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Design, Analysis and Optimum Selection of Mold Runner Section by using AHP (Analytical Hierarchy Process) method

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Abstract - Injection Molding is a manufacturing process for plastic parts. For designing a mold for injection molding process used various parameters for proper design. Runner is a one of the effective parameter for product quality output. Runner has different cross sections like square, full round, triangle and hexagonal. Here we design mold using designing software CREO 2.0. and also simulate in CREO SIMULATION. There are various cross sections available for the runner of mold so the best runner cross section is the criteria for the optimization. Here we select the runner cross section by using the analytical hierarchy process.by using this method we arrived at particular solution of the multivariable problem and this method gives the optimum result. For injection molding mold we select various variables for the AHP method like maximum stress, maximum principle stress, maximum displacement and volume to be removed by machining process.

I. INTRODUCTION

Injection molding process is a widely used mass production of plastic components. For injection molding Process Mold is a main Component of the Process. Mold Are Available in Different Sizes and Different Types like two plate Mold, Three plate mold etc. Mold Design is based on the Size of Components which we want to Manufacturing. Form Component Design We Create Cavity in The Mold As Using Designing Parameters. In mold We Create the path For Fluid Flow Through injection Unit to Mold Cavity, Which is known as a Runner.

The various literature for the mold design For Mold design are listed as follow for mold design (G. Menges, P. Mohren, 1993), analysis (17 X. Chen, Y.C. Lam, D.Q. Li , 1999), optimization Injection molding design (Pandelidis, Q. Zou,1990),For Quality Monitoring of injection molding (B.H. Min 2002),Optimization technique and Analytical Hierarchy Process (Saaty, TL 1977), (Saaty, TL 1980). AHP based on decision modeling (D. Liu, G. Duan, N. Lei, J.S. Wang 1999).

II. MOLD DESIGN

Mold design is a process of Designing of mold dimensions and selects the data from the standard design data book. The runner is as specific which follows the Path for the material to flow.The section of the runner is the variable, as we change the different cross section. The Flow Diagram Shows the process of mold Design. In the Flow Diagram Shows Main Objective Function is Stress Reduction and Secondary is improving Quality.

The Design variables for mold are Different Shapes of Runner and location of runner. Constrains are Dimension of Mold and Runner size. By using those three parameters we design the mold. After design of mold by using the analysis of design we get resultant effects like principal stress, deformation, von-misses stress on mold. From that wemodify the design and again Analysis is to be carried out. If stresses will Reduces then design will perfect for the Manufacturing. If stresses will be more then redesign the mold runner section.This procedure for the design of the mold is well listed in the flow chart. We select the proper method for that and arrived at the optimum solution. Flow Diagram of Mold Design Process is shown in fig.1

The fig. 1 shows the flow diagram for the design of the mold runner for the multivariable problem, we select the number of variable for the different cross section of the runner and if the stress would not minimize then we redesign the mold runner cross section.

