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Feature Library of Gating System for a Die-Casting Die

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ABSTRACT: Gating system design takes much time of the die-casting expert since it requires lot of manual input and a number of iterations to finalize the design. This requires a good knowledge of die-casting process, making this activity completely dependent on the user. In modern day industry lot of CAD/CAM tools are being applied for design, development and manufacturing of a die-casting die. However, dependency on a die-casting expert throughout design and manufacturing of die-casting die makes it a quite lengthy process. Gating system design being one of the major activities in die design also takes much time. Designs of various components of the gating system like runner, gate and overflow have been attempted. A feature library has been proposed.

Keywords: die-casting, die design, feature library, gating system, CAD file

I. INTRODUCTION

Gating System of a die-casting die consists of Gate, Runner, Overflow well and Biscuit. These elements of the gating system have also been shown in the Fig. and are being explained in following paragraphs.
Runners are channels where material flows from the sprue to the cavities. *The narrow and shallow portion of the runner as it enters the cavity is called the gate and the system of the two is called gate and runner system. The gate and runner system design as well as placement is very crucial for obtaining a defect free casting.*

Gate – Runner and Overflow System

Designing the gating system is an iterative process that can be very prolonged and pricey [5]. There are a number of factors that must be considered while designing and placing gate and runner system in the die-casting die. These factors are influenced by design of the part and the die-casting alloy.

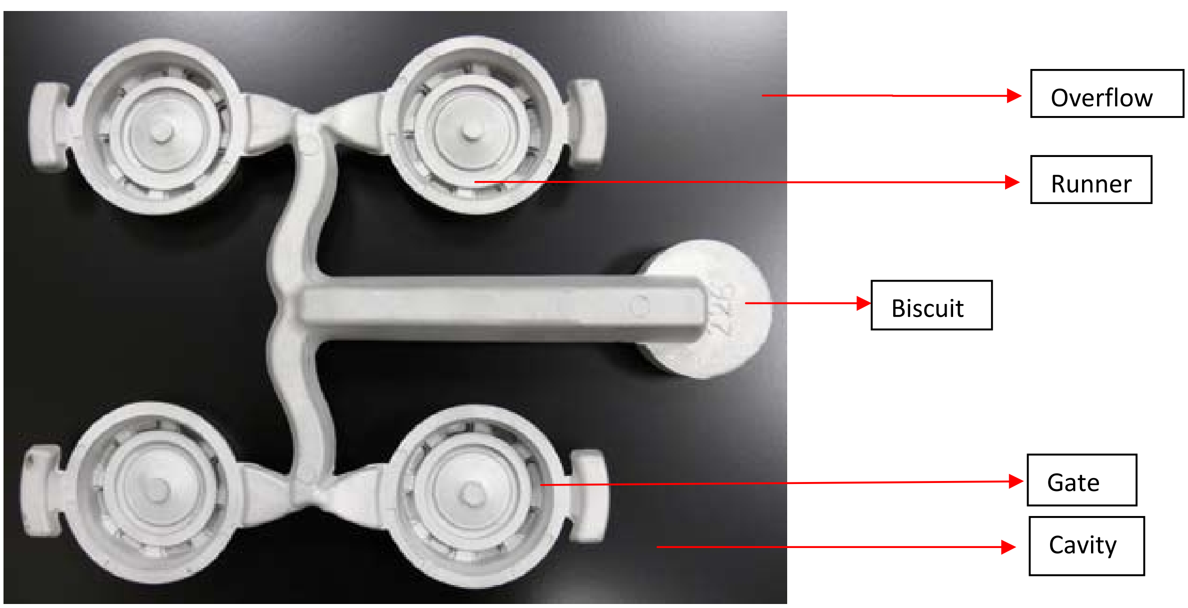

Fig. 1. Gating system nomenclature [22].

