

Optimal selection of parting line for die-casting

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Abstract

In design of die-casting die, selection of parting line is time consuming and tedious work. Normally a die-casting engineer with considerable knowledge and experience of die-casting performs the task of parting line selection. There can be a number of possible parting lines for a given part. The die-casting engineer has to consider a number of conflicting factors for selecting an optimal parting line out of candidate parting lines. A methodology for optimal parting line selection is proposed in this paper. The methodology considers different factors like number of undercuts, dimensional stability, flash, draw, position of ejector pins etc. for evaluation of parting line alternatives. These factors are classified on the basis of their priority i.e. high, medium and low priority. Candidate parting lines are rated qualitatively on a five point scale for each of the factors. Optimal parting line is found by using Dominic method of concept evaluation. It has been observed that results obtained are similar to as being followed in industrial practice.

Key words: die-casting, die-design, parting direction, parting line

1. Introduction

Parting line is a contour of intersection of a parting surface with casting surface. It is the line that could be seen on the cast part where two halves of the die (core and cavity) meet. Parting line coincides with part of bounding line of parting surface. Parting lines can be classified as flat, stepped, angled and profiled parting lines, which are shown in figure 1.

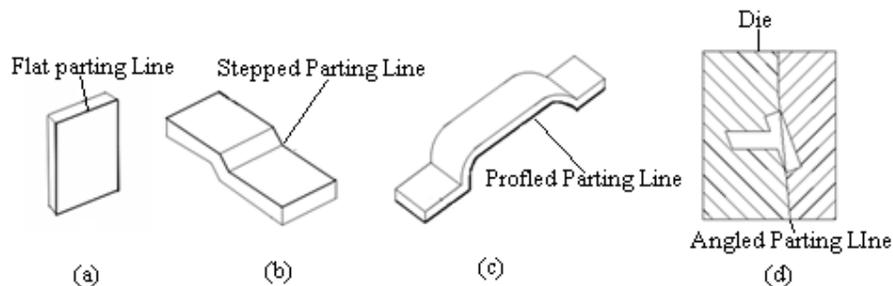


Fig.1. Parting Line types [13]

In die-casting process much of the time and cost is incurred on determination of parting direction and parting line. Moreover there are a number of factors which affect this decision [9]. Therefore a methodology needs to be evolved which could help in this decision making. Present work is an attempt to propose a methodology for determination of parting line. Rest of the paper is organised as follows: previous work is discussed in section 2. Section 3 discusses factors affecting selection of parting direction and parting line. Decision criteria of parting line selection are discussed in section 4. Section 5 presents implementation and discussion of the proposed method. Finally the paper is concluded in section 6 along with future scope of work.

2. Previous work

This section presents some of the research done in the area of parting line determination. Ravi and Srinivasan [9] gave the criteria for selecting a parting line for a part based on nine criteria like, projected area of the part, flatness of the parting line, draw distance, draft, undercuts dimensional stability, flash etc. Nee et al. [7 & 8] used number of undercuts and their volume to determine parting direction and parting line. Wong et al. [11] used only six criteria like flatness of parting line, draw distance, projected area, undercut volume, undercut length etc. Khardekar and Mains [4] used the criteria of flatness for selection of the parting line. Madan et al. [6] used eleven factors like dimensional tolerance, projected area, draw distance, number of side cores, symmetrical surface etc. for selection of optimal parting line and parting direction. Hui [3] studied the relation between the parting direction and undercuts either external or internal, of a component to find the main parting direction, side core and split core directions. Weinstein and Manoocheri [10] proposed a method to find the optimal parting line based on the criteria of parting line complexity, draw depth, number of undercut features and number of side cores and machining complexity of a die or mould. Kumar et al. [5] proposed a method for recognition of parting surface of the moulded parts. Criteria of minimum number of undercuts, flatness of parting line and draw distance were used to select an optimal parting surface. Chen [2] proposed a method of determining the parting direction based on the criteria of minimum number of undercuts, draw and projected area for injection moulding part. Three possible parting directions were rated on the basis of weighted sum for the chosen criteria to select the optimum parting direction. Chakraborty and Reddy [1] proposed a system in which selection of best parting direction and surfaces was based on minimum number of undercuts, flatness of parting surface and draw depth.

From the study of previous work it is concluded that the criteria considered for the selection of parting line are not sufficient. In actual practice there are some more factors that a die casting engineer considers for the selection of parting line. Some of the factors which have not been considered previously are: consideration of placement of feeding system, placement and design of vents, placement of ejector pins, trimming and finishing of the cast part, placement of inserts, amount of scrap generated etc. All the factors when considered must also be weighed according to their relative importance.

Before moving further to the implementation of the parting line selection criteria the following section throws some light on the factors affecting selection of parting line.

