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Design and Simulation of Injection Mold for a Laryngoscope

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Abstract*: *To overcome difficulty in airway management for elderly because in elderly due to loss of teeth, mouth will be collapsed and other old age factors. Troublesome intubation is a bad dream for an Anesthesiologist, especially so in an unforeseen difficult airway which will be harmful to the patient as well as Anesthesiologist particularly in rustic arrangement. In the present work we like to design and fabricate an indigenous camera based laryngoscope which is of ease, effectively accessible and reasonable technique for intubation. This video laryngoscope is integrated with the mobile which can be used as a video display device. It will improve the capability of airway management and will be free from many risk factors along with the existing laryngoscope. In the work mechanical model was design with Catia-V5 and the 3D model was imported into Ansys Software for FEM static structural analysis. Along with this a mold flow analysis is carried to obtain better results while fabricating an actual model

***Index Terms*: : Injection molding, structure analysis, Mold flow analysis**

I. INTRODUCTION

Early laryngoscope was designed for larynx examination and laryngeal activity. With the advancement of medical, laryngoscopy is not just utilized in laryngeal science, yet additionally broadly utilized in other clinical fields. From the initial indirect laryngoscope, as of not long ago the video laryngoscope, it most likely encountered a hundred and sixty years of development. Several researchers studied extensively on laryngoscopes, the researchers have made some medical experiments on patients using laryngoscope

Injection molding is a continuous process, usually the mold is forced with a high tonnage load to close and to get a cavity, and through it the molten plastic is infused. The nozzle then moves forward act as a piston which forces the molten plastic material into the sprue with a high injection pressure so that the molten material forced into the cavity. This process is called filling process. After filling pressure at the pit is maintained so that it adds required material to make up for the shrinkage as it gets cooled in the cavity. This pressure is holding pressure. The injection molded parts will have a high precision and surface finish.

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Wu-Lin Chen et al.[1] this paper demonstrates the method of determining the absolutely optimized separation of process parameter with only few repetitions of experiments when different quality indices are looked attentively for injection molding . Babur Ibrahim Sonat [2] in their study, the influence of the injection process parameter on warpage for multiple thickness value were inspected by applying taguchi method .they utilized ANOVA analysis for this study and results shown that the packing pressure is the most prominent parameter for the polycarbonate/ acrylonitrile butadiene styrene material. Shih-Chih Niah [3] in his paper he describes local mold temperature arrangement for a cooling system that can protect a frightful warpage in an non identical thermoplastic over for hand held communication devices. They proposed neutral axis theory to analyze the temperature diffusion in the cross section of a part and then warping trend were forecasted.

Zhenyu Zhao et al.[4] this paper shows that mold flow simulation can optimize mold design, it can simulate the whole production operation and determined that mold or forming in advance the caliber of present problems and thus focused to alter the design to modulate the process parameter to overcome the reiterate in genuine manufacturing of test mold or maintenance mold. Zhu Hao et al[5], in their work, they designed a cogent gating system. Simulation result of volume shrinkage, weld lines, fill time, sink mark index, location of air traps, are analyzed. the simulation increases the effectiveness of testing mold and also caliber of product. Huang Guijian et al[6] in this paper, the efficient design plan of feed system is fixed in view of the specific structure of the mold part. Afterwards the mold flow analysis of injection molding is carried into accomplishment on the basis of CAE analysis. Designed the entire mold structure and performance of the injection mold is asserted. Huang Guijian et al [7]this paper demonstrates the effectively designed the cavity layout and the efficient scheme of feed system is designed based on the CAE analysis on the two idea of feed system using mold flow simulation software. Then the comprehensive structure of injection mold is proposed. X.M.Cheng et al[8] they have examined on the correlation in the middle of warpage and injection molding process, by tailoring the process parameter and by designing cooling system and casting established on the simulated analysis .the efficient processing parameter have been obtained by the compared examination of the warpage with multiple gates, maximum flow pressure, shear to the mold, casting time and the freezing time.