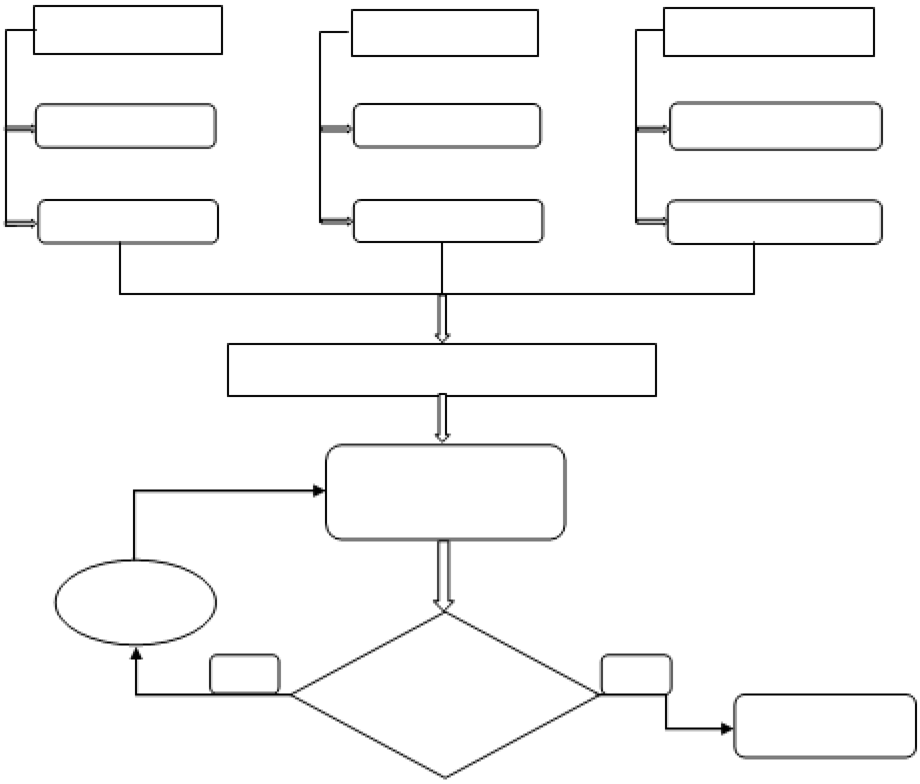


Fig. 1 Flow diagram of Mold design Process

A) MOLD RUNNER DESIGN

Runner is our main focus area for the design of mold. Runner of Mold is most Effective Parameter for the Mold Design because it forms the cavity in the mold and create the stress concentration in the mold. Runner is Different in the shapes like Square, Hexagonal, Rectangle, Triangle, Circular, and Semi-circular etc. For Different Shapes of Runner the Effect of Stress is different. Our work is Focus on Selection of shape of Runner section. For Design of runner we want to know the diameter of runner. Runner Diameter is Calculate from the following Formula.

$$D = \frac{\sqrt{W * L}}{3.7} \qquad \ldots (1)$$

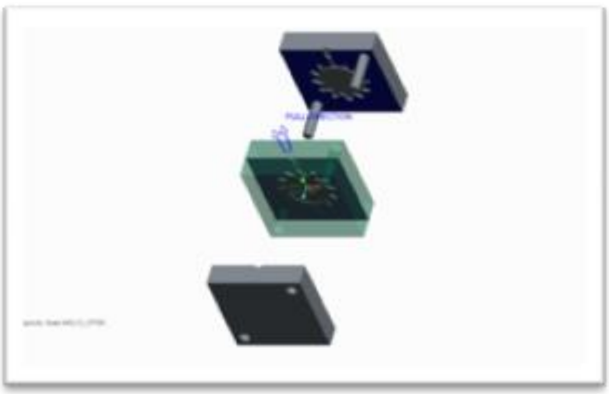
Where,

D= Diameter of runner (mm),

W= Part weight (gm.),
L=Runner length (mm).

For mold design, we did calculations for all dimensions. The length, width, and thickness of the mold are selected from the Standard Design Data book.By using all the dimensions we Designed mold in Designing Software Creo 2.0. The 3D View of Mold is

Fig. 2. Mold Design 3D view.

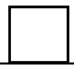
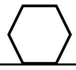
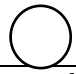
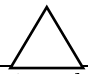


Shown in the Figure 2.

B) VARIABLE USING FOR RUNNER DESIGNING

To design the mold various variables are available for the design we select the section of the runner as the variable. The various section of the runner are listed in Table 1.

Table 1. Cross Section of Runner

			
Square Cross Section	Hexagonal Cross Section	Round Cross Section	Triangular Cross Section

By using this cross section for the runner we design the four different cross section runner as shown in Table 1.

C) ANALYSIS OF MOLD

We make the design of Mold for above Four Cross Section of Runners. After Mold Design, We check its feasibility by Using Simulation Software. For that we use Creo simulator Software for Analysis of mold. The analysis are Shown in Below Figures. By carrying the analysis in software we get the software results of the various stresses for the different cross section area of runner and the stresses Value are listed in table 4.

For the various cross section of the runner the analysis of the mold is carried out and the results are listed in following figures.

