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SAND CAST PROTOTYPE SYSTEM PROVIDING MATERIAL PROPERTIES THAT REPLICATE HIGH PRESSURE DIE-CASTING

Abstract

A prototype sand-casting system for producing a sand cast prototype that duplicates material properties of a high pressure die casting part is provided. The prototype sand-casting system includes a sand-casting mold, a plurality of ingates in fluid connection with the mold cavity, a runner system, a first furnace, and a second furnace. The plurality of ingates are configured to direct multiple concurrent casting alloys including a first molten metal alloy and a second molten metal alloy into the mold cavity to form the casting. The runner system is fluidly coupled to the plurality of ingates. The first furnace and the second furnace is fluidly coupled to the runner system. The first molten metal alloy and the second molten metal alloy are concurrent casting alloys.

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Background/Summary

[0001] The present disclosure relates to developing sand cast prototypes, and, more particularly, to developing sand cast prototypes having similar properties as a high pressure die cast production part.
[0002] High pressure die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity having a predetermined shape of a casting. Modern vehicles, especially those of hybrid and electric vehicles, are moving toward simpler vehicle body designs by die casting ultra-large single-piece panels and components that serve as a load bearing structure of the vehicle body. These ultra-large single-piece castings are often referred to as mega-castings or giga-castings due to the huge size of the die casting machines used to make these castings. Ultra-large castings allow vehicle bodies to be lighter and less complex to manufacture by replacing the large number of stamped panels required to form the vehicle body with a single-piece casting.
[0003] Aluminum-silicon based alloys are typically used in die casting of vehicle body components and in the ultra-large single-piece castings due to the alloys' lightweight, superior moldability, mass producibility, and high strength. Traditionally, only one melt is used for each cast component.
[0004] Development of a high-pressure die cast (HPDC) prototype, particularly for ultra-large or giga casting, can be very expensive and time-consuming (often more than one year) in developing a die tooling. Development of prototypes for other metal mold casting processes, for example low-pressure die casting, counterpressure casting, and semi-permanent molding, may also suffer from expensive and time-consuming metal mold development. Because of high cost and long lead times of metal molds, a sand-casting process is often employed for prototype development. However, due to intrinsic differences between sand casting and metal mold processes (e.g., cooling rate, filling patterns, fill times, and so forth), sand cast prototypes do not match levels or distribution of mechanical properties of production metal mold parts.
[0005] Thus, while high-pressure die cast prototyping achieves its intended purpose, there is a need for a new and improved method for prototyping high-pressure die cast or other metal mold production parts that minimizes time and expense.
SUMMARY
[0006] According to several aspects of the present disclosure, a prototype sand-casting system for producing a sand cast prototype that duplicates material properties of a high pressure die casting part is provided. The prototype sand-casting system includes a sand-casting mold, a plurality of ingates in fluid connection with the mold cavity, a runner system, a first furnace, and a second furnace. The sand-casting mold includes a mold cavity having a predetermined shape of a casting. The plurality of ingates are configured to direct multiple concurrent casting alloys including a first molten metal alloy and a second molten metal alloy into the mold cavity to form the casting. The runner system is fluidly coupled to the plurality of ingates, and the first molten metal alloy at least partially mixes with the second molten metal alloy in the runner system. The first furnace is fluidly coupled to the runner system, and the first furnace provides the first molten metal alloy to the runner system. The second furnace is fluidly coupled to the runner system, and the second furnace provides the second molten metal alloy to the runner system. The first molten metal alloy and the second molten metal alloy are concurrent casting alloys.
[0007] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a runner system having a single runner that receives the first molten metal alloy and the second molten metal alloy. The first molten metal alloy and the second molten metal alloy mix in the single runner.
[0008] In accordance with another aspect of the disclosure, the first molten metal alloy and the

second molten metal alloy are different compositions.

[0009] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a runner system having a first runner that fluidly couples the first furnace and the mold cavity and includes a second runner that fluidly couples the second furnace and the mold cavity.