Xue Bing Li[9] he has designed a injection mold for the structural configuration of plastic cup part. The mold was analyzed for the freezing time, the temperature on the wall of the loop tubes, clamping force, cavitations, filling time and validated by determining the pulling force, stripping force and the clamping force of the mold so that to calculate the auspicious injection parameters. Sasa Randelovic et al[10] they have proposed a detailed study on failure modes and effective analysis potentiality are illustrated in the case of injection molding method to fabricate the pipe fittings. In that sense predictable failures and their reasons are completely determined firstly using the finding from FEM analysis and experiment, as in the next step preventive actions found on this analysis were interpreted.

II. METHODOLOGY

2.1 Mechanical Structure Design of the Video Laryngoscope

Design is the criterion of plan or convection for the construction of an object or system. Designing frequently requires considering anesthetic, functional, economic and manufacturing measurements of both the design object and design procedure. It may include considerable experimentation, thought, modeling, interactive adaptation and redesigning. Through studies and references it can be concluded that laryngoscopy technique is very expensive and have many complications. It is needed to develop and altered device which is provided with endotracheal tube and camera.

In the attempt to reduce the exerted force on device from organs such as tooth and soft tissue lesion and to the development of alternative device by making video through camera that is transmission of video from laryngoscope to device (mobile, computer), to make this we need to design model to ease the camera installation and to pass endotracheal tube through it, we can achieve this by providing the separate channel like structure guide to endotracheal tube. We have designed the expected design using CATIA V5, the drafted drawing of video laryngoscope as shown below.

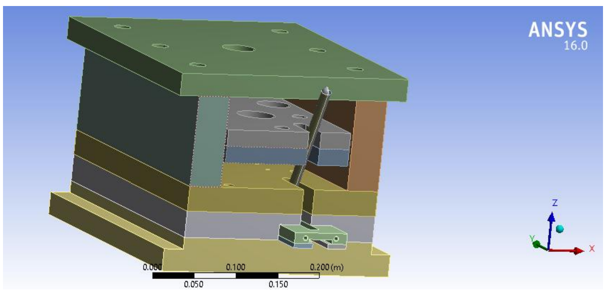
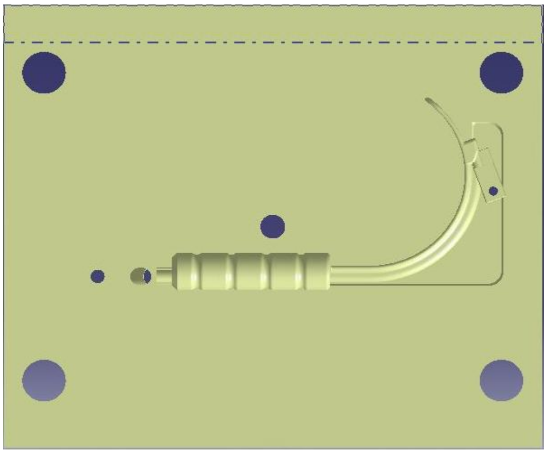
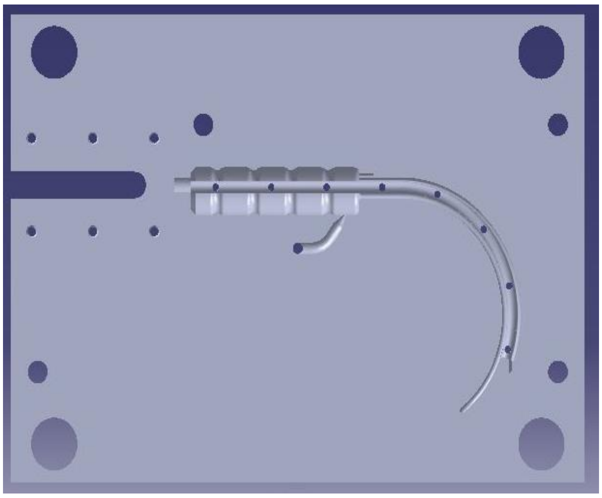