[1] ANALYSIS OF THE SQUARE CROSS SECTION RUNNER

We select the first cross section of the runner as the square and analysis of the mold is to be carried out for the square section of the runner and the various result of the mold are listed for the further calculation

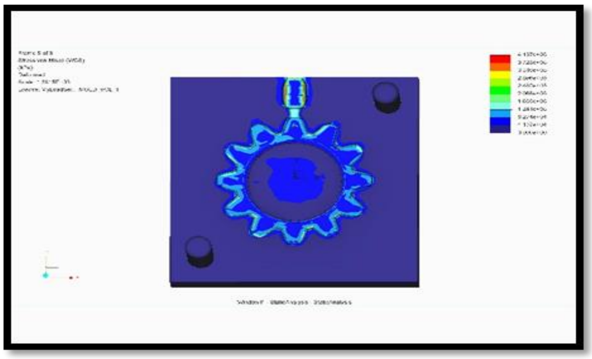


Fig 3-a Max. stress for upper mold

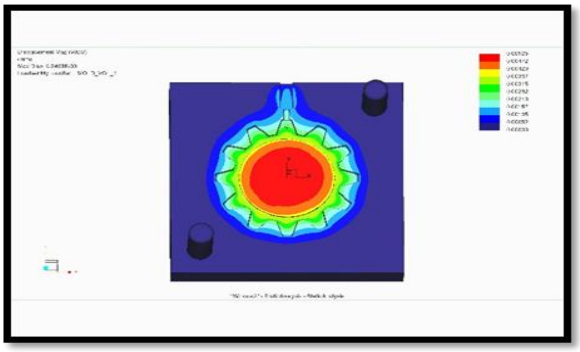


Fig 3-b Max. principal stress for upper mold

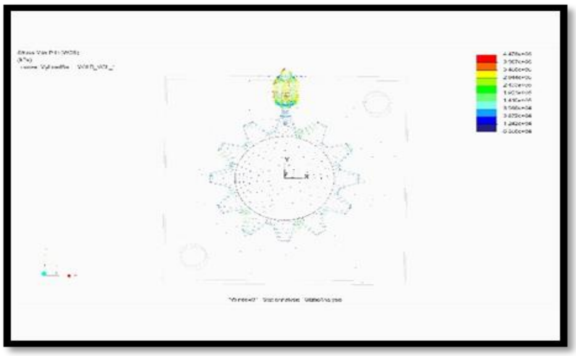


Fig 3-c Max. displacement for upper mold

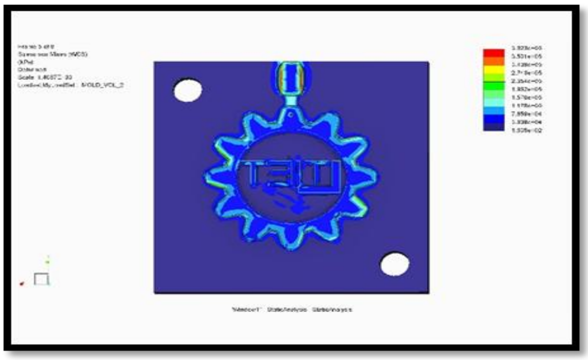


Fig 3-d Max. stress for lower mold

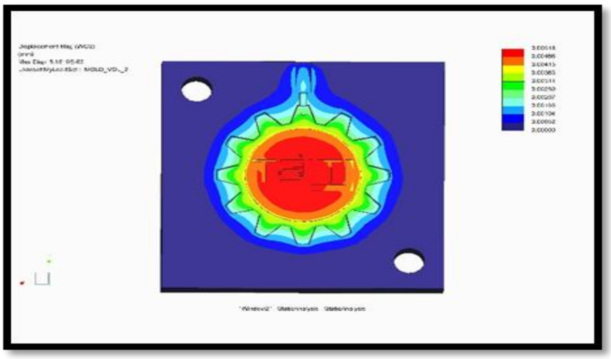


Fig 3-e Max. principal stress for lower mold

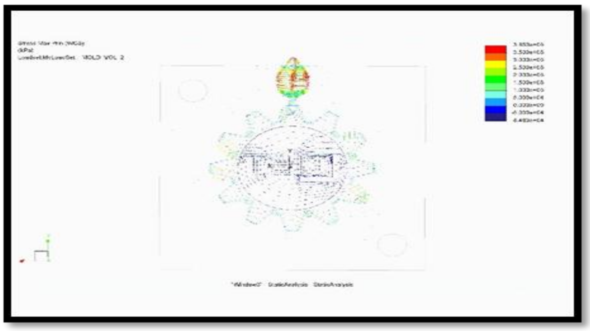


Fig 3-f Max. displacement for lower mold

[2] ANALYSIS OF MOLD FOR HEXAGONAL CROSS SECTION.