Cross-sectional area of gate is determined in accordance with wall thickness of part, part and overflow volume, gate velocity, die and metal temperature, etc. It can be accurately estimated by using the PQ^2 technique. Usually, the tangential gate is employed where the segment of a die-casting is shaped like a parallelogram and fan gate is adopted if the segment approximates the shape of a trapezoid. In fact, they are often used together if the die-casting part is complex in shape. Runner is to distribute metal from the sprue or shot sleeve to the gates. The cross-sectional area of runner must be larger than that of gate so as to produce an increase of flow velocity along the flow path. If a cavity has two or more gates, branch-runners are used to connect the gates with the main runner. The area of the main runner should be larger than the sum of the area of all the branch-runners [5].

Overflow is needed in most aluminum die-casting applications to reduce non-metallic inclusions and air entrapment, besides helping in balancing the thermal effect during the die filling. In practice, if the 3-D model of die-casting is divided into several segments according to the flow paths, the overflow of each segment will be sized in proportion to the volume of the segment. The flow distance of molten metal also affects the volume of overflow due to the heat loss. The overflow should be enlarged accordingly when the flow distance increases. Generally, the overflow is located at the point the flow reaches last or the point where two flows meet. [5]

Gate

The gate is normally a restricted area that facilitates separation of runner from the part. The size, shape and placement of gate can significantly mold a product. The key feature of the gate is to allow for easy, potentially automatic, separation of the part from the runner system, while allowing for filling and packing of the part. It is desirable that the gate be designed to allow for easy removal from the part.

Runners

The runner is immediately downstream from the source of the casting alloy and serves as a conduit between metal supply at the biscuit for the cold chamber process or the nozzle for the hot chamber process. Since the liquid metal follows the path of least resistance, abrupt changes in direction should be avoided or provided for in the design of the metal feed system.

Overflow Well

Overflows are the part of the system and serve several purposes. The primary reason for them is that they act as heat sinks and are normally located adjacent to the last location in the cavity to receive metal, which is the coldest in the system and where the incidence for a cold shut defect is strong. Fig. 2 shows the overflow well. In this case, the overflow is designed with as much volume and as little surface as possible [15]. Different Gates and Runners are discussed below:

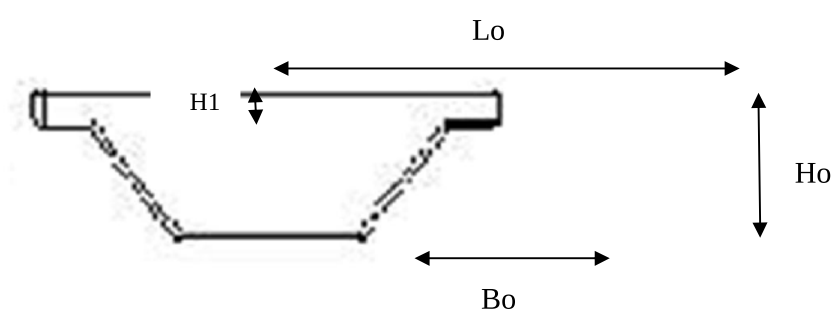

Fig. 2. Overflow well with its different views and parameters [13].

Fan Gate

A fan gate is a wide-edged gate with variable thickness. It permits rapid filling of large parts or fragile mold sections through a large entry area. It is used to create a uniform flow front into wide parts. The gate land is a narrow portion of the gate just before it enters the part. Typically, this will be of a uniform cross section. The body of the gate is a balanced portion to achieve the balanced nature of the gate. The land thickness can be very thin relative to the part thickness because the gate is very wide. Often fan gates are as wide as the part itself. Fig. 3 shows a fan gate. The gate should taper in both width and thickness, so the flow front

at the end of the gate is uniform. This will ensure that:

- The melt velocity will be constant at the end of the gate.
- The entire width is being used for the flow.
- The pressure is the same across the entire width.

Another advantage of the fan gate is its ability to replace several more restrictive gates on a part. The disadvantage is that its width causes a problem with degating [19].