[0010] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a mold cavity in which the first molten metal alloy and the second molten metal alloy mix.

[0011] In accordance with another aspect of the disclosure, the first molten metal alloy and the second molten metal alloy are determined at least partially based on a virtual casting tool simulation to duplicate material properties of high-volume high pressure die casting (HPDC) production parts.

[0012] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a third ingate in fluid connection with the mold cavity configured to direct a third molten metal alloy into the mold cavity to form the casting.

[0013] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a third furnace that provides a third molten metal alloy to the runner system.

[0014] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a third molten metal alloy different than the first molten metal alloy and the second molten metal alloy.

[0015] In accordance with another aspect of the disclosure, the prototype sand-casting system includes at least one riser fluidly coupled to the mold cavity.

[0016] According to several aspects of the present disclosure, a prototype sand-casting system for producing a sand cast prototype that duplicates material properties of a high pressure die casting part is provided. The prototype sand-casting system includes a sand-casting mold, a first runner system, a second runner system, a first furnace, and a second furnace. The sand-casting mold includes a mold cavity having a predetermined shape of a casting. The first runner system is in fluid connection with the mold cavity, and the first runner system directs a first molten metal alloy into the mold cavity to form the casting. The second runner system is in fluid connection with the mold cavity, and the second runner system directs a second molten metal alloy into the mold cavity to form the casting. The second molten metal alloy at least partially mixes with the first molten metal alloy in the mold cavity. The first furnace provides the first molten metal alloy to the first runner system. The second furnace provides the second molten metal alloy to the second runner system, and the first molten metal alloy and the second molten metal alloy concurrently flow into the mold cavity.

[0017] In accordance with another aspect of the disclosure, the first molten metal alloy and the second molten metal alloy are different compositions.

[0018] In accordance with another aspect of the disclosure, the first molten metal alloy and the second molten metal alloy are different compositions. The first molten metal alloy and the second molten metal alloy are determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts.

[0019] In accordance with another aspect of the disclosure, the prototype sand-casting system includes a third furnace that provides a third molten metal alloy to a third runner system. The third runner system is fluidly coupled and provides the third molten metal alloy to the mold cavity.

[0020] In accordance with another aspect of the disclosure, the third molten metal alloy is different than the first molten metal alloy and the second molten metal alloy.

[0021] In accordance with another aspect of the disclosure, the prototype sand-casting system includes at least one riser fluidly coupled to the mold cavity.

[0022] According to several aspects of the present disclosure, a method for providing a sand cast prototype replicating material properties of a high pressure die cast is provided. The method includes providing a first molten metal alloy to a runner system from a first furnace. The first molten metal alloy is determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts. The method further includes providing a second molten metal alloy to the runner system from a second furnace. The second molten metal alloy is determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts. The method further includes flowing the first molten metal alloy and the second molten metal alloy from the runner system to a sand-casting mold including a mold cavity having a predetermined shape of a casting.

[0023] In accordance with another aspect of the disclosure, the first molten metal alloy and the second molten metal alloy are different compositions.

[0024] In accordance with another aspect of the disclosure, the method includes providing a third molten metal alloy to the runner system from a third furnace. The third molten metal alloy is determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts.

[0025] In accordance with another aspect of the disclosure, the third molten metal alloy is different than the first molten metal alloy and the second molten metal alloy.

[0026] Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0028] FIG. **1** is a diagrammatic illustration of a simplified prototype sand-casting system having a runner system with a single runner, in accordance with the present disclosure;

[0029] FIG. **2** is a diagrammatic illustration of a simplified prototype sand-casting system having a runner system with a first runner and a second runner, in accordance with the present disclosure;

[0030] FIG. **3** is a top view of the prototype sand-casting system illustrated in FIGS. **1** and **2**, in accordance with the present disclosure;

[0031] FIG. **4** is a side cross section view of the prototype sand-casting system shown in FIGS. **1** and **2** along lines **4-4** illustrated in FIG. **3**, in accordance with the present disclosure; and

[0032] FIG. **5** is a flowchart illustrating a method for providing the sand cast prototype that replicates material properties of a high pressure die cast using the prototype sand-casting system depicted FIGS. **1** and **2**, in accordance with the present disclosure.