3. Factors affecting selection of parting direction and parting line

The first step for determining parting line is to select an appropriate parting direction. One set of alternatives for the parting direction is generally provided by the centrelines of the minimal bounding box of the casting. Other alternatives are given by the direction of normal to large faces in the casting. For each candidate parting direction there can be one or more candidate parting lines. Because multiple alternatives for parting line are available, a designer will choose the most suitable one that optimizes a set of decision criteria. Since determination of parting line depends on the selection of parting direction, the influencing factors have a common affect on selection of parting direction and parting line. These factors are being discussed in the following paragraphs.

Undercut- A feature of part that is not mouldable in selected parting direction is called an undercut. Having an undercut is not desirable as it increases process cycle time and, tooling and manufacturing cost. One such feature is shown in figure 2(b). For selecting an optimal parting direction or parting line the number of undercut are to be minimised [9].

Draw- Draw is the minimum distance through which a component is linearly translated in order to clear it from the mould as shown in figure 2 (b). The draw distance is kept to a minimum for selecting a parting direction and a parting line. Draw distance is compared with the smallest overall dimension to evaluate this criterion [9].

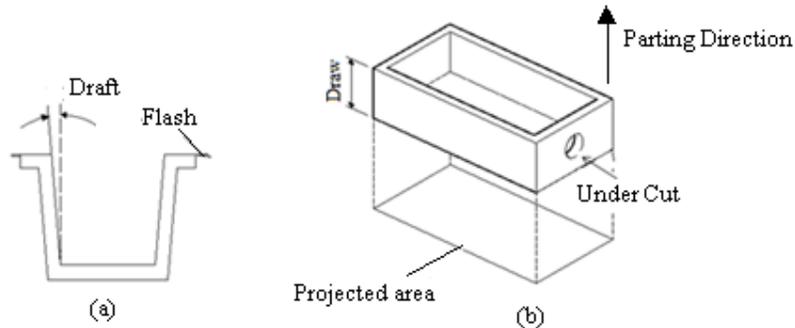


Fig. 2 Factors affecting parting line selection

Projected area- It is the area of projection of a part on a plane perpendicular to parting direction as shown in figure 2 (b). The boundary of projected area gives the boundary of the parting surface. Generally a parting direction with maximum projected area is selected as the optimal parting direction [9].

Draft- To facilitate removal of manufactured component from mould the cross-sectional area should gradually decrease from the parting surface in parting direction. This condition is applicable to flat as well as irregular parting surface. Necessary draft has to be applied to the part in the parting direction if the projected area does not decrease on the parting direction as show in figure 2(a). Draft adds to the extra material and finishing cost of the part. An optimal parting direction and line will have minimum possible draft [9].

Flash- Material flowing into gaps at the plane of separation of the two mould halves produces fin like protrusions or flash and is treated as imperfection and is shown in figure 2(a). This is generally trimmed after manufacturing. For optimal parting direction and parting line the flash must be less and easy to trim [9].

Flatness- The selection of the parting direction should ensure the flatness of the parting line. A flat parting line alone can take care of the other aspects like side thrust, dimensional stability, sealing off, flash etc. The complexity of a non-flat parting line should be minimum possible [9].

Dimensional stability- It refers to reduction of the mismatch between the mould segments which affects the faces through which the parting line passes. In order to obtain dimensional stability the faces requiring high dimensional stability and tolerances are kept completely on either side of the parting line [9].

Side thrust- Side thrust occurs in die casting when the parting line is non-planer and asymmetric about vertical plane. Side thrust can be reduced with the selection of a flat parting line. In the process of selection of the parting direction and line, side thrust is taken into account as side thrust is responsible for occurrence of mismatch between two mould parts. [9]

Placement and design of overflow wells and vents- Generally overflow wells and vents are placed opposite to the feeding system. Overflow wells appear as extra material on the casting after solidification which must be removed. This causes some marks on the casting. Parting line should be such that the overflow wells should not be placed on surfaces requiring high surface finish [14].

Placement of ejector pins- Placement of the ejector pins is done by considering the strength of the part which is function of wall thickness. The ejector pins should be placed on surface with considerable strength and that does not require high surface finish.

Trimming and finishing operations- Trimming and finishing operations are used to cut the unnecessary flash and feeding system from the casting. The trimming operation is done with the help of trimming dies. Sometimes even a flat parting line with inaccessible corners could pose problems for trimming and finishing operations. The parting line should be such that the trimming and finishing operations could be performed easily without considerable investment in the trimming dies [14].

Placement of inserts- Some casting require placement of inserts. The selection of parting line also depends on easy and suitable placement of the insert. Parting line should be selected such that the inserts maintain their position even under the feeding pressure.

Amount of scrap generated- The metal is injected into the cavity through feeding system which comprises of sprue, biscuit, runners and gates. The feeding system remains attached to the cast part after solidification along with the flash at the parting line. This extra material is then trimmed off and scrap is generated. Parting line should be so located that the scrap produced is less.

4. Decision criteria for parting line selection

In the previous section, factors affecting parting line determination have been discussed. However, some of these factors are conflicting which necessitates selection of an optimal parting line. This section gives the out line for selection of parting line. These steps are explained as under.

