Assessment of Optimum Molding Conditions of Injection Molding Process by Discrete Optimum Technique

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ABSTRACT

The numerical analysis methods have been developed to evaluate the behavior of the resin during a processing of the injection molding. These analysis codes adopt time incremental method to calculate a unsteady flow. In this study, the numerical method is developed to estimate the molding condition of the injection molding using the conventional fluid analysis. This numerical method is that adding a genetic algorithm of an optimum analysis to calculate the optimum conditions modifies the conventional fluid analysis for the injection molding. Finally, we aim to develop the global fluid analysis system, which can automatically estimate the molding conditions of the injection molding by means of an integration of the above optimum methods.

1. Introduction

The injection molding is the most popular processing method for the among various polymer processing method. In this processing method, a behavior of the materials cannot be observed since this processing is performed in metal die. However this behavior affects not only material properties and a dimension stability of the products but also a defects of the products such as the weld and the sink.

The numerical analysis methods have been developed to evaluate the behavior of the resin during a processing of the injection molding. These analysis codes adopt the time incremental method to calculate an unsteady flow. The time incremental method estimates the final state of a flow pattern by the initial condition and step-by-step calculation. According to this numerical method, the optimum conditions of the injection molding must be decided by a large number of repetitions of the fluid analysis. Thus, the numerical analysis methods, which can estimate effectively the

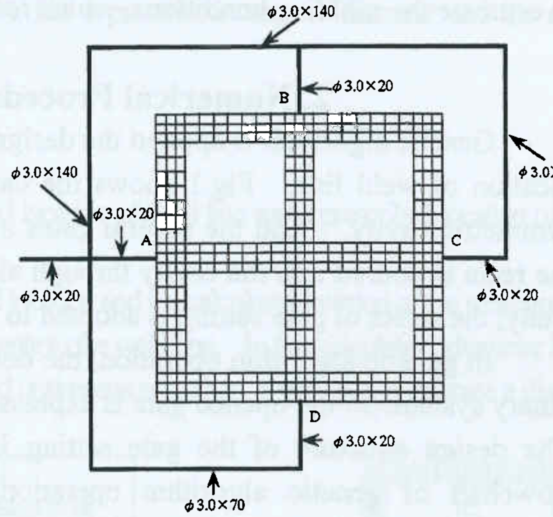

Fig.1 Analysis target of cavity

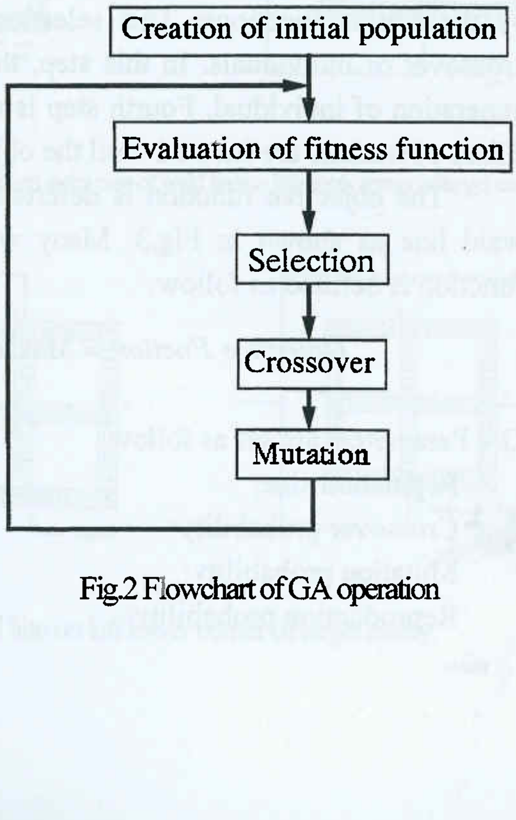

Fig.2 Flowchart of GA operation

optimum initial conditions of the injection molding, have not been developed to the present.

The aim of this study is the investigation of an optimum analysis method to estimate the molding condition. We have developed the numerical method, which can estimate the molding condition of the injection molding using the conventional fluid analysis. This numerical method is that adding an algorithm of an optimum analysis to calculate the optimum conditions modifies the conventional fluid analysis for the injection molding. Using proposed optimum method; we try to estimate the molding conditions, which realize a weld line at a prescribed location.

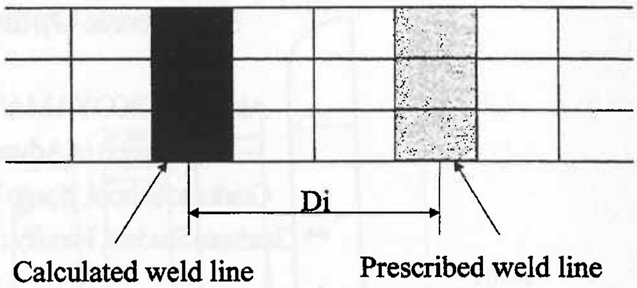

Fig.3 Objective function of weld line

2. Numerical Procedure of Optimum Analysis

Genetic algorithm is applied the design of the runner gate setting to realize the control of location of weld line. Fig.1 shows the cavity of target. This cavity is the thin shell and symmetric cavity. And the several gates are set on a center of each sides of this target. If the resin is poured into the cavity through all gates, many weld lines arise in product. In this study, the select of gate setting is adopted to control the location of weld line.