DETAILED DESCRIPTION

[0033] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. The illustrated embodiments are disclosed with reference to the drawings, where like numerals indicate corresponding parts throughout the several drawings. The figures are not necessarily to scale, and some features may be exaggerated or minimized to show details of particular features. The specific structural and functional details disclosed are not intended to be interpreted as limiting, but as a representative basis for teaching one skilled in the art as to how to practice the disclosed concepts.

[0034] The system and method disclosed herein use a virtual casting tool and multiple concurrent casting alloys for matching sand cast prototype mechanical properties and distribution throughout a mold with a simulated high pressure die cast (HPDC) production part. Typical mechanical property variation predicted in HPDC or other metal mold castings are achieved by using these multiple concurrent casting alloys in a sand cast prototype.

[0035] FIG. **1** is a diagrammatic illustration of a simplified prototype sand-casting system **10** in accordance with one aspect of the present disclosure. The prototype sand-casting system **10** is configured to provide a sand-casting prototype with mechanical properties and mechanical distribution similar or equivalent to mechanical properties and distribution of a HPDC or other metal mold production part. The prototype sand-casting system **10** includes a sand-casting mold **12**, at least one ingate **14**, a runner system **16**, a first furnace **18**, and a second furnace **20**.

[0036] The sand-casting mold **12** depicted in FIG. **1** has an internal surface **22** defining a mold cavity **24**. The mold cavity **24** is configured to receive a molten metal to form a casting having a predetermined shape of the mold cavity **24**. The internal surface **22** includes protruding details and cavities to define the mold cavity **24** having a predetermined shape and geometry for forming the desired contours and features of a cast component, for example for a vehicle (e.g., an engine block). Such protruding details and cavities can form walls and structural elements, for example bosses and ribs (not shown). The shape of the mold cavity **24** is a negative impression of the shape of the predetermined casting. The sand-casting mold **12** can be an additively manufactured (e.g., three-dimension (3D) printed sand cores and molds) and may include a variety of sand compositions (e.g., silica) and sand bonding materials and processes.

[0037] Shown in FIG. **1**, a riser **26** can be fluidly coupled to the mold cavity **24**. The riser **26** is a reservoir coupled to the sand-casting mold **12** for preventing cavities within the mold due to shrinking and for letting gas and steam be released from the mold cavity **24**. When molten metal flows into the mold cavity **24**, the molten metal enters the riser **26** once the mold cavity **24** is full. As the molten metal is less dense than when in a solid state, a void forms in the casting due to shrinkage caused by cooling. Molten metal is supplied from the riser to feed the mold cavity **24** as the molten metal solidifies and shrinks. Thus, a void forms in the riser **26** instead of the casting. Each riser **26** location and size may be manipulated in the prototype sand-casting system **10** to match porosity expected from HPDC parts. While FIG. **1** illustrates three risers **26**, it will be appreciated that less or more risers **26** can be disposed as part of the sand-casting mold **12** and fluidly coupled to the mold cavity **24**.

[0038] At least one molten metal or alloy, for example a molten aluminum-silicon based alloy, is provided to the mold cavity **24**. When determining the molten metal or alloy type and the detailed composition, some considerations for mechanical properties and distribution (e.g., ultimate tensile strength (UTS), yield strength (YS), elongation) and fatigue of each prototype may include porosity/oxide volume fraction (more porosity farther from each ingate), secondary phase particle volume fraction and sizes, secondary dendrite arm spacing (a sand casting cools slower than a HPDC casting and thus secondary dendrite arm spacing in sand casting in typically larger than that of a HPDC casting), and so forth. Factors to consider when determining molten metal alloys that affect local microstructure and defects may include alloy composition (when multiple ingates are used), melt treatment, gating/riser design, melt pouring temperature, a local 3D print core, local chill, heat treatment design, multiple sand types used in the sand core, and/or sand bonding processes. The molten metal or molten alloy can include a variety of elements, for example, aluminum (Al), silicon (Si), iron (Fe), copper (Cu), magnesium (Mg), manganese (Mn), zinc (Zn), strontium (Sr), and the like. The simulated molten metal alloy can be used for early product development, weldability, machining, mechanical property testing, and/or early product validation.