Figure. 1. Mold structure





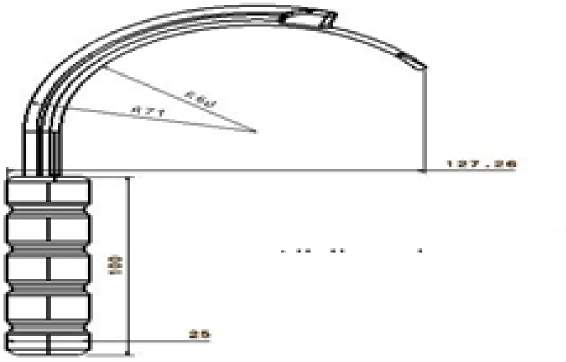


Figure. 2. Drafted view of video laryngoscope

2.3 Material selection

As our one of the major objective of our work is to reduce the cost by using material which act major role for disposal of laryngoscope so that cannot be reusable to avoid the risk of transmission of infection through antigens of pre patient, by all these factors and from literature survey the suitable material for requirement we taken as acrylic fibers. Reasons for selecting acrylic fiber are, it does not react with human body, easy for mass production, light weight, rigid thermoplastic, it is generally transparent in nature, low cost.

2.4 Force analysis

The forces applied on laryngoscope by the anesthesiologist are counteracted by the tissues of the pharynx which comes in contact with the blade. Figure 2 shows the force acted by the maxillary incisors, tissues and hand of the anesthesiologist on laryngoscope. The direction or way of action of the forces is not necessarily perpendicular to the surface of the blade handle.

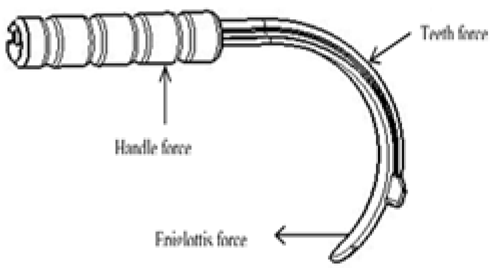


Figure 3: Force distribution on laryngoscope.

2.5 Finite Element Analysis.

The 3D model was imported into Workbench statics analysis module of ANSYS. The form a new part method was used to make the grid have a common node on the interface. When the grid is divided, the global grid size is set to 10mm. From the theoretical point of view, the position where the stress and strain are relatively high appears on the curved portion of laryngoscope, so the subdivision size of grid is set to 5mm, and the whole model was divided into 6134 grid cells, as shown in fig. 3.

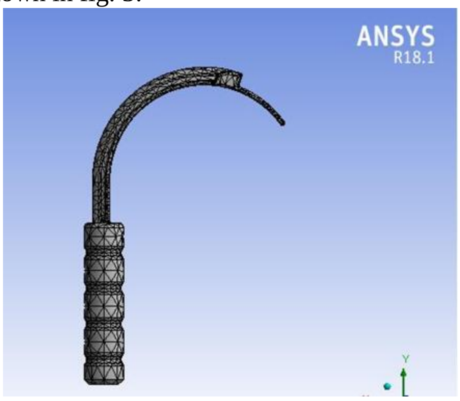


Fig. 4. Proximity and curvature type meshing

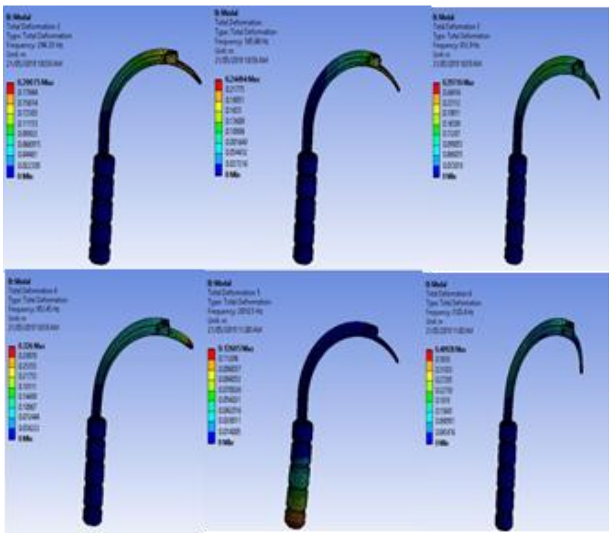


Figure 5: Modal analysis results of laryngoscope

For a finite element analysis it is necessary to assign some mechanical boundary conditions. According to the force of the video laryngoscope in human throat, it is equivalent to apply a vertical upward force to the top surface blade for finite element analysis and at the end of the blade we constrains is fixed with respect to the axis of rotation. The following fig. 4 shows the force distribution in video laryngoscope.