In genetic algorithm operation, the design parameter is expressed by the series of bit on binary system. So the opened gate is expressed as '1', and the closed gate is represented as '0'. The design structure of the gate setting is expressed by four-bit code. Fig.2 shows the flowchart of genetic algorithm operation. This operation essentially consists of four individual operations. First step is generation of initial population by random number. Objective functions of all individual are calculated by fluid analysis and fitness functions of all individual are evaluated by linear scaling method. Second step is selection of the individuals by the fitness functions. This selection is performed by roulette selection. Third step is crossover of individuals. In this step, the single point crossover is adopted to generate next generation of individual. Fourth step is mutation operation to avoid local optimum condition. These operations are iterated until the objective function satisfies prescribed optimum value.

The objective function is deferent length between calculated weld line and prescribed weld line as shown in Fig.3. Many weld lines might arise in target cavity. So objective function is defined as follow.

$$Objective\ Fnction = Max\{D1, D2, D3, D4\}$$

GA Parameters are set as follow

Population size:	5
Crossover probability:	60%
Mutation probability:	3%
Reproduction probability:	30%

3. Numerical Results

Figure 4 shows the numerical results of the optimum gate selection which is realize to control the location of weld line in case of occurrence of weld line on right upper corner of cavity. Two candidates of optimum gate selection are selected by GA operation. And it is clear that these gate selections realize the best location of weld line. Figure 5 shows the numerical results of the optimum gate selection which is to arise the weld line on left corner of target cavity. It is also considered that these gate selections is effective. From these results, the proposed optimum operation is great candidate for optimum design method of these discrete problem such as the selection of the injection gate.

Next, this proposed operation is applied to another design problem which have continuous varied design parameter. The analytical object is a rectangular thin plate with two injection gates as shown in Fig.6. In this figure, R_1 and R_2 are runners D_{R1} and D_{R2} are diameters of each runner. The optimum diameters of the runners is calculated by the proposed operation.. So, runner R_1 has a prescribed value of diameter and the design parameter is adopted as

$$r = \frac{D_{R2}}{D_{R1}}$$

The objective function is a distance between a calculated location of weld line and a prescribed location of weld line as same as previous problem.

Figure 7 shows the relation between the prescribed location and the calculated location of the weld line. In this figure, the location indicates a distance from the left gate to the weld line. In this calculation, diameter D_{R1} of runner R_1 is fixed at 5.0mm. It is clear that the proposed optimization method is effective to estimate a diameter of the runner for the control of the location of the weld line since this relation have a linearity as shown in this figure.

Figure 8 shows the numerical results of the optimum diameters of the runner. In the case that the location of the weld line is near by left gate, the diameter of runner R_2 is relatively small and is not affected

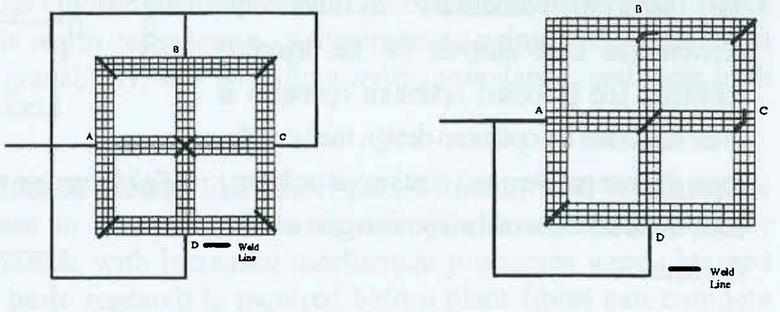

Fig.5 Optimum gate selection in the case of weld line on left upper corner of target cavity.

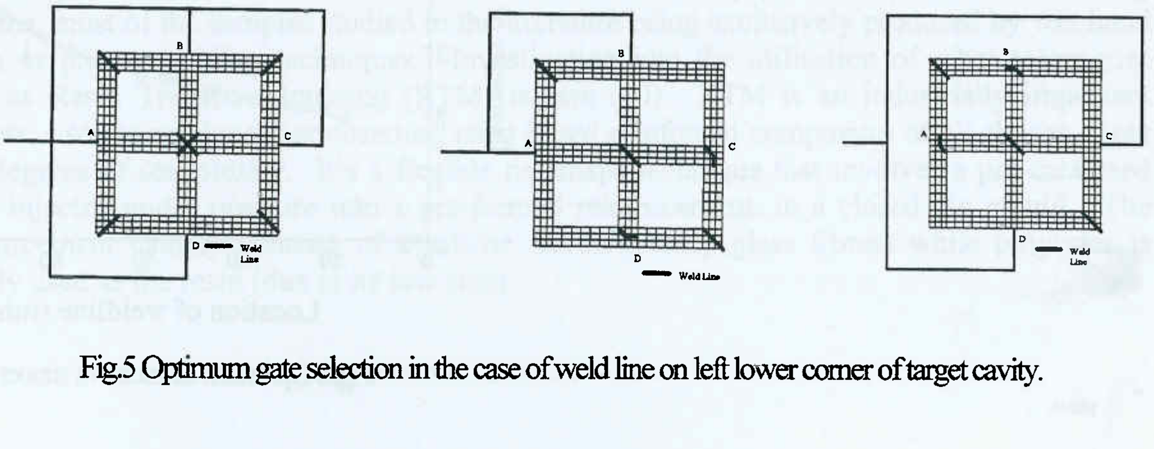

Fig.5 Optimum gate selection in the case of weld line on left lower corner of target cavity.