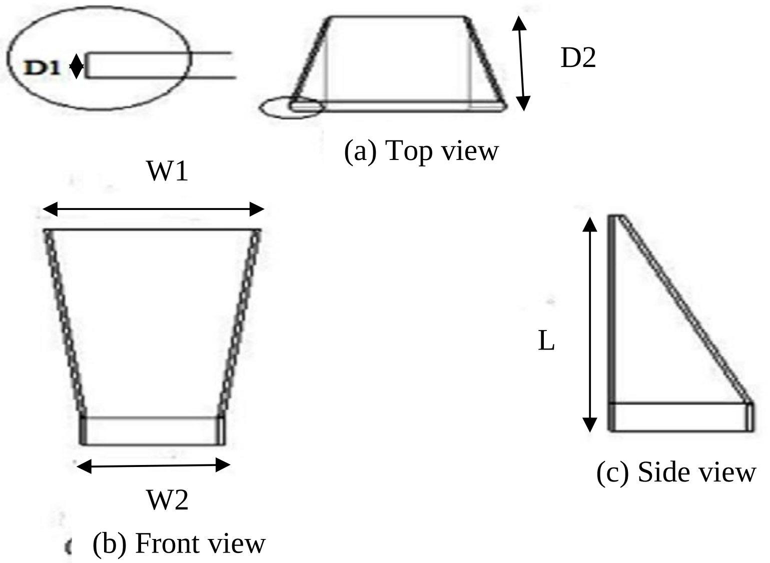

Fig. 3. Fan gate with its different views and parameters [13].

Chisel Gate

A chisel gate is a cross between a tunnel gate and a fan gate. Like a tunnel gate, the chisel gate tunnels into the part and is torn, or sheared, off during ejection. Instead of having a circular cross-section, however, the chisel gate has a flat profile. To eliminate an undercut, the chisel gate is the widest where it attaches to runner. It then tapers with a decreasing width and thickness as it tunnels towards the cavity wall. The chisel gate is used mostly to feed remote portions of the cavity where the help is needed to strengthen the feed for surface and internal integrity of the casting. Like the fan gate, the speed varies and is faster at the center. However, the width is usually so narrow that the swirling effect is greatly diminished [19]. Fig. 4 shows a chisel gate.

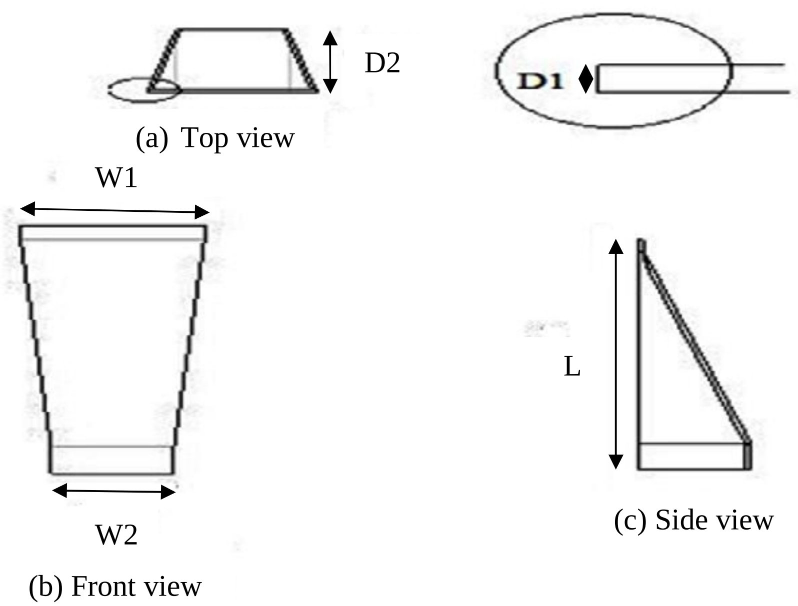

Fig. 4. Chisel gate with its different views and parameters [13].

