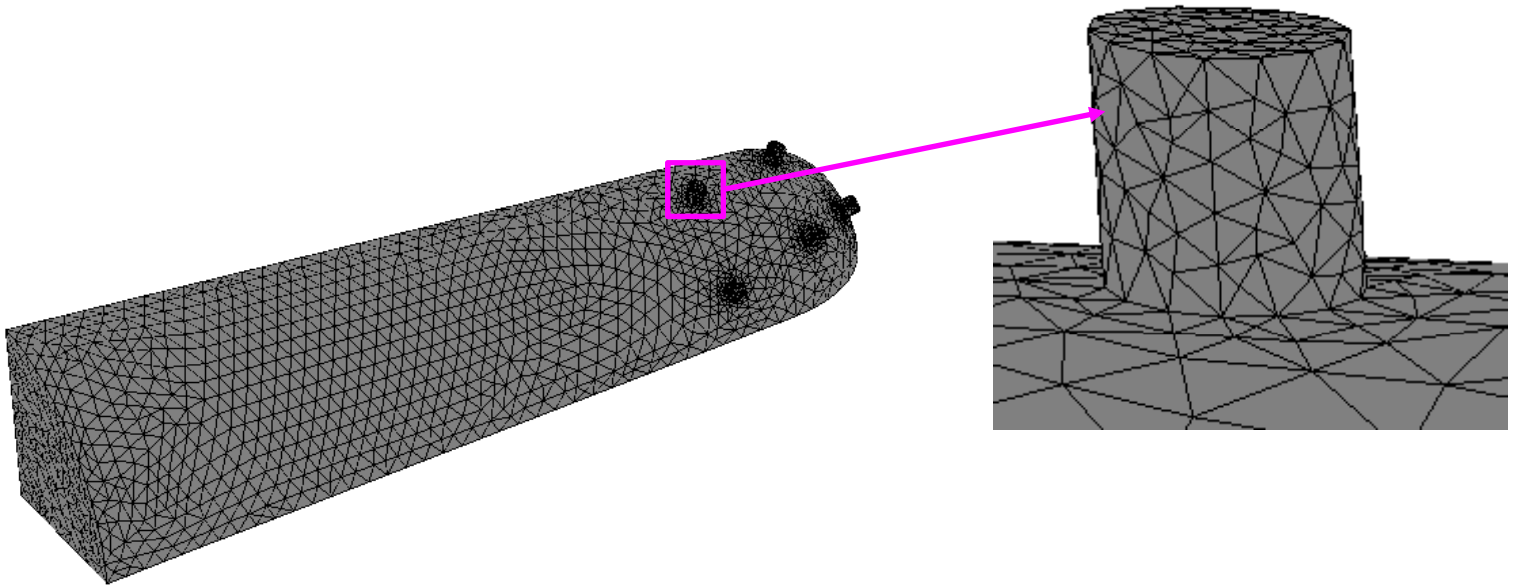


- Above shown is the shape of the fluid that is extracted from the given nozzle geometry
- A quarter symmetry model is used to take advantage of the symmetry.
- The nozzle inner wall that interacts with fluid was modeled as rigid wall
- Viscosity of the fluid (which is a shear thinning fluid) was defined as function of shear rate.

Assumptions

- Only single phase flow has been considered.
- No slip condition has been assumed.
- The fluid is assumed to be incompressible
- Atmospheric pressure has been assumed at the outlet.
- Chemical reactions have not been considered.
- Spray droplet formation is out of scope of the FEA.

FE modeling



• Meshing refinement was conducted till the discrepancy in the inlet and outlet mass flow rates is less than 1%.

