DIE-CASTING SYSTEM WITH ENHANCED ADHERENCE SHOT SLEEVE POUR LINER

BACKGROUND

[0001] The present disclosure relates to die-casting and, more particularly, to an enhanced adherence slot sleeve pour liner for a shot sleeve.

[0002] In a die-cast tooling system, the plunger tip and the shot sleeve commonly encounter tool life limits. Shot sleeves typically encounter three issues which may limit their continued use: thermal shock by molten metal on the steel part at the pour area; warpage of the shot sleeve due to temperature differentials created inside the shot tube; and wear along the inner barrel of the shot sleeve whilst the piston moves.

[0003] Various methods have been attempted to increase shot sleeve life. Amongst these re-boring and installation of a larger diameter piston may resolve wear. However, thermal shock at the pour area and warpage of the shot tube has not been effectively resolved and are only exacerbated from high melting point alloys. Thus, die-casting has often been limited to relatively low melting-point alloys to avoid thermal shock at the pour area and warpage of the shot sleeve that may otherwise contribute to jamming of the shot piston during operation.

[0004] Some die-cast tooling systems utilize a pre-fabricated pour insert of a refractory alloy welded into the shot sleeve body. The pour insert effectively reduces the effect of thermal shock and facilitates rapid heat dissipation compared to typical tool steels. Since the pour insert is only welded into the tool steel, replacement is readily facilitated, however, the interface may not be sufficiently durable for continued die-casting operations.

SUMMARY

[0005] A pour liner for a shot sleeve of a die-casting system according to one disclosed non-limiting embodiment of the present disclosure can include a bonding layer within a slot in a shot sleeve substrate; and a refractory metal layer adjacent to the bonding layer.

[0006] A further embodiment of the present disclosure may include, wherein the pour liner is circular in cross section.

[0007] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the pour liner is semi-circular in cross-section.

[0008] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the bonding layer and the refractory metal layer are applied via a laser cladding process.

[0009] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the bonding layer and the refractory metal layer are applied layer-by-layer.

[0010] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the bonding layer includes a nickel alloy.

[0011] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the bonding layer is Inconel.

[0012] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the refractory metal layer includes a tantalum alloy.

[0013] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the refractory metal layer includes a tungsten alloy.

[0014] A die-casting system according to one disclosed non-limiting embodiment of the present disclosure can include a shot sleeve having a pour liner adjacent a pour hole, the pour liner including a bonding layer.

[0015] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the bonding layer is adjacent to a shot sleeve substrate and a refractory metal layer is adjacent to the bonding layer.

[0016] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the pour liner is circular in cross-section.

[0017] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the pour liner is semi-circular in cross-section.

[0018] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the pour liner is flush with a cut in the shot sleeve.

[0019] A method of manufacturing a shot sleeve according to one disclosed non-limiting embodiment of the present disclosure can include forming a slot in the slot sleeve; laser cladding a bonding layer within the slot; and laser cladding a refractory metal layer onto the bonding layer.

[0020] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the bonding layer includes Inconel.

[0021] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the refractory metal layer includes a tantalum alloy.

[0022] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein the refractory metal layer includes a tungsten alloy.

[0023] A further embodiment of any of the foregoing embodiments of the present disclosure may include, wherein forming the slot includes forming the slot adjacent to a pour hole.

[0024] A further embodiment of any of the foregoing embodiments of the present disclosure may include comprising subjecting the bonding layer to a post weld heat treatment prior to laser cladding the laser cladding the refractory metal layer onto the bonding layer.

[0025] The foregoing features and elements may be combined in various combinations without exclusivity, unless expressly indicated otherwise. These features and elements as well as the operation thereof will become more apparent in light of the following description and the accompanying drawings. It should be understood, however, the following description and drawings are intended to be exemplary in nature and non-limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiment. The drawings that accompany the detailed description can be briefly described as follows:

[0027] Figure 1 is a schematic cross-sectional view of a die casting mold;

[0028] Figure 2 is a schematic longitudinal sectional view of a shot sleeve; and

[0029] Figure 3 is a schematic lateral sectional view of the shot sleeve according to one disclosed non-limiting embodiment;

[0030] Figure 4 is a schematic lateral sectional view of the shot sleeve according to another disclosed non-limiting embodiment; and

[0031] Figure 5 is a method for the manufacture of a pour liner for a shot sleeve according to one disclosed non-limiting embodiment.

DETAILED DESCRIPTION

[0032] Figure 1 schematically illustrates a die-casting system 10. The die casting system 10 generally includes a reusable die 12 having a plurality of die elements 14, 16 that function to cast a component. Although two die elements 14, 16 are depicted, it should be appreciated that the die 12 could include more die elements, as well as other parts and configurations. The example die casting system 10 is illustrative only and could include more or less sections, parts and/or components including, but not limited to, horizontal, inclined, and vertical die casting systems.