Paddle Gate

The paddle gate is quite similar to fan gate with slight variation and elongation in design. Fig. 5 shows a paddle gate.

Edge Gate Common edge gates are the most basic type of gate. They are normally rectangular in cross section and attach to the part, along its perimeter, at the parting line of the mould. They are used when automatic degating is impractical or undesirable. An edge gate would be preferable in multi-cavity mold where parts are to be positioned for automated post molding assembly.

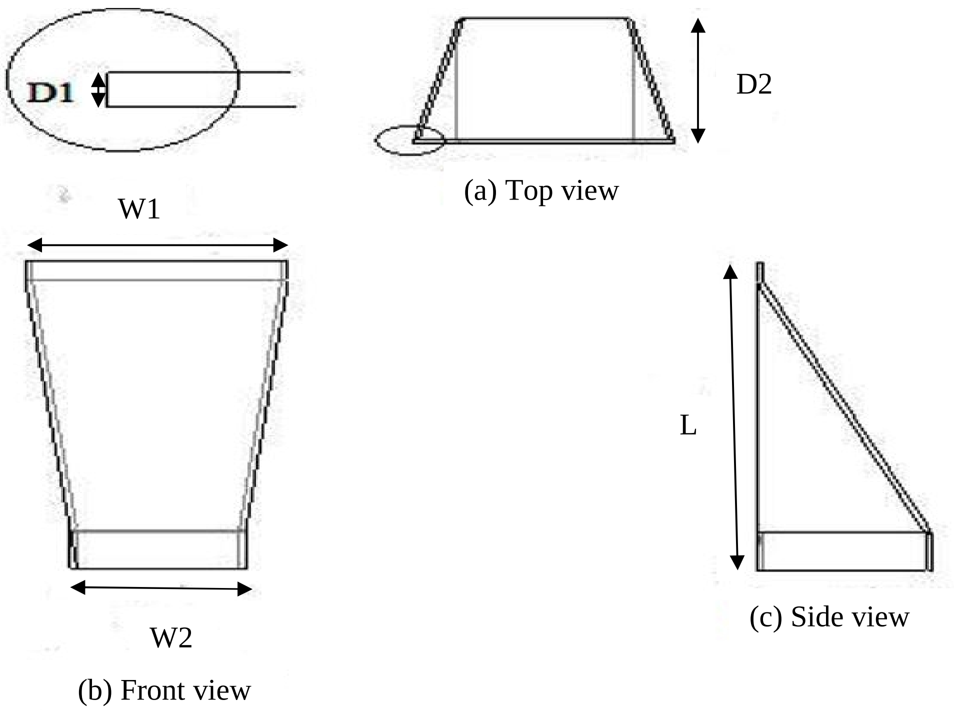

Fig. 5. Paddle gate with its different views and parameters [13].

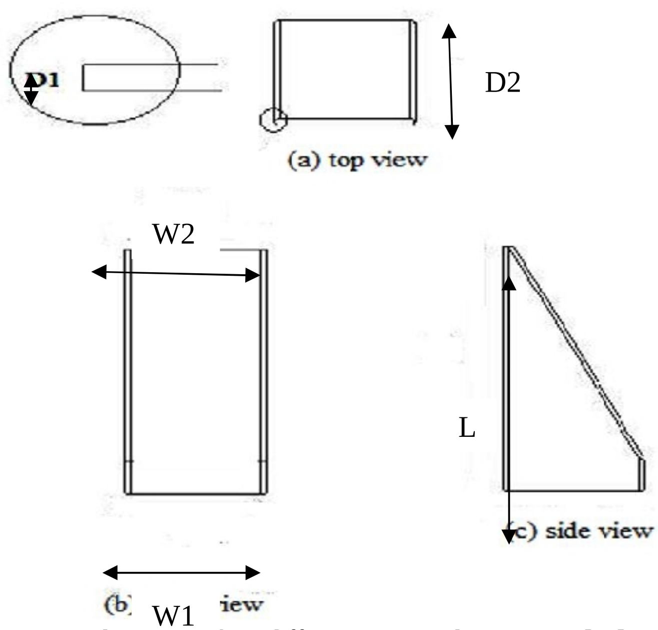

Fig. 6. Edge gate with its different views and parameters [19].