Each item has an interior frequency at which the object can naturally vibrate. It is necessary to study these frequencies at which the structure can act unpredictably. Here we carried modal analysis for Laryngoscope by ansys workbench 16.2, during

Table 1: Mode shape results

Mode shape no.	Frequency (Hz)
Shape 1	165.84
Shape 2	294.33
Shape 3	812.9
Shape 4	952.45
Shape 5	2018.5
Shape 6	2103.4

Analysis we have to specify the number of mode shape that we required and we have to specify fixed support. In our analysis for time being we have considered 6mode shapes. The obtained modal analysis results are as follows.

III. MOLD FLOW ANALYSIS

A period of time in the injection cycle where the speed of the machine screw is utilized to fill up the mold. The filling time begins towards the start of the injection cycle and finishes at the speed/pressure switch-over point. The filling time corresponding to the minimum injection pressure is the rational filling time. The filling time is too short which implies that flow rate (shear rate) is excessively high and extremely high injection pressure is necessary to fill up the mold. In the event that the filling time is excessively long, the cooling impact will amplify the melt viscosity which require high injection pressure. If the injection time to fill the cavity is too short, it should have high injection velocity, in this way, should have too high pressure. When the injection time is too long, the molten temperature diminishes, viscosity builds, in this way it increases the trouble to fill and need more injection pressure.

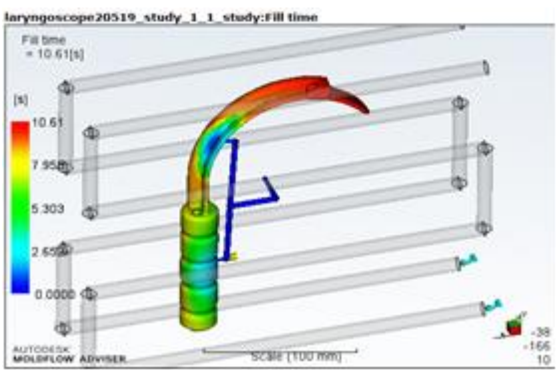


Figure. 5 Fill time

There is a lowest point in the center of the curve and this point is the optimal filling time which is relating to the most minimal injection pressure

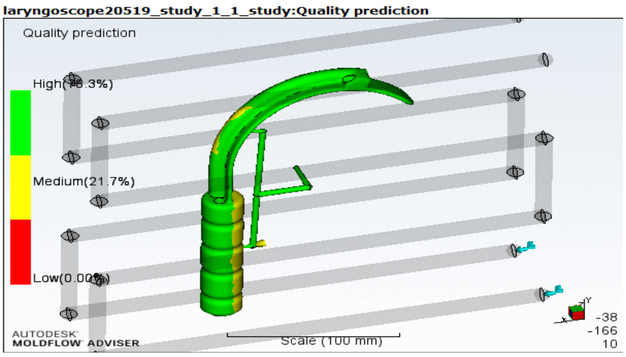


Figure. 6 Study Quality production

The Quality result gives a sign of how the general standard of your object will vary as the input variables temperature of mold, injection time vary and melt temperature. This quality measurement is gotten from the outcomes got for least flow front temperature, maximum shear rate, injection pressure, maximum shear stress, maximum cooling time and maximum shear rate under a given arrangement of molding conditions