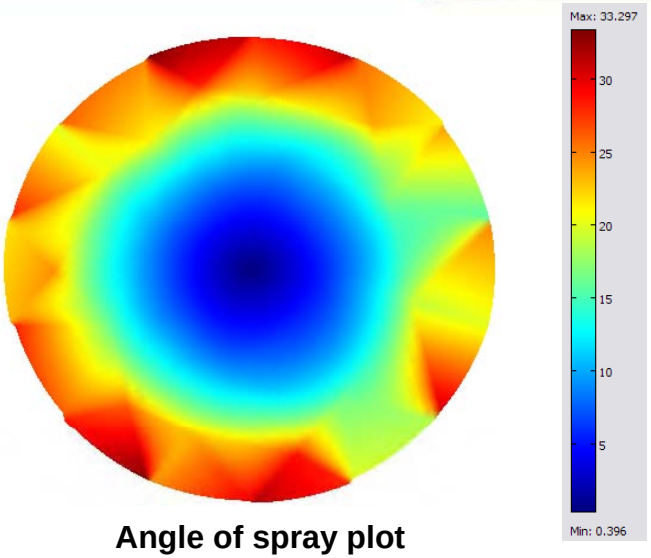
• Special attention has been paid to refine the mesh at nozzle outlets to provide sufficient resolution for post processing.(Since, the nozzle outlets are the primary areas of interest.)

Theoretical Calculations

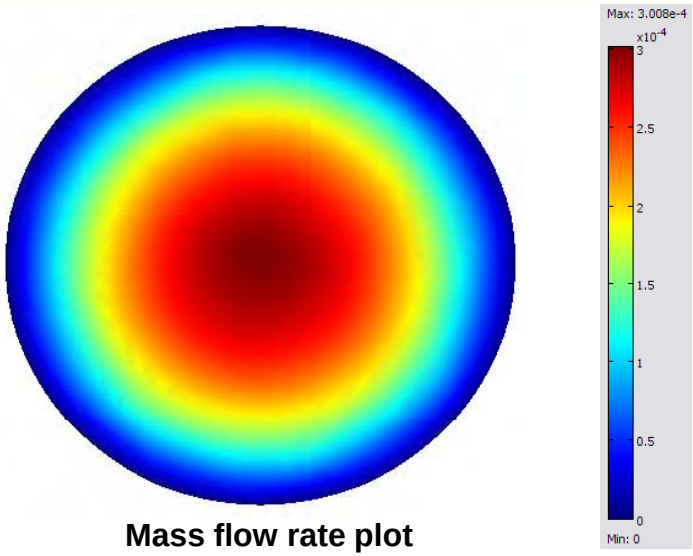
Inlet pressure (p_1)	= 0.184 Mpa
Inlet velocity (v_1)	= 0.15m/s
Outlet pressure (p_2)	= 0.1MPa ----► Atmospheric Pressure
Outlet velocity (v_2)	= $\sqrt{\left(\frac{v_1^2}{2}+\frac{p_1}{\rho}-\frac{p_2}{\rho}\right)}*2$ ----►Based on Bernoulli's Principle =13.37 m/s
Density of the fluid (ρ)	= 940 kg/m^3
Inlet diameter	= 0.005 m
Outlet diameter	= 0.003 m
Reynolds number at inlet	= 1.08
Reynolds number at outlet	= 58.03

- It can be observed that the Reynolds number of the flow is below the start of turbulent transition 2300, i.e., by a factor of 40.
- Even if real life factors tend to increase the Reynolds number of the flow, it will be fair to assume that the flow is laminar.