The edge gate will remain with the part maintaining the molded part's position and orientation on the runner, which will provide for easy post-mold handling, such as assembly, decoration, or inspection. The primary disadvantage of the edge gate is the need for manual degating when control post-molding positioning is not required. Fig. 6 shows the designs of the edge gate [19].

Sprue Gate

Sprue gating refers to the cases where there is no traditional runner system or conventional gate. It is different from any other type of gate because the part is gated directly from the sprue as the sprue feeds material directly into the cavity rapidly with minimum pressure drop. Sprue gates are used with single cavity molds and provide for the melt to be delivered to the center of the cavity. This is ideal for many cylindrical or symmetrical shaped parts. The sprue gate is tapered to facilitate ejection with molded part. It has the tendency to increase the probability of gate blush, particularly when used with glass-filled materials. Fig. 7 shows a sprue gate. Direct sprue gating does not allow for cold slug wells. The disadvantage of using this type of gate is the gate mark left on the part surface after the runner is trimmed off. Typically, the shrinkage near the sprue gate will be low while it will be high within the gate. This results in high tensile stresses near the gate [19].

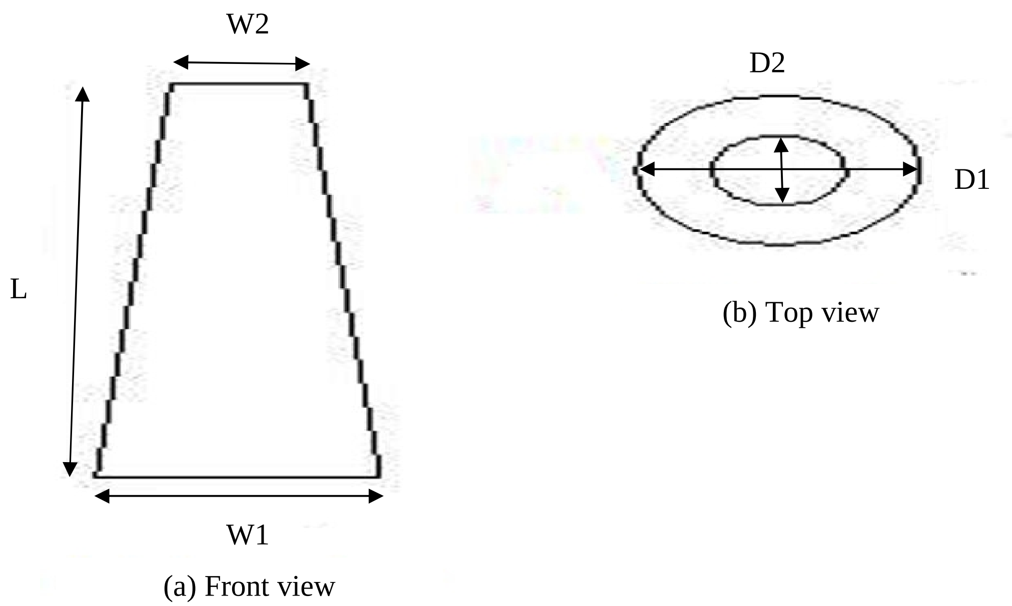

Fig. 7. Sprue gate with its different views and parameters [19].

Circular Runner

The circular runner is the best in terms of maximum volume to surface ratio, which minimizes pressure drop and heat loss. However, the tooling cost is generally higher because both halves of the mold must be machined so that the two semi circular sections are aligned when the mold is closed. Fig. 8 shows a circular runner [18].