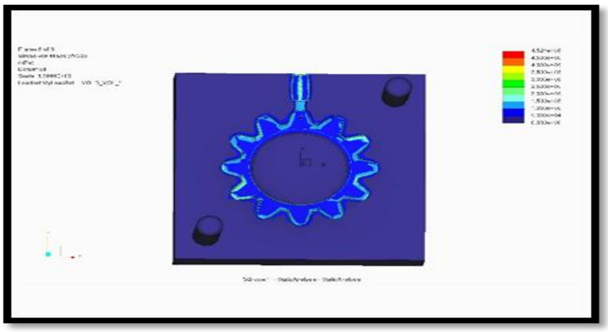


Fig 4-a Max. stress for upper mold

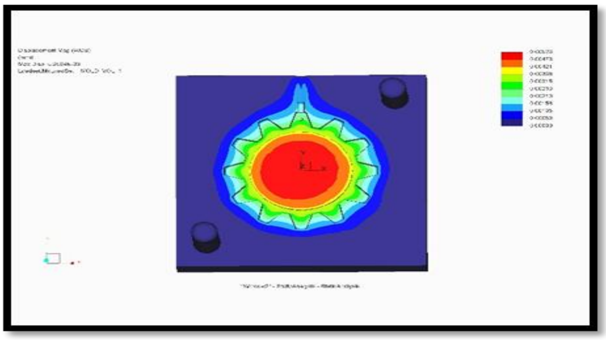


Fig 4-b Max. principal stress for upper mold

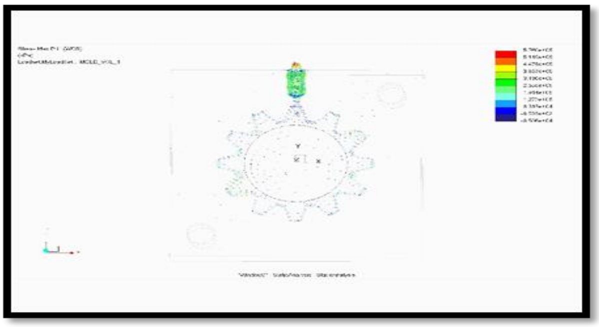


Fig 4-c Max. displacement for upper mold

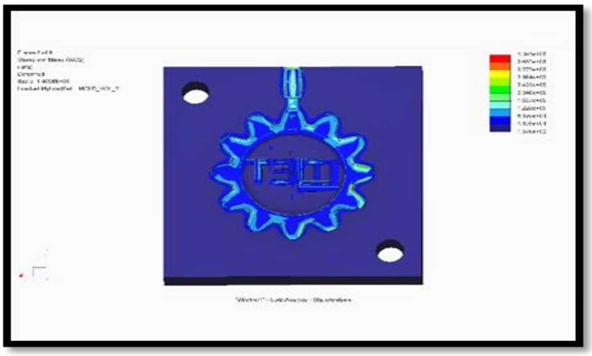


Fig 4-d Max. stress for lower mold

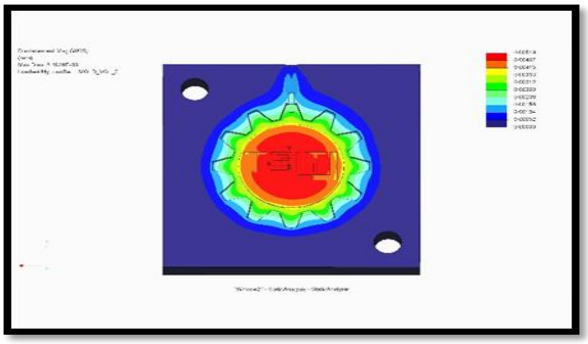


Fig 4-e Max. principal stress for lower mold

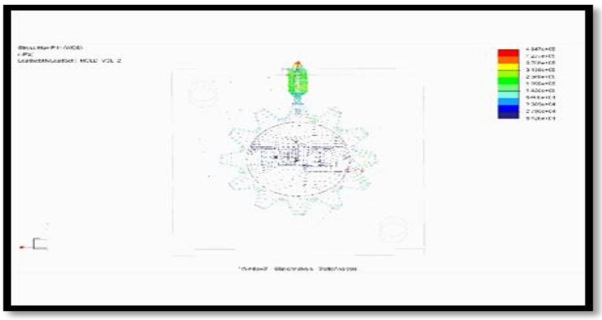


Fig 4-f Max. displacement for lower mold

[3] ANALYSIS OF MOLD FOR CIRCULAR CROSS SECTION.