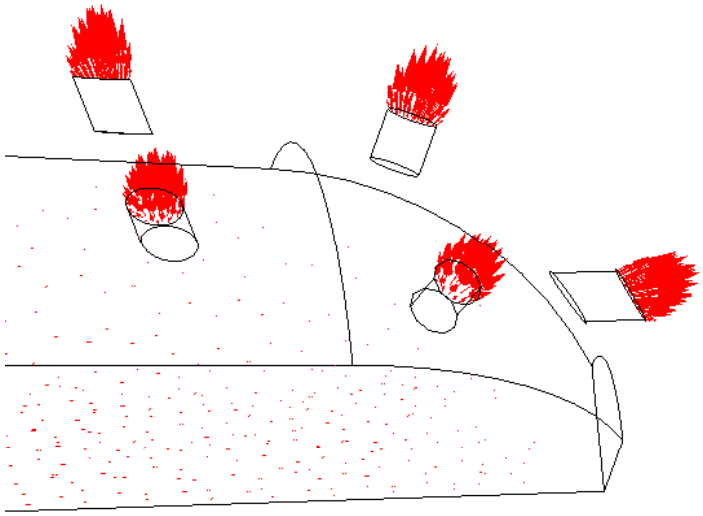
Results discussion



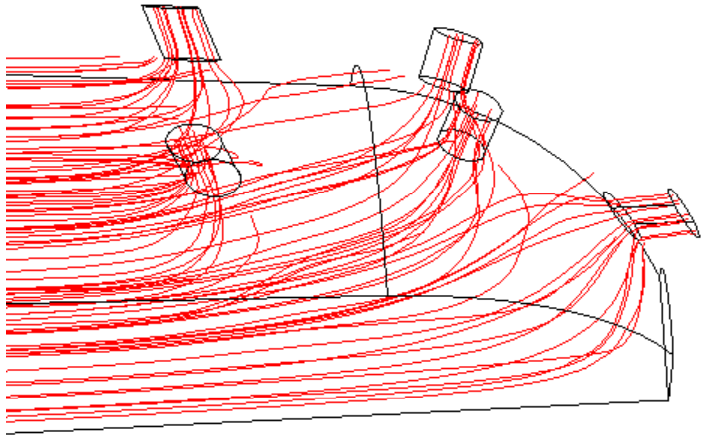
Angle of spray plot



Mass flow rate plot



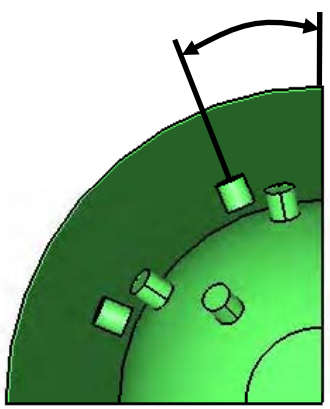
Mass flow rate – Arrow plot

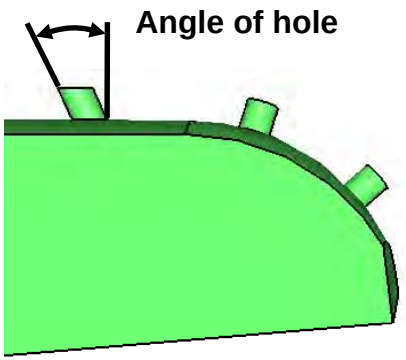


Stream line plot

Sensitivity study

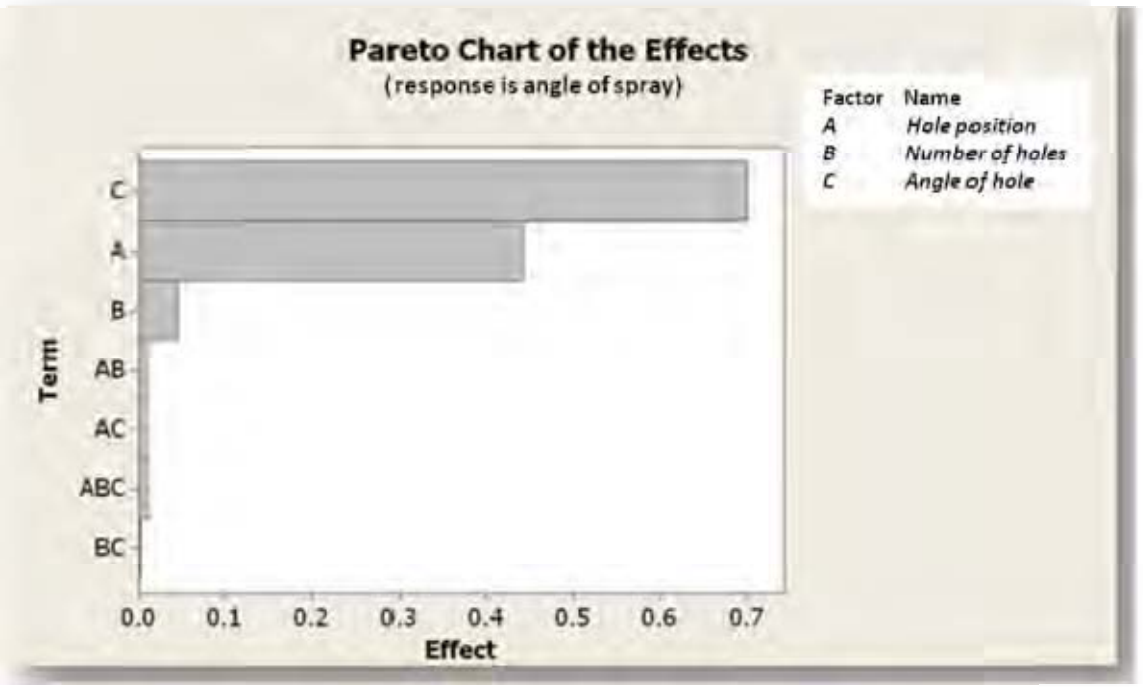
	Angle of Hole, C (°)			Hole position, A (°)			Number of Holes, B		
Concept	Min	Normal	Max	Min	Normal	Max	Min	Normal	Max
1	0			0			16		
2			35	0			16		
3	0					15	16		
4			35			15	16		
5	0			0					24
6			35	0					24
7	0					15			24
8			35			15			24
9		22.5			7.5			20	