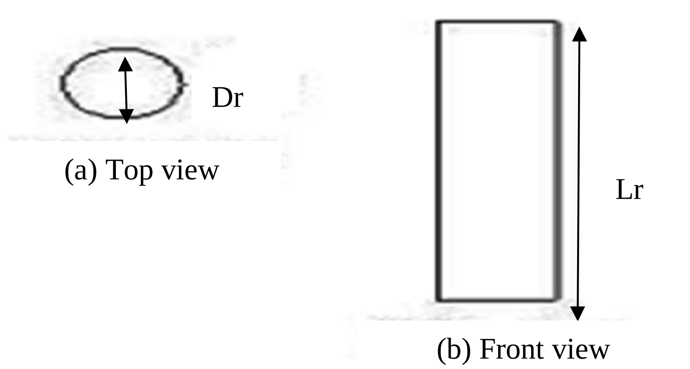

Fig. 8. Circular runner with its different views and parameters [13].

Semi circular Runner
Its quite similar to circular runner as it forms one half of it. Moreover, circular runner is formed by combining two semi-circular runners.

Trapezoidal Runner The trapezoidal runner also works well and permits the runner to be designed and cut on one side of the mold. It is commonly used in three-plate molds, where the full-round runner may not be released properly, and at the parting line in molds, where the full-round runner interferes with the mold sliding action. The shape of the trapezoid is critical [18].

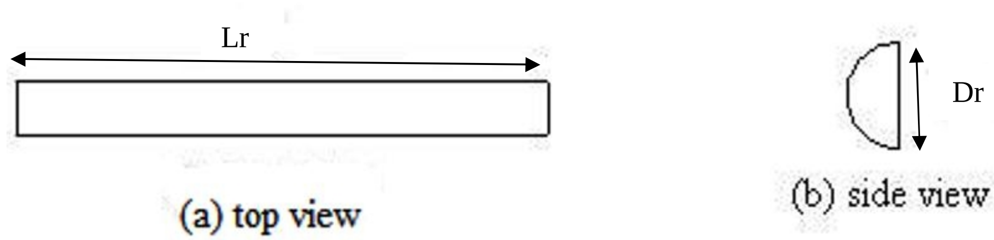

Fig. 9. Semi-circular runner with its different views and parameters [13].

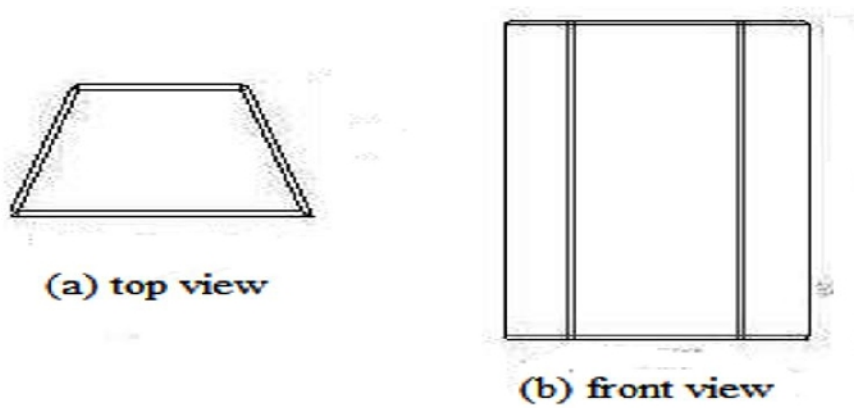

Fig. 10. Trapezoidal runner with its different views and parameters [13].

Modified Trapezoidal Runner
This cross section is a combination of round and trapezoidal shapes. The bottom of the runner is fully round and extends to the parting line at the included angle of the trapezoid.