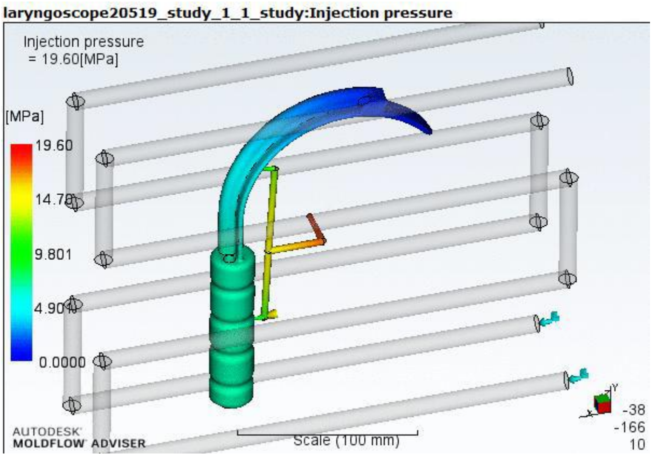


Figure 7 Injection Pressure

The pressure that is put in to the molten plastic by the ram throughout the injection phase, making the material to flow. Injection pressure is the pressure that makes the molten material to stream, and it might be approximately estimated by a transducer situated in the hydraulic line or in the spout or nozzle. It does't have a steady value but increases as mold filling becomes more compound. There is a direct connection between injection line pressure and injection pressure.

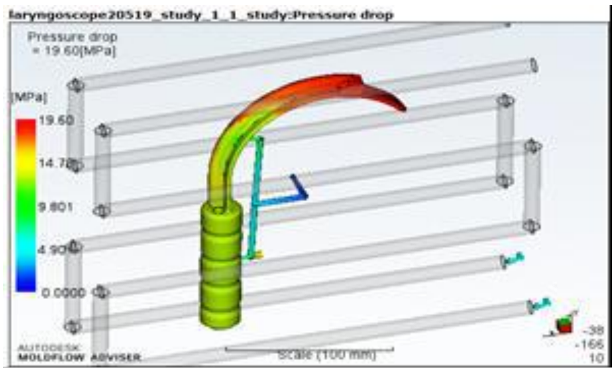


Figure. 8 Pressure Drop

As molten plastic flows into the various sections of the injection molding machine and the mold, due of drag and frictional impacts there is a drop of the applied pressure at the flow front of the plastic. Furthermore, as the plastic hits the walls of the mold, it starts to cool, increasing the viscosity of the plastic requiring extra pressure to push the plastic

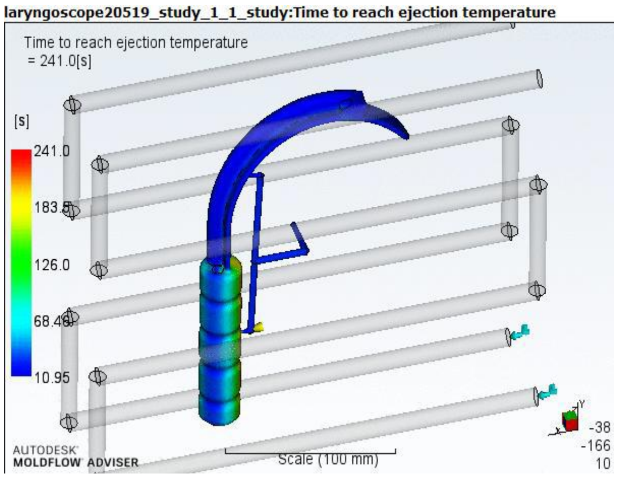


Figure. 9 Injection Temperature

The Time to arrive ejection temperature, cold runner result is produced from a Cool analysis, and demonstrates the measure of time taken for all components, considering the cold runner, to freeze to ejection temperature. Towards the beginning of the analysis (time zero), all components, including the cold runner, are suppose to be charge with material at the melt temperature.