Fig 5-a Max. stress for upper mold

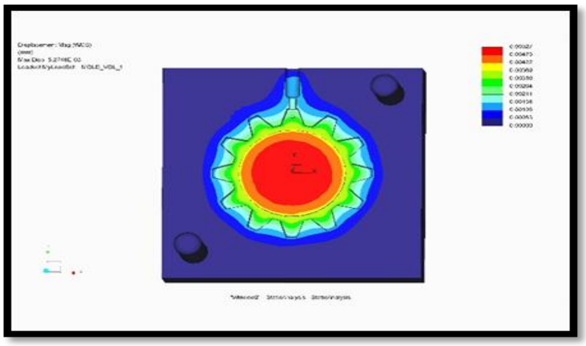


Fig 5-b Max. principal stress for upper mold

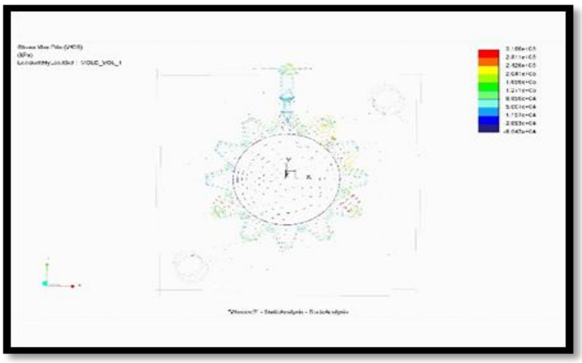


Fig 5-c Max. displacement for upper mold

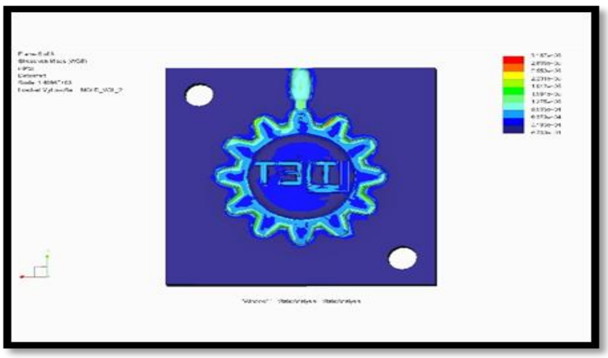


Fig 5-d Max. stress for lower mold

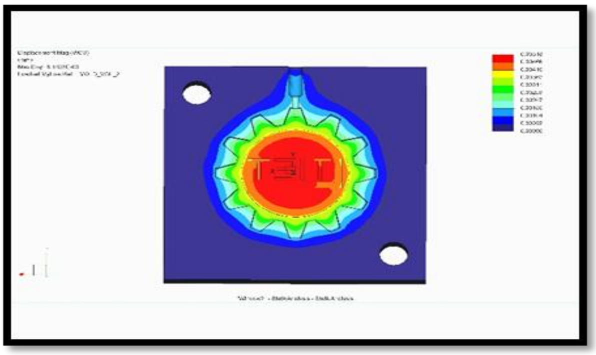


Fig 5-e Max. principal stress for lower mold

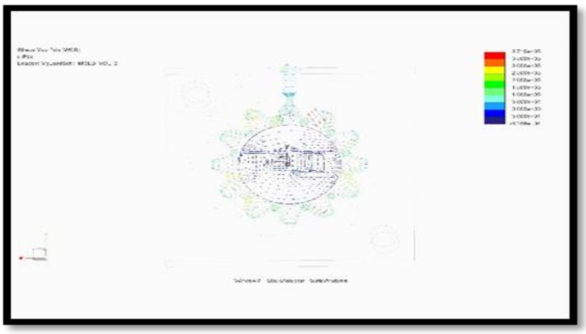


Fig 5-f Max. displacement for lower mold

[4] ANALYSIS OF MOLD FOR TRIANGLE CROSS SECTION.