[0033] The die 12 is assembled and retained at a desired position via a clamp mechanism 18. Such as a hydraulic, pneumatic, electromechanical and/or other configurations. The mechanism 18 also separates the die elements 14, 16 subsequent to casting.

[0034] The die elements 14, 16 define internal surfaces that cooperate to define a die cavity 20. A shot sleeve 24 is in fluid communication with the die cavity 20 via one or more ports 26 located in the die element 16, the die element 14, or both. A shot sleeve plunger 28 is received within the shot sleeve 24 and is moveable between a retracted and injection position (arrow A) within the shot sleeve 24 by an actuator 30 such as a hydraulic, pneumatic, electromechanical, or any combination thereof.

[0035] The shot sleeve 24 is positioned to receive a molten metal from a melting unit 32, such as a crucible, for example. The melting unit 32 operates to melt an ingot of metallic material to prepare a molten metal for delivery to the shot sleeve 24, including but not limited to, vacuum induction melting, electron beam melting and induction melting. The molten metal is melted by the melting unit 32 at a location that is separate from the shot sleeve 24 and the die 12.

[0036] Example molten metals for the die cast component include, but are not limited to, nickel based super alloys, titanium alloys, high temperature aluminum alloys, copper based alloys, iron alloys, molybdenum, tungsten, niobium, or other refractory metals. This disclosure is not limited to the disclosed alloys, and it should be appreciated that any high melting temperature material may be utilized to die cast the component. As used herein, the term "high melting temperature material" is intended to include materials having a melting temperature of about 1500° F (815° C) and higher.

[0037] The molten metal is transferred from the melting unit 32 to the shot sleeve 24 such as via pouring the molten metal into a pour hole 33 of the shot sleeve 24. A sufficient amount of molten metal is poured into the shot sleeve 24 to fill the die cavity 20. The shot sleeve plunger 28 is actuated to inject the molten metal under pressure from the shot sleeve 24 into the die cavity 20 to cast the component. Although the casting of a single component is depicted, the die casting system 10 could be configured to cast multiple components in a single shot.

[0038] Although not necessary, at least a portion of the die casting system 10 may be positioned within a vacuum chamber. The vacuum chamber provides a non-reactive environment for the die casting system 10 that reduces reaction, contamination, or other

conditions that could detrimentally affect the quality of the cast component, such as excess porosity of the die cast component that can occur as a result of ingressed air during molten metal solidification.

[0039] With reference to Figure 2, the shot sleeve 24 adjacent to the pour hole 33 includes a pour liner 40 within a shot sleeve substrate 50. The pour liner 40 utilizes powdered refractory material deposited metallurgically and fused layer-by-layer into a slot 42 machined into an inner diameter of the shot sleeve substrate 50 axially located adjacent to the pour hole 33. In one embodiment, the slot 46 extends for about 180 degrees opposite the pour hole 33 (Figure 3). In another embodiment, the slot 42 extends for about 360 degrees at the axial location of the pour hole 33 (Figure 4).

[0040] The pour liner 40 is formed in a multi-layer manner in which a bonding layer 44 such as Inconel e.g. IN625, is applied to the exposed tool steel in the slot 42, then a refractory metal layer 46 such as tantalum or tungsten alloys is applied to the bonding layer 44. In one example, the bonding layer is about 3.8mm thick and the refractory metal layer is about 0.2mm thick. The bonding layer 44 provides a buffer against deleterious alloy diffusion from the highly alloyed base tool steel substrate into the refractory metal powder layer 46. The refractory metal powder layer 46 is thereby provided with increased adherence.

[0041] With reference to Figure 5, a method 100 to manufacture the shot sleeve 24 initially includes machining the slot 42 (step 102). In one example, the slot 42 is either a semicircular (Figure 3) or a circular (Figure 4) slot that extends for about six inches and is located adjacent to the pour hole 33.

[0042] Next, the bonding layer 44 is applied (step 104). In one embodiment, the bonding layer 44 may be applied via a laser cladding process in which a nickel alloy powder, such as IN625 powder is communicated into the slot 42 while interacting with an impinging laser beam. The laser melts the powder and the melt is fused into the base metal substrate 50 of the shot sleeve 24. The powder is thereby solidified and built-up layer-by-layer to a desired thickness leaving a final clad thickness awaiting deposit.

[0043] The bonding layer 44 may then be subjected to a post weld heat treatment (step 106). The optional post weld heat treatment may be performed to reduce the thermal stress before the final refractory metal layer 46 clad.