[0039] In an example, a first molten metal alloy **28** and a second molten metal alloy **30**, which are different alloys and have different metal alloying treatment, flow into and at least partially mix within the mold cavity **24**. Multiple concurrent casting alloys are used to mimic HPDC casting. When HPDC prototype casting with a single melt, the melt may have different material properties (e.g., elongation) at different locations within the mold, which may be difficult to predict. For example, when HPDC casting, prediction of material properties close to the ingates is good, while farther from the ingates is less accurate, which is also amplified when giga-casting. Using different molten metal alloys within a sand cast is advantageous because each alloy behaves differently in different portions of the mold cavity **24** and can predict molten metal alloys within a prototype

HPDC mold. The first molten metal alloy **28** and the second molten metal alloy **30** may be disposed in different regions/zones of the mold cavity **24** to match mechanical property predictions to that of a metal mold (e.g., a HPDC mold). Thus, using a sand cast prototype with multiple molten metal alloys gives better predicted uniform qualities throughout the casting.

[0040] In an example, the first molten metal alloy **28** includes an aluminum-silicon based alloy, and the second molten metal alloy **30** is an aluminum-silicon based alloy that is different than the first molten metal alloy **28**. In some instances, and as shown in FIG. **1**, a third molten metal alloy **32** may also flow into the mold cavity **24** from a third furnace **34** and at least partially mix with the first molten metal alloy **28** and the second molten metal alloy **30** within the mold cavity **24**. In some instances, two of the first molten metal alloy **28**, the second molten metal alloy **30**, or the third molten metal alloy **32** may be the same alloy while the other is a different alloy.

[0041] Shown in FIG. **1**, the prototype sand-casting system **10** includes at least one ingate **14** (or inner gate). The ingate **14** is in fluid connection with the mold cavity **24** and is a conduit configured to direct a molten metal alloy (e.g., first molten metal alloy **28**, second molten metal alloy **30**, third molten metal alloy **32**) into the mold cavity **24** to form the prototype sand casting. Each ingate **14** is configured to ensure that molten metal alloy flow is proportional to the volume of the mold cavity **24** for a given casting section and to ensure that the molten metal alloy completely fills that respective section of the mold cavity **24**. Additionally, each ingate **14** can facilitate mixing of multiple molten metal alloys (e.g., first molten metal alloy **28**, second molten metal alloy **30**, third molten metal alloy **32**).

[0042] Location (e.g., an ingate **14**, the mold cavity **24**, and the like) of mixing of the molten metal alloys can be determined by a virtual casting tool to optimize sand cast material properties, for example porosity. Another mechanical property variation that may be predicted is elongation distribution throughout the sand cast prototype. Typically, elongation distribution and degradation increases proportionally to distance from each ingate **14**. Thus, when multiple ingates are used and location of each ingate is optimized, less degradation throughout the sand cast prototype occurs. In the example depicted in FIG. **1**, the prototype sand-casting system **10** has multiple ingates including a first ingate **14**A, a second ingate **14**B, a third ingate **14**C, and a fourth ingate **14**D. In some aspects, the prototype sand-casting system **10** may include additional ingates (e.g., a fifth ingate, a sixth ingate, and so forth) or less ingates (e.g., three ingates, two ingates).