Fig 6-a Max. stress for upper mold

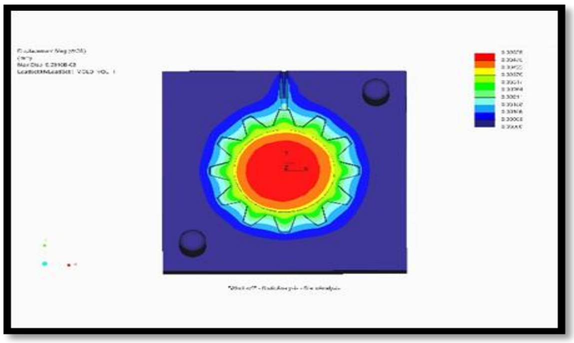


Fig 6-b Max. principal stress for upper mold

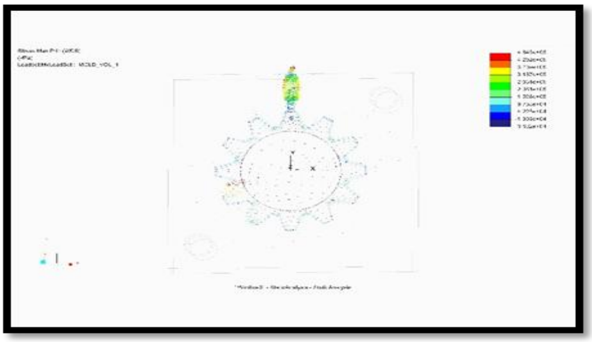


Fig 6-c Max. displacement for upper mold

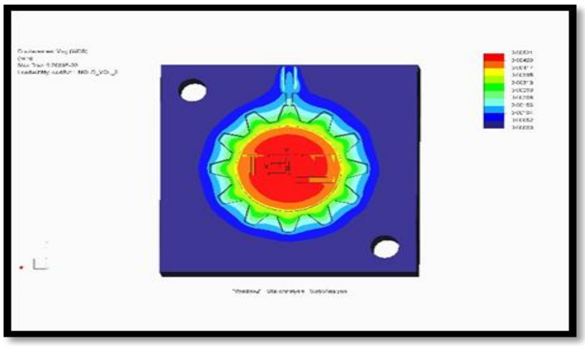


Fig 6-d Max. stress for lower mold

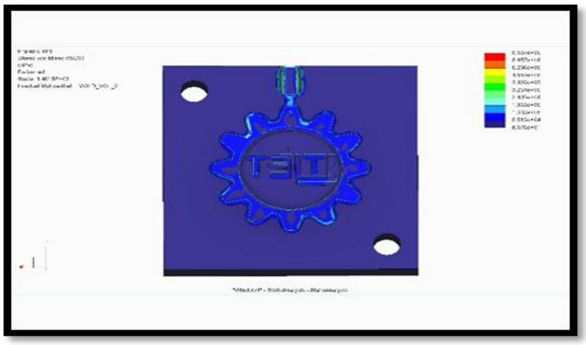


Fig 6-e Max. principal stress for lower mold

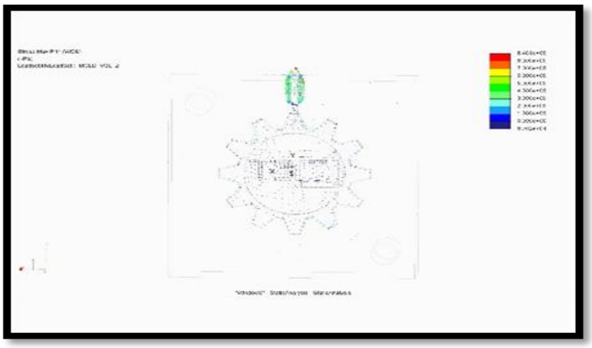


Fig 6-f Max. displacement for lower mold

III. OPTIMIMUM SELECTION OF RUNNER CROSS SECTION.

We have various cross section for the design of the mold as discuss earlier, the problem arises for the optimum selection of these runner cross section. This is the case of multi variable modelling problem. For that purpose here we use Analytical Hierarchy Process as Multiple Criteria Decision Making Method. This Method is developed by Prof. Thomas L. Saaty.In this method Derived Ratio scale from Prepared Comparisons. Its inputs are obtained by actual Measurement value as a Force, Stress, and Weight etc. and by subjective opinion as preference.

We Make Hierarchy algorithm for problem formulation. Then make pairwise comparison and Rate them and calculation for AHP to obtained final result. The weight