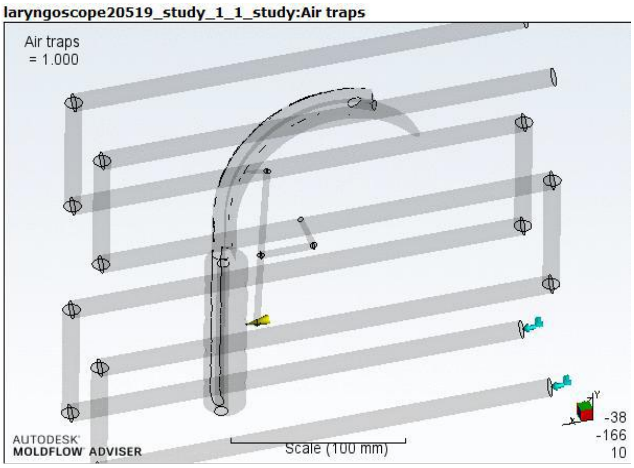


Figure. 10 Study air traps

An gas or air bubble that has been trapped against the cavity wall, or trapped by meeting flow fronts, which results in surface imperfection on the plastic component. It can be counteracted by changing the thickness of the component or the gate location. Vents are provided at the location where air trap occur.

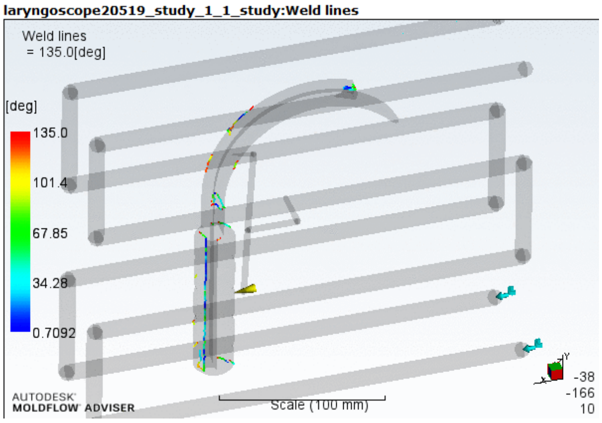


Figure. 11 Weld Line

A frailty or visible flaw generated when two or more flow paths join in the time of filling. Weld lines can be brought about by openings or inserts in the mold part, multiple injection gates, or changing wall thickness where "race tracking" or hesitation can happen. If the inconsistent flow fronts have cooled ahead of joining, they may not combine well, which results a frailty in the molded component. A color change, line, and/or notch can also occur.

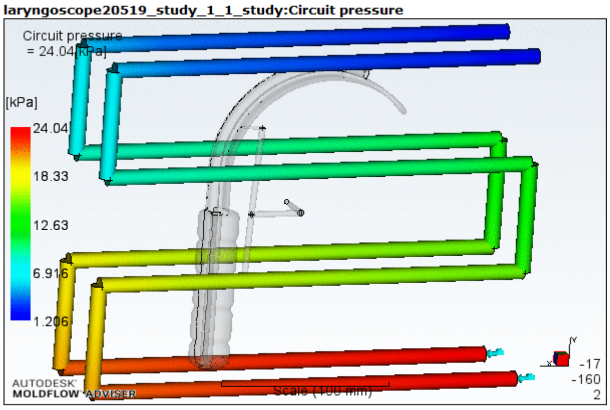


Figure. 12 Circuit Pressure

The Circuit pressure result is produced from a Cool analysis to demonstrate the appropriation of pressure along a cooling circuit, averaged above the cycle. The pressure inside the cooling circuits ought to remain uniformly distributed from the outlet circuit pressure to the inlet circuit pressure. Huge pressure fall in the cooling circuits are created by cooling issues, such as the baffle or the bubbler dimensions being excessively little.

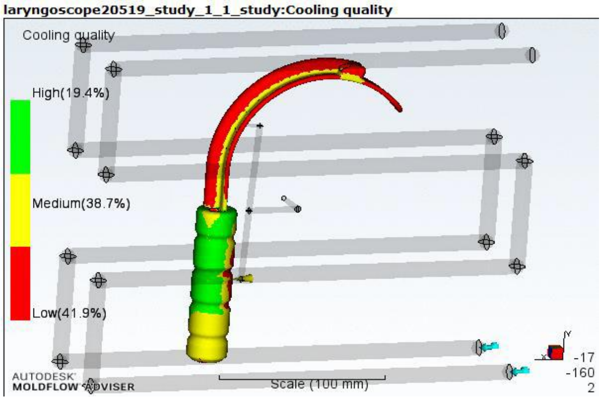


Figure. 13 Cooling Quality

The Quality result gives a sign of how the entire quality of your component will differ as the input fluctuates melt temperature, injection time, and mold temperature vary. This quality estimate is gotten from the outcomes acquired for injection pressure, maximum shear stress, minimum flow front temperature, maximum shear rate, maximum cooling time under a given arrangement of molding conditions.