[0043] Still referring to FIG. **1**, the runner system **16** is at least one runner **36** (e.g., a channel) fluidly coupled to the at least one ingate **14**. The runner system **16** facilitates smooth flow of molten metal to the at least one ingate **14** and reduces velocity of the molten metal ensuring a steady flow and preventing slag from entering the mold cavity **24**. Shown in FIG. **1**, the runner system **16** has a single runner **36** fluidly coupled to the first ingate **14**A, the second ingate **14**B, the third ingate **14**C, and the fourth ingate **14**D. When a single runner **36** is used, the first molten metal alloy **28**, the second molten metal alloy **30**, and the third molten metal alloy **32** (when included) mixes in the single runner **36** giving a softer mechanical property differential of the casting within the mold cavity **24**.

[0044] Referring to FIG. **2**, a prototype sand-casting system **10** is illustrated having a runner system **16** with a first runner **38** and a second runner **40**. In this example with multiple runners, the prototype sand-casting system **10** also includes a sand-casting mold **12**, a first furnace **18**, and a second furnace **20**. The first runner **38** fluidly couples the first furnace **18** directly to the mold cavity **24** of the sand-casting mold **12** such that the first molten metal alloy **28** does not contact the second runner **40**. The first runner **38** flows the first molten metal alloy **28** to the mold cavity **24**. The second runner **40** fluidly couples the second furnace **20** directly to the mold cavity **24** such that the second molten metal alloy **30** does not contact the first runner **38**. The second runner **40** flows the second molten metal alloy **30** directly into the mold cavity **24**. The first runner **38** and the second runner **40** may not include a separate ingate as in the prototype sand-casting system **10** illustrated in FIG. **1** or may not include an ingate at all. As the first molten metal alloy **28** and the second molten metal alloy **30** flow into the mold cavity **24**, the first molten metal alloy **28** and the second molten metal alloy **30** at least partially mix while in the mold cavity **24** to replicate material properties of a HPDC casting within the prototype sand-casting system **10** and in accordance with predictions of the virtual casting tool.

[0045] Referring again to FIG. **1**, the first furnace **18** is fluidly coupled to the runner system **16**. The first furnace **18** is configured to melt and provide the first molten metal alloy **28** to the runner system **16** and the mold cavity **24**. The first furnace **18** can include, for example, an induction furnace, an electric arc furnace, a crucible furnace, and the like. Additionally, the first furnace **18** may be a low-pressure furnace and configured to provide the first molten metal alloy **28** under no or low pressure to the runner system **16**.

[0046] Additionally, FIG. **1** shows the second furnace **20** fluidly coupled to the runner system **16**. The second furnace **20** is configured to provide the second molten metal alloy **30** to the runner system **16** and the mold cavity **24**. The second furnace **20** can include, for example, an induction furnace, an electric arc furnace, a crucible furnace, and the like. FIG. **1** also illustrates the optional third furnace **34**, which is fluidly coupled and provides the third molten metal alloy **32** to the runner system **16**. In some aspects, the prototype sand-casting system **10** can include additional furnaces (e.g., a fourth furnace, a fifth furnace, and so forth). Moreover, the prototype sand-casting system **10** may include additional components, for example a pouring device (not shown) for pouring each molten metal alloy from respective furnaces.

[0047] FIG. **3** is a top view of the prototype sand-casting system **10** illustrated in FIGS. **1** and **2**. The first molten metal alloy **28** is shown flowing into a first portion **42** of the mold cavity **24**, and the second molten metal alloy **30** is shown flowing into a second portion **44** of the mold cavity **24**. The first molten metal alloy **28** and the second molten metal alloy **30** at least partially mix with in the mold cavity **24**.

[0048] FIG. **4** is a side cross section view of the prototype sand-casting system **10** along lines **4-4** illustrated in FIG. **3**. As shown in FIG. **3**, the first molten metal alloy **28** flows into the first portion **42** of the mold cavity **24** through a first ingate **14**A, and the second molten metal alloy **30** flows into the second portion **44** of the mold cavity **24** through a second ingate **14**B. The view in FIG. **4** shows the first molten metal alloy **28** and the second molten metal alloy **30** mixing proximate to a central location **46** between the first ingate **14**A and the second ingate **14**B. In other instances, the first molten metal alloy **28** and the second molten metal alloy **30** (and other alloys, if included) also mix throughout the mold cavity **24**.