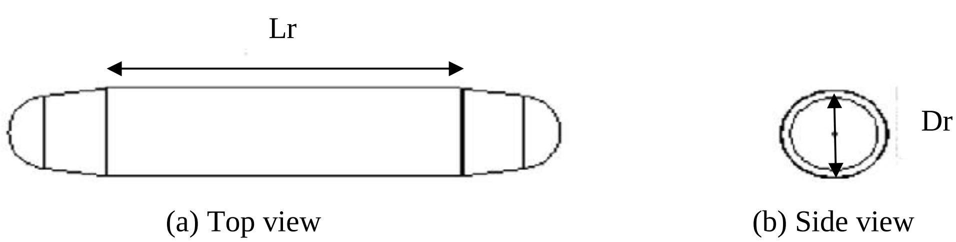

Fig. 11. Modified trapezoidal runner with its different views and parameters [18].

Hexagonal Runner
The hexagonal runner is basically a double trapezoidal runner, where the two halves of the trapezium meet at the parting surface. The cross-sectional area of this runner type is about 82% of that of the corresponding round runner. Naturally, if similar cross-sectional areas are required, then the value for diameter must be increased accordingly. Some toolmakers feel that it is easier to match the two halves of the hexagonal runner than matching of two halves of circular runner [20].

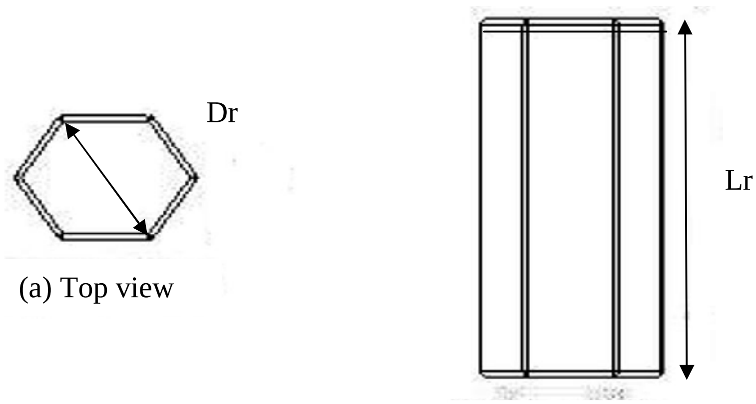

Fig. 12. Hexagonal runner with its different views and parameters [18].

Square Runner

The square runner is not a very satisfactory option because it is difficult to eject. In practice, because of this, an angle of 10^o is incorporated on the runner wall thus, modifying the square runner to the trapezoidal section [20]. Summing up the points concerning the cross sectional shape, we can say that for simple two plate moulds which have a flat parting surface, the fully round runner or hexagonal runner is to be preferred, the increased mould cost being relatively small. For moulds which have complex parting surfaces, where it would be difficult to match accurately the semi circular channels of the round runner or for multi-plate moulds, the trapezoidal or modified trapezoidal section should be used [21].

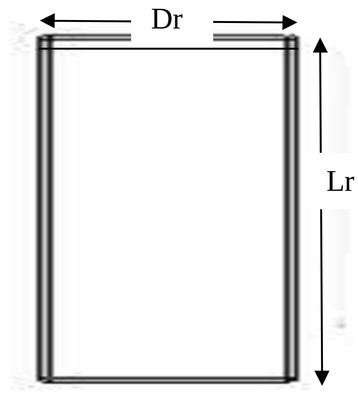

Fig. 13. Square runner with its different views and parameters [18].

CONCLUSION

The system has inbuilt feature library for gate, runner and overflow designs. The system helps a die-casting engineer in reducing time and efforts as there is no need to design the gating system for a part from scratch. The system would go a long way in bridging the gap between designing and manufacturing of die-casting. The present work has overcome the short comings of the previous systems but there are certain limitations that could be addressed in the future. The future scope for this work is appended below.

- System could be modified to incorporate parts with complex geometrical features
- Feature library for gating system could be enhanced
- Gating design for multiple cavity die could be included.

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