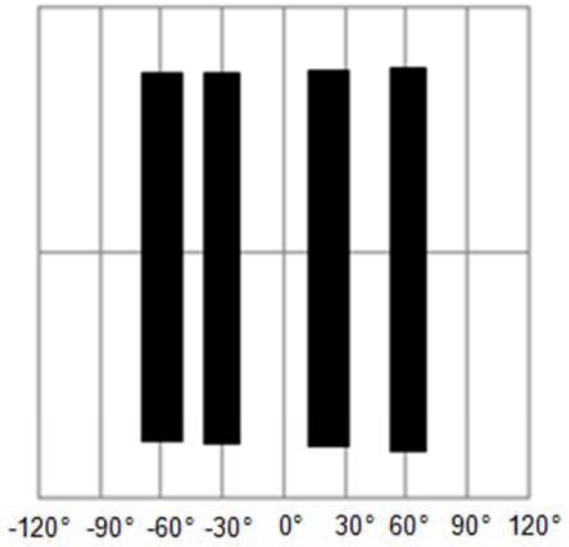
- The sensitivity study is done to understand the effect of various design parameters on the sprayer.
- To optimize the flow rate and angle of spray, Design of Experiment (DOE) approach has been implemented .
- Angle of hole, Hole position, and No. of holes have been taken as design parameters.
- Flow simulation has been performed for the different combinations of the design parameters.

Sensitivity study

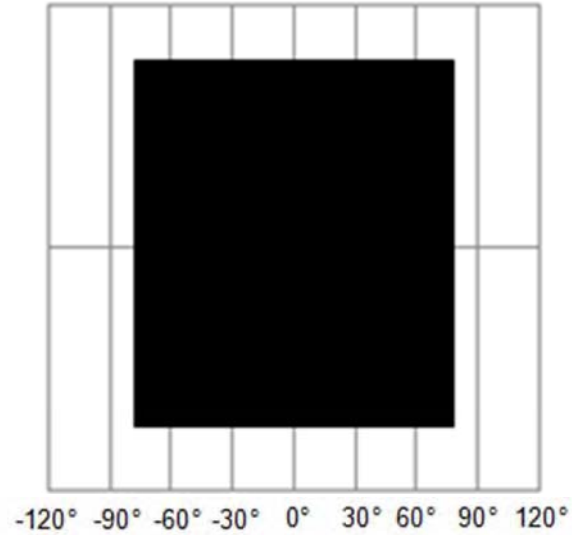


Factors	Influence on Angle of spray
Hole position (A)	37.6%
Number of holes (B)	4.0%
Angle of hole(C)	58.4%

Validation



Old design



Optimized design

Conclusion & Future Scope

- In this study, COMSOL along with Minitab has been used to achieve an optimized fluid flow through nozzle.
- Further study on flexible nozzles for certain endoscopic wound management requirements can be performed.
- Further, there many surgical procedures that need nozzles for irrigation and medicinal coats. These instruments can be optimized with approaches similar to what we have followed in this case.

Acknowledgements/Credits

Our sincere thanks to

HCL CAE Team

and

COMSOL Team

I’m HCL

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