[0049] FIG. **5** is a flowchart illustrating a method **100** for providing the sand cast prototype that duplicates material properties of a high pressure die casting part using the prototype sand-casting system **10** illustrated in FIGS. **1** and **2**.

[0050] Starting at block **102**, method **100** includes providing the first molten metal alloy **28** to a runner system **16** from the first furnace **18**. Providing the first molten metal alloy **28** may include determining a composition of the first molten metal alloy **28**. The first molten metal alloy **28** composition is determined at least partially based on a virtual casting tool. The virtual casting tool may include a software simulation configured to design and tailor multi-scale defects and microstructure in the sand cast prototype. The virtual casting tool determines the first molten metal alloy **28** composition to duplicate or replicate material properties of high-volume high pressure die casting (HPDC) production parts. In an example, the virtual casting tool determines a castable product geometry, provides a sand-casting process simulation, provides a sand cast prototype microstructure and porosity prediction, and provides a sand cast prototype part local property prediction. The simulation and resulting predictions are then used to determine and provide the composition of the first molten metal alloy **28**. The method **100** then proceeds to block **104**.

[0051] Block **104** includes providing the second molten metal alloy **30** to the runner system **16** from the second furnace **20**. The composition of the second molten metal alloy **30** is determined at least partially based on the virtual casting tool. Similarly for the first molten metal alloy **28**, the virtual casting tool determines the second molten metal alloy **30** composition to duplicate material properties of high-volume high pressure die casting (HPDC) production parts from the sand-casting simulation predictions. Method **100** may then proceed to block **106**.

[0052] Block **106** includes an optional step of providing a third molten metal alloy **32** to the runner system **16** from a third furnace **34**. When included, the third molten metal alloy **32** composition is determined at least partially based on the virtual casting tool. The virtual casting tool determines the third molten metal alloy **32** composition, to duplicate material properties of high-volume high pressure die casting (HPDC) production parts. Method **100** then proceeds to block **108**.

[0053] Block **108** includes flowing the first molten metal alloy **28** and the second molten metal alloy **30** from the runner system **16** to the sand-casting mold **12** and the mold cavity **24**. Flowing the first molten metal alloy **28** and the second molten metal alloy **30** includes pouring each molten metal alloy respectively from the first furnace **18**, the second furnace **20**, and/or the third furnace **34**. The virtual casting tool prediction and prototype casting steps (e.g., block **102**, block **104**, block **106**, and/or block **108**) may be repeated until the mechanical properties of the sand cast prototype are similar or equivalent to predicted mechanical properties of the HPDC product. The method **100** then ends.

[0054] The prototype sand-casting system **10** and method **100** for providing a sand cast prototype of the present disclosure offers several advantages. Because development of a high-pressure die cast (HPDC) prototype can be expensive and time-consuming, the prototype sand-casting system **10** is advantageous and designed to duplicate a HPDC process rather than be optimized for peak sand-casting material properties. Using sand casting method for developing the HPDC prototype reduces the amount of time required and expense because of the reduced time requirement and the expense of sand casting.

Claims

1. A prototype sand-casting system for producing a sand cast prototype that duplicates material properties of a high pressure die casting part, comprising: a sand-casting mold including a mold cavity having a predetermined shape of a casting; a plurality of ingates in fluid connection with the mold cavity, wherein the plurality of ingates are configured to direct multiple concurrent casting alloys including a first molten metal alloy and a second molten metal alloy into the mold cavity to form the casting; a runner system fluidly coupled to the plurality of ingates, wherein the first molten metal alloy at least partially mixes with the second molten metal alloy in the runner system; a first furnace fluidly coupled to the runner system, wherein the first furnace provides the first molten metal alloy to the runner system; and a second furnace fluidly coupled to the runner system, wherein the second furnace provides the second molten metal alloy to the runner system, and wherein the first molten metal alloy and the second molten metal alloy are concurrent casting alloys.