[0044] The refractory metal layer 46 is then applied (step 108). As with the bonding layer 44, the refractory metal layer 46 may be applied via a laser cladding process. In another embodiment, a separate nozzle configuration may be utilized to pre-place the refractory metal powder mixed with binder material.

[0045] The refractory metal layer 46 clad forms relatively fine grain sizes of tunable hardness by laser beam operation adjustments and the interplay between the power type power, feed rate, and/or time rastering layer-by-layer. Layer-by-layer, the refractory metal layer 46 may be built up until proud of the slot 42. The bonding layer 44 provides a relatively stronger joint since the layers are metallurgical bonded layer by layer and reduced crack susceptibility for improved adherence due to the nickel buffering layer operating as a diffusion barrier against the highly alloyed tool steel.

[0046] Finally, the shot sleeve 24 may be machined such as by being honed to size to yield the localized refractory metal clad area within the shot sleeve 24 (step 110).

[0047] The refractory metal lined shot sleeve provides enhanced tool life due to reduced thermal fatigue cracks at the pour area. The refractory metal lined shot sleeve 24 also avoids potential fluid / oil line leakage as cracks are reduced and wash-out effects at the pour area are avoided. The powdered laser clad process further permits tunable properties at the pour area as well as repair.

[0048] The use of the terms "a," "an," "the," and similar references in the context of description (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or specifically contradicted by context. The modifier "about" used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., it includes the degree of error associated with measurement of the particular quantity). All ranges disclosed herein are inclusive of the endpoints, and the endpoints are independently combinable with each other. It should be appreciated that relative positional terms such as "forward," "aft," "upper," "lower," "above," "below," and the like are with reference to the normal operational attitude of the vehicle and should not be considered otherwise limiting.

[0049] Although the different non-limiting embodiments have specific illustrated components, the embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from any of the non-limiting embodiments in combination with features or components from any of the other non-limiting embodiments.

[0050] It should be appreciated that like reference numerals identify corresponding or similar elements throughout the several drawings. It should also be appreciated that although a

particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit herefrom.

[0051] Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present disclosure.

[0052] The foregoing description is exemplary rather than defined by the limitations within. Various non-limiting embodiments are disclosed herein, however, one of ordinary skill in the art would recognize that various modifications and variations in light of the above teachings will fall within the scope of the appended claims. It is therefore to be appreciated that within the scope of the appended claims, the disclosure may be practiced other than as specifically described. For that reason the appended claims should be studied to determine true scope and content.

CLAIMS

What is claimed is:

1. A pour liner for a shot sleeve of a die-casting system, comprising:

a bonding layer within a slot in a shot sleeve substrate; and

a refractory metal layer adjacent to the bonding layer.

2. The pour liner as recited in claim 1, wherein the pour liner is circular in cross section.

3. The pour liner as recited in claim 1, wherein the pour liner is semi-circular in cross-section.

4. The pour liner as recited in claim 1, wherein the bonding layer and the refractory metal layer are applied via a laser cladding process.

5. The pour liner as recited in claim 4, wherein the bonding layer and the refractory metal layer are applied layer-by-layer.

6. The pour liner as recited in claim 1, wherein the bonding layer includes a nickel alloy.

7. The pour liner as recited in claim 1, wherein the bonding layer is Inconel.

8. The pour liner as recited in claim 1, wherein the refractory metal layer includes a tantalum alloy.

9. The pour liner as recited in claim 1, wherein the refractory metal layer includes a tungsten alloy.

10. A die-casting system, comprising:

a shot sleeve having a pour liner adjacent a pour hole, the pour liner including a bonding layer.

11. The system as recited in claim 10, wherein the bonding layer is adjacent to a shot sleeve substrate and a refractory metal layer is adjacent to the bonding layer.

12. The system as recited in claim 10, wherein the pour liner is circular in cross-section.

13. The system as recited in claim 10, wherein the pour liner is semi-circular in cross-section.

14. The system as recited in claim 10, wherein the pour liner is flush with a cut in the shot sleeve.

15. A method of manufacturing a shot sleeve, comprising:

forming a slot in the slot sleeve;

laser cladding a bonding layer within the slot; and

laser cladding a refractory metal layer onto the bonding layer.

16. The method as recited in claim 15, wherein the bonding layer includes Inconel.

17. The method as recited in claim 15, wherein the refractory metal layer includes a tantalum alloy.

18. The method as recited in claim 15, wherein the refractory metal layer includes a tungsten alloy.

19. The method as recited in claim 15, wherein forming the slot includes forming the slot adjacent to a pour hole.

20. The method as recited in claim 15, further comprising subjecting the boding layer to a post weld heat treatment prior to laser cladding the laser cladding the refractory metal layer onto the bonding layer.