Disclosed is a metal-molding conduit assembly, including a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy having a light-metal alloy.
METAL-MOLDING CONDUIT ASSEMBLY OF METAL-MOLDING SYSTEM

TECHNICAL FIELD

[0001] The present invention generally relates to, but is not limited to, molding systems, and more specifically the present invention relates to, but is not limited to a metal-molding conduit assembly of either a metal-molding system or a metal injection-molding system.

BACKGROUND

[0002] Examples of known molding systems are (amongst others): (i) the HyPET (trademark) Molding System, (ii) the Quadloc (trademark) Molding System, (iii) the HyPET (trademark) Molding System, and (iv) the HyPET (trademark) Molding System, all manufactured by Husky Injection Molding Systems (Location: Canada; Web Site: www.husky.ca).

[0003] U.S. Pat. No. 5,040,589 (Inventor: BRADLEY et al.; Published: 1991-08-20) discloses the following (from line 4 to 24 of column 6): “The barrel is preferably bimetallic having an outer shell of alloy 1-718, which is a high nickel alloy and provides strength and fatigue resistance at operating temperatures in excess of 600° C. Since the alloy 1-718 will corrode rapidly in the presence of magnesium at the temperatures under consideration, a liner of a high cobalt material, such as Stellite 12 (Stoody-Doloro-Stellite Corporation) is shrunk fit onto the inner surface of the barrel. Any appropriate bimetallic barrel having chemical and thermal resistance, sufficient strength to withstand shot pressures, and resistance to wear may be used. A typical magnesium alloy that can be used in practice is AZ91B, containing 90% Mg, 9% Al, and 1% Zn. This alloy has a solidus temperature of 465° C., a liquidus temperature of 596° C., and a desirable slush morphology temperature of approximately 580°-590° C., preferably 585° C. Thus, the apparatus of the subject concept must operate at temperatures which are much higher than those encountered in thermoplastic injection molding.” It appears that U.S. Pat. No. 5,040,589 discloses a barrel (which is an example of a conduit) that uses the combination of Inconel 718 (in the outer shell) and Stellite 12 (in the inner shell).

[0004] U.S. Pat. No. 5,983,975 (Inventor: NILSSON; Published: 1999-11-16) discloses the following (from line 59 of column 3 to line 12 of column 4): “Since the nickel content of the alloy 718 is subject to be corroded by molten magnesium, currently the most commonly used hypereutectic magnesium bar rels have been lined with a sleeve or liner of a magnesium resistant material to prevent the magnesium from attacking the alloy 718. Several such materials are Stellite 12 (nominal 30Cr, 8.3W and 1.4C; Stoody-Doloro-Stellite Corp.), PM 0.80 alloy (nominal 0.8C, 27.81 Cr, 4.11 W and bal. Co. with 0.66N) and Nb-based alloys (such as Nb—30Ti—20W). Obviously, the coefficients of expansion of the barrel and the liner must be compatible to one another for proper working of the machine. Because of the significant cycling of thermal gradient in the barrel, the barrel experiences thermal fatigue and shock. This was found to cause cracking in the barrel and in the barrel liner. Once the barrel liner has become cracked, magnesium can penetrate the liner and attack the barrel. Both the cracking of the barrel and the attacking of the barrel by magnesium were found to have contributed to the premature failure of the above mentioned barrels.” It appears that U.S. Pat. No. 5,983,975 discloses a barrel (an example of a conduit), which uses the combination of Inconel 718 (in the outer shell) and Stellite 12 (in the inner shell).

[0005] U.S. Pat. No. 6,520,762 (Inventor: KESTLE et al.; Published: 2003-02-18) discloses the following (from line 66 of column 11 to line 5 of column 12): “In an application of the machine where the melt of material is a metal in a hexisotropic state, for example, magnesium, the nozzle may be made from DIN 2888 or DIN 2991. The accumulator, first barrel coupler (including the axial force isolator), and the second portion may all be made from INCONEL 718 (a nickel alloy) with a STELLITE 12 (wear-resistant cast non-ferrous alloy) liner. In an application of the machine where the melt of material is plastic, the nozzle may be made from SAE 1440 steel with an H13 tip. The accumulator and first barrel coupler (including the axial force isolator) may be made from 1440 with a cast liner. The second portion may be made from 1440 with a cast liner.” It appears that U.S. Pat. No. 6,520,762 discloses a barrel (an example of a conduit), which uses the combination of Inconel 718 (in the outer shell) and Stellite 12 (in the inner shell).