2. The prototype sand-casting system of claim 1, wherein the runner system is a single runner that receives the first molten metal alloy and the second molten metal alloy, and wherein the first molten metal alloy and the second molten metal alloy mix in the single runner.

3. The prototype sand-casting system of claim 1, wherein the first molten metal alloy and the second molten metal alloy are different compositions.

4. The prototype sand-casting system of claim 1, wherein the runner system includes a first runner that fluidly couples the first furnace and the mold cavity and includes a second runner that fluidly couples the second furnace and the mold cavity.

5. The prototype sand-casting system of claim 3, wherein the first molten metal alloy and the second molten metal alloy mix in the mold cavity.

6. The prototype sand-casting system of claim 1, wherein the first molten metal alloy and the second molten metal alloy are determined at least partially based on a virtual casting tool simulation to duplicate material properties of high-volume high pressure die casting (HPDC) production parts.

7. The prototype sand-casting system of claim 1, further comprising: a third ingate in fluid connection with the mold cavity configured to direct a third molten metal alloy into the mold cavity to form the casting.

8. The prototype sand-casting system of claim 1, further comprising: a third furnace that provides a third molten metal alloy to the runner system.

9. The prototype sand-casting system of claim 8, wherein the third molten metal alloy is different than the first molten metal alloy and the second molten metal alloy.

10. The prototype sand-casting system of claim 1, further comprising: at least one riser fluidly coupled to the mold cavity.

11. A prototype sand-casting system for producing a sand cast prototype that duplicates material properties of a high pressure die cast part, comprising: a sand-casting mold including a mold cavity having a predetermined shape of a casting; a first runner system in fluid connection with the mold cavity, wherein the first runner system directs a first molten metal alloy into the mold cavity to form the casting; a second runner system in fluid connection with the mold cavity, wherein the second runner system directs a second molten metal alloy into the mold cavity to form the casting, and wherein the second molten metal alloy at least partially mixes with the first molten metal alloy in the mold cavity; a first furnace that provides the first molten metal alloy to the first runner system; and a second furnace that provides the second molten metal alloy to the second runner system, wherein the first molten metal alloy and the second molten metal alloy concurrently flow into the mold cavity.

12. The prototype sand-casting system of claim 11, wherein the first molten metal alloy and the second molten metal alloy are different compositions.

13. The prototype sand-casting system of claim 11, wherein the first molten metal alloy and the second molten metal alloy are determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts.

14. The prototype sand-casting system of claim 11, further comprising: a third furnace that provides a third molten metal alloy to a third runner system, wherein the third runner system is fluidly coupled and provides the third molten metal alloy to the mold cavity.

15. The prototype sand-casting system of claim 14, wherein the third molten metal alloy is different than the first molten metal alloy and the second molten metal alloy.

16. The prototype sand-casting system of claim 11, further comprising: at least one riser fluidly coupled to the mold cavity.

17. A method for providing a sand cast prototype replicating material properties of a high pressure die cast, comprising: providing a first molten metal alloy to a runner system from a first furnace, wherein the first molten metal alloy is determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts; providing a second molten metal alloy to the runner system from a second furnace, wherein the second molten metal alloy is determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts; and flowing the first molten metal alloy and the second molten metal alloy from the runner system to a sand-casting mold including a mold cavity having a predetermined shape of a casting.

18. The method of claim 17, wherein the first molten metal alloy and the second molten metal alloy are different compositions.

19. The method of claim 17, further comprising: providing a third molten metal alloy to the runner system from a third furnace, wherein the third molten metal alloy is determined at least partially based on virtual casting tools to duplicate material properties of high-volume high pressure die casting (HPDC) production parts.

20. The method of claim 19, wherein the third molten metal alloy is different than the first molten metal alloy and the second molten metal alloy.