by the location of weld line. But when the weld line is allocated near by a center of the cavity, the diameter of the runner calculated location of weld line R_2 become large and is sensitive to the location of weld line. This result is not able to get without a numerical technique. Therefore, it can consider that the proposed numerical procedure has a possibility to become the numerical technique for the designing of the injection molding.

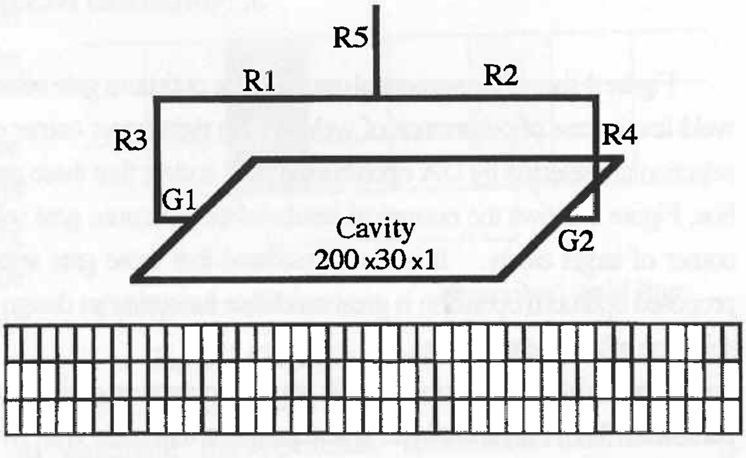

Fig.6 Cavity of analysis target to decide optimum runner diameter

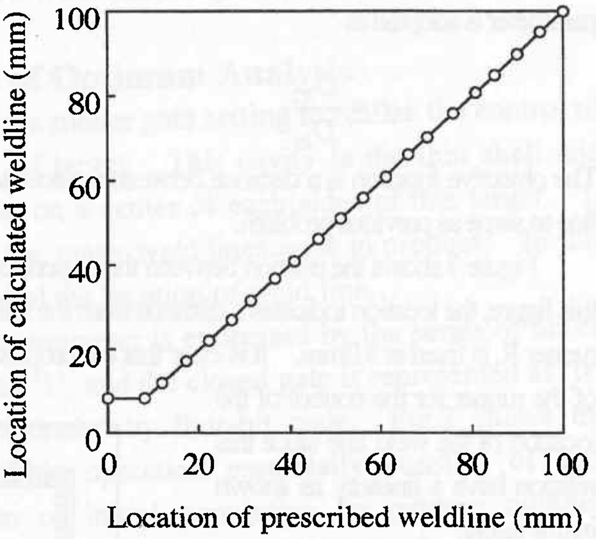

Fig.7 Comparison between calculated and prescribed weld line

4. Conclusion

The numerical method is developed to estimate the molding condition of the injection molding using the conventional fluid analysis. This numerical method is that adding a genetic algorithm of an optimum analysis to calculate the optimum conditions modifies the conventional fluid analysis for the injection molding. The proposed optimum operation is great candidate for optimum design method of these discrete problem and continuous problem such as the selection of the injection gate and its diameter.

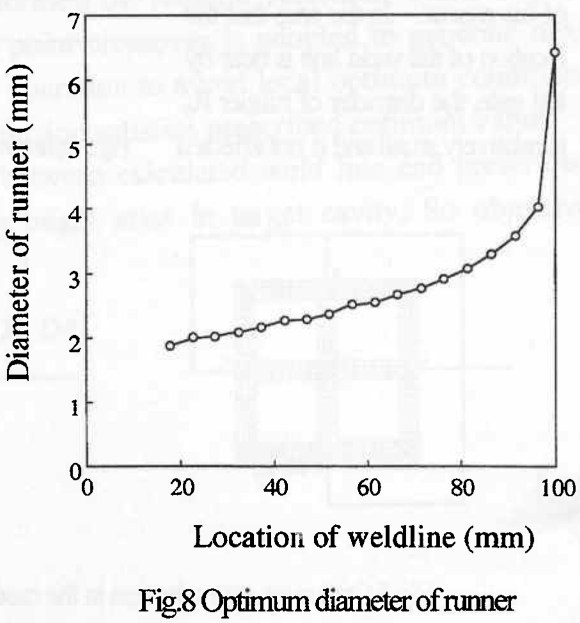

Fig.8 Optimum diameter of runner