- i. The part is examined carefully and different features of the part are identified.
- ii. Candidate parting directions are identified which are generally along three principal axes of the part.
- iii. Optimal parting direction is selected by following the criteria of minimum number of undercuts.
- iv. Possible parting lines for chosen parting direction are identified.
- v. Candidate parting lines are evaluated using decision criteria to find optimal parting line.

For deciding optimal parting line Dominic method of concept evaluation has been followed. This method gives us the procedure for evaluating concepts using qualitative rating of chosen criteria. Factors affecting parting line selection which have been discussed in previous section are rated according to high, medium and low priority. The criteria with high priority are number of undercuts, draft, projected area and dimensional stability. Criteria with medium priority are draw, flash, flatness and placement of ejector pins. The criteria with low priority are side thrust, placement of overflow wells, trimming and finishing operations, scrap generated. Each parting line is evaluated using these criteria on a five point scale viz. excellent (E), good (G), fair (F), poor (P) and unacceptable (U).

Application of this proposed methodology when applied on an example part is being discussed in the next section.

5. Implementation and discussion

Proposed decision criteria were applied on a die-cast part. Results obtained from application of above methodology are being discussed in this section.

Step1- A die cast part is shown in figure 3 (a) along with its identified features. For example feature No.1 is a hollow portion, feature No.2 is a boss, feature No. 3 is a hole (4 in number) and feature No. 4 is a side hole (2 in number).

Step 2- The possible parting directions are identified which are along the three principal axes X, Y and Z axes.

Step 3- Number of undercuts in X, Y and Z directions are 4,3 and1 respectively. Therefore direction Z is chosen as parting direction.

Step 4- For Z as parting direction there are three candidate parting lines PL1, PL2 and PL3 as shown in figure 3 (b) & (c).

Step 5- Candidate parting lines are evaluated qualitatively based on the decision criteria for the factors that are grouped on the basis of their priority, as discussed in section 4. Table 1 gives rating of each criterion for all parting lines and evaluation matrix is given in table 2 as per the Dominic method. Thick line in table 2 is the boundary for good alternative. It is concluded that PL1 is a good alternative out of possible parting lines.

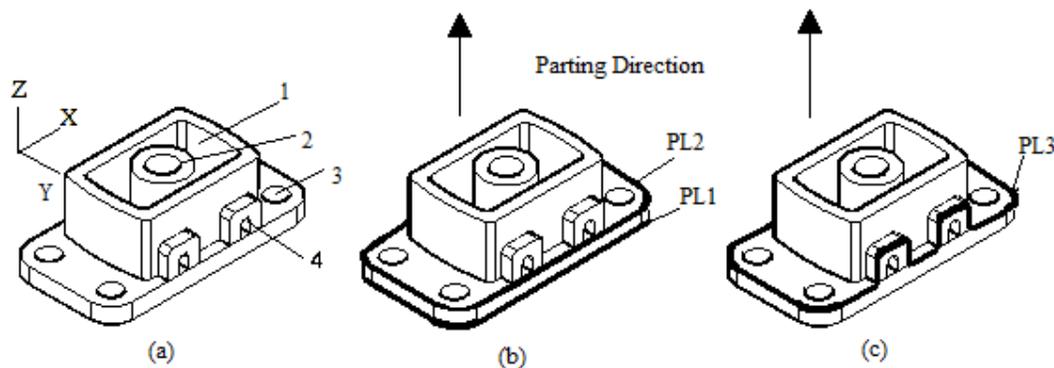


Fig.3. Example Part

Table 1. Rating of parting line for each criteria

Parting line option	High priority criteria	Medium priority criteria	Low priority criteria
PL1	G,G,E,E	G,E,E,G	G,G,G,G
PL2	G,E,G,F	E,E,E,G	G,G,G,G
PL3	G,E,G,F	E,F,F,G	G,G,G,G

Table 2. Evaluation matrix

Ratings	High priority criteria	Medium priority criteria	Low priority criteria
Excellent	PL1,PL1,PL2,PL3	PL1,PL1,PL2,PL2,PL2,PL3	
Good	PL1,PL1,PL2,PL2,PL3,PL3	PL1,PL1,PL2,PL3	PL1,PL1,PL1,PL1,PL2,PL2,PL2,PL2,PL3,PL3,PL3,PL3,
Fair	PL2,PL3	PL3,PL3	
Poor			
Unacceptable			

6. Conclusion and future scope

A method for optimal selection of parting direction and parting line has been presented. Factors affecting selection of parting direction and parting line have been discussed and proposed. Candidate parting directions are identified by analysing different features of the part. Possible parting lines for suitable parting direction are identified. Dominic method of concept evaluation has been used to identify the optimal parting line.

Proposed methodology takes into account a number of factors which have been ignored previously. Presently, this method involves lot of manual interpretation and evaluation. Proposed method can be used for development of an automated system for parting line selection, for which research work is being attempted by the authors.

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