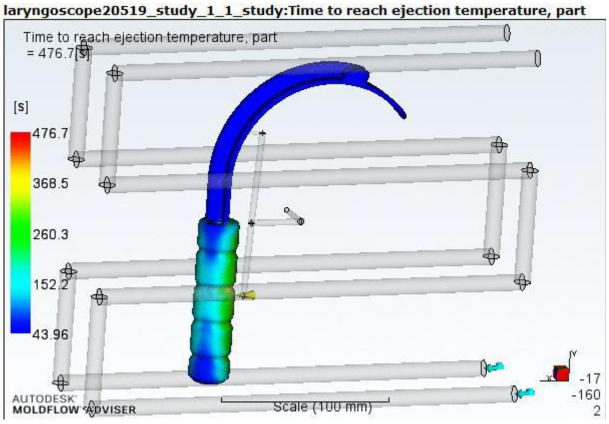


Figure. 14 Time to reach injection temperature

The Time to outreach ejection temperature, part (profile) result is a Dual Domain result which is created by a Cool analysis and demonstrates the time need to reach the ejection temperature.

Clamp force estimate during packing using:	
20% of the injection pressure	2.248 (tonne)
80% of the injection pressure	8.993 (tonne)
120% of the injection pressure	13.489 (tonne

Maximum temperature, part	171.3 (C)
Minimum temperature, part	49.6 (C)
Average temperature, part	69.7 (C)
Mold exterior temperature	42.3 (C)
Cycle time	35.00 (s)
Percentage frozen (at end of cycle)	49.38 (%)

Actual filling time	10.61 (s)
Actual injection pressure	19.603 (MPa)
Clamp force area	56.2519 (cm^2)
Max. clamp force during filling	3.654 (tonne)
Velocity/pressure switch-over at % volume	99.02 (%)
Velocity/pressure switch-over at time	10.42 (s)
Estimated cycle time	297.83 (s)
Total part weight	37.357 (g)
Shot volume	50.3746 (cm^3)
Cavity volume	48.3793 (cm^3)
Runner system volume	1.9953 (cm^3)

Carrying out analyzing the laryngoscope by injection time, injection pressure, clamping force and injection temperature in mold flow And when we compare the experimental results and analysis results it found to be analogous, such that we found injection time of the laryngoscope mold is 9 sec and experimental results shows 10.61 sec. clamping force we got 3.654 ton and experimentally we got 3.365 ton, like that we got injection pressure of 19.60 Mpa and injection temperature 221.7 °c by mold analysis and experimentally we found 19.306 Mpa and 230°c respectively.

IV. CONCLUSION

The results show that the various calculations of theories and advantages in mature CAD and CAE software, taking the mold design, product design and experimental verification before manufacturing into a comprehensive consideration, can reduce the cost on material and time caused by some unreasonable design, can increase the reliability of the product design. It can help avoid the defects on designing, shorten the cycle for producing The method here for design and checking analysis to this injection mold can provide some reference during the injection processing. But there are still some deficiencies in the study of some parameters for this mold. So further research must be needed in some related aspects.

The results of the experiments demonstrated sequential phenomena leading from the mould temperature distinction to injection moulded part warpage. On the off chance that the mould temperature isn't same on two mould walls this prompts to thermokinetical asymmetry of melt flow. Best location of the gate got from the analysis has been chosen for manufacturing.

- ❖ The present gate size and location is finalized after balanced filling and other factors. Computer simulation improves the engineer's ability to accurately predict the optimum process conditions.
- ❖ The extent of shrinkage and warpage was determined.
- ❖ Achieving balanced cooling is not difficult when using the appropriate injection moulding simulation software.
- ❖ The Cooling channel provided is sufficient for over work

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