In Table 2. Show the Ranking Scale for Analytical Hierarchy method. In that table the Importance given to Our Criteria is selected. For Maximum Importance give value From Above 5 Up to 9. For Intermediate 3 & 4, and For Similar importance Gives 1 as a value

Table 2. Ranking Scale For AHP Method

Numerical Ratings	Judgments
1	Equally important (preferred)
3	Moderately more important
5	Strongly more important
7	Very strongly more important
9	Extremely more important

Table 3. Pairwise comparison Of AHP method

	MAX. STRESS	MAX. DISPLACEMENT	MAX. PRINCIPLE STRESS	VOLUME
MAX. STRESS	**1**	**3**	**2**	**5**
MAX. DISPLACEMENT	**1/3**	**1**	**1/3**	**4**
MAX. PRINCIPLE	**1/2**	**3**	**1**	**1/2**
VOLUME	**1/5**	**1/4**	**2**	**1**

Table 3. Shows the pairwise comparison for our decision making Criteria. We Gives four criteria As Maximum Stress, maximum Displacement, maximum Principle stress and volume of Section. From Analysis We Get the Values of maximum stress, maximum principle stress and maximum Displacement for above Four Sections.

Problem for Selecting Multi variable Decision Making process, we make Hierarchy algorithm for problem formulation. Then make pairwise comparison and Rate given them and calculation for AHP to obtained final result.

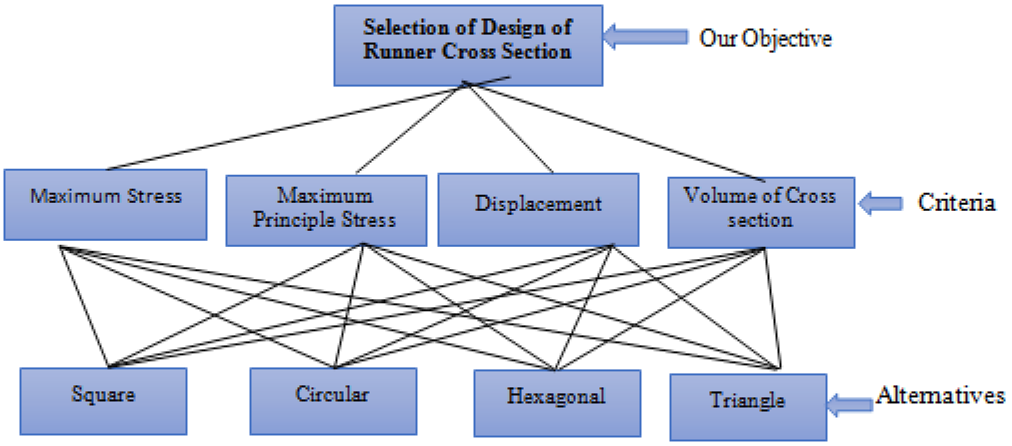


Fig.7. Hierarchy algorithm for selection of runner cross section.

RESULT OF AHP METHOD

Table 4. Result of AHP method for section of mold.

CROSS SECTION	FINAL VALUE BY AHP(FIRST HALF SECTION)	FINAL VALUE BY AHP(SECOND HALF SECTION)
Square Section	$3.074*10^5$	$2.745*10^5$
Hexagonal Section	$3.424*10^5$	$3.029*10^5$
Circular Section	$2.103*10^5$	2.347*105
Triangular Section	$2.971*10^5$	$4.969*10^5$

Our Objective

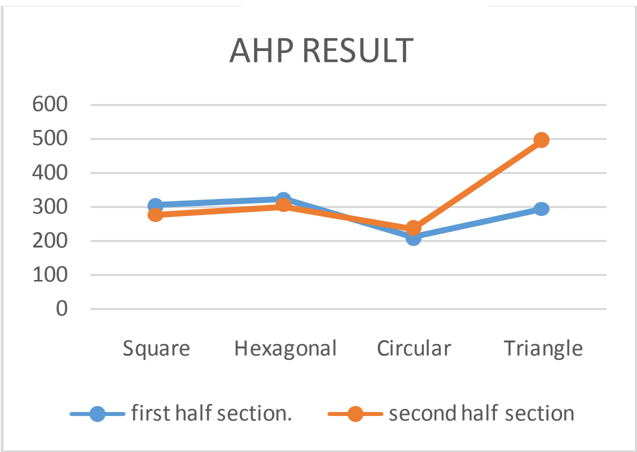


Fig. 8 result of various different cross section runner.

The results of AHP Method are entered in the graph Graphical representation of analytical values are shows in the Figure 8.From AHP method calculation for different four sections of runner the Circular section have all value minimum so for Manufacture of mold Circular Section runner give optimum Result. By using AHP method for multiple Criteria Decision making we get the value AHP Solutions for Four Different Sections as Shown in the Table 4, in Table 4 the Values are listed for both section of mold. For final selection of mold Runner section is based on the values of the AHP solution. For problem of maximization we select the maximum Value and for Minimization problem we select minimum value of theAHP solution. The Graphical Representation of the AHP solution Value shows in the Figure 8.

FINAL RESULT AND DISCUSSION

By using Analysis of Data and Observing the table 4 For Both Section Of moldwhich Shows the analytical values.In that for first section of mold the Stress in Hexagonal Cross section Runner has maximum and for Circular section the value is minimum. For second half section the maximum value in triangular section and minimum in the circular section. Displacement is in the maximum in the triangle section and minimum in square cross section of runner.

For Second half section the maximum in the hexagonal section and minimum in the circular section. Maximum principle stress in the hexagonal has to maximum and in circular has minimum value for first section of mold and for second half section the triangular section Has maximum and Circular Section Has Minimum Principle Stress value. Volume of runner section is lower to

IV. CONCLUSION

Our aim is to minimization of all the Parameters we are select as minimum Value of the AHP solution. So we select the circular section, because for the circular section AHP method we get best result.

Now a day most of the decisions are to be taken in complex Work situation. Most of them are required Specific value System and need of experts Knowledge for solution of problem. The Solution By using their Knowledge and Experience is Not Precise. Software Analysis Results Will does not get proper solution. So AHP is the technique which enables to decision making by use of Ranking, Pairwise Comparison and Synthesis. By use of that select optimal solution of problem.

In this paper we solve the Engineering Problem by use AHP Method as Multi Criteria Selection Process.

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