SUMMARY

[0007] The inventor believes that the problem (which is associated with barrels or conduits used in metal-molding systems) is not understood by persons of skill in the art. According to the current state of the art, molten magnesium alloys are not currently processed above 650 degrees Centigrade by metal-molding systems or metal injection-molding systems because the known barrel assemblies include an outer layer that has an Inconel-718 alloy. Specifically, due to the chemistry associated with the Inconel-718 alloy, heating of molten magnesium alloy above approximately 650 degrees Centigrade is not possible. The problem arises when attempting to manufacture thin-walled metallic articles, such as cell phone housings and/or computer laptop cases because the molten magnesium heated below approximately 650 degrees Centigrade tends to have relatively large globular particles (that is, in relation to the size of the thin-walled article that is to be molded). The large globular particles tend to become stuck in the mold cavity that is configured to mold very thin-walled articles; thus the large globular particles disadvantageously prevent or retard the flow of molten magnesium toward the edges of the mold cavity. Using molten magnesium heated below 650 degrees Centigrade leads to molded articles that have unacceptable thin-walled properties and/or qualities. It is extremely advantageous to manufacture thin-walled articles to be as thin as possible so that there is a savings in weight reduction, and also opens the possibility of making even smaller articles (than what is currently possible with the state of the art in molding thin-walled metallic articles).

[0008] According to a first aspect of the present invention, there is provided a metal-molding conduit assembly, including a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy having a light-metal alloy.
According to a second aspect of the present invention, there is provided a metal-molding conduit assembly, having a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy having a light-metal alloy, the body having: (i) an outer shell, including an Inconel-720 alloy; and (ii) an inner shell being fitted within the outer shell, the inner shell including a corrosion-resistant alloy.

According to a second aspect of the present invention, there is provided a metal-molding conduit assembly, having a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material that includes a molten metallic alloy having a light-metal alloy, such as a magnesium alloy. For manufacturing metallic thin-walled articles, such as cell-phone housings or laptop cases, etc, processing molten magnesium above 650 degrees Centigrade improves the ability to manufacture thin-walled metallic articles (that is, ability to mold even thinner articles), and these thinner articles are not possible to manufacture by using a molding process that uses conduits and/or barrels operating at temperatures of less than approximately 650 degrees Centigrade.

**DETAILED DESCRIPTION OF THE DRAWINGS**

A better understanding of the non-limiting embodiments of the present invention (including alternatives and/or variations thereof) may be obtained with reference to the detailed description of the non-limiting embodiments along with the following drawings, in which:

**FIGS. 1A and 1B depict cross sectional views taken along a longitudinal axis of a metal-molding conduit assembly 100 (hereinafter referred to as the “assembly 100”) according to a first non-limiting embodiment; and**

**FIG. 2 is a schematic representation of the assembly 100 according to a second non-limiting embodiment, a metal-molding system 200 (hereinafter referred to as the “system 200”) according to a third non-limiting embodiment, and a metal injection-molding system 202 (hereinafter referred to as the “system 202”) according to a fourth non-limiting embodiment.**

The drawings are not necessarily to scale and are sometimes illustrated by phantom lines, diagrammatic representations and fragmentary views. In certain instances, details that are not necessary for an understanding of the embodiments or that render other details difficult to perceive may have been omitted.

**DETAILED DESCRIPTION OF THE NON-LIMITING EMBODIMENTS**

**FIG. 1A depicts the cross sectional view taken along the longitudinal axis 101 of the assembly 100, in accordance with a first non-limiting variant of the first non-limiting embodiment. The system 200 may incorporate the assembly 100. The system 202 may incorporate the assembly 100. The assembly 100 may be sold with or sold separately from the system 200 or the system 202. A molded article 204 (depicted in FIG. 2) may be manufactured or made by the system 200 or the system 202 incorporating the assembly 100. The longitudinal axis 101 extends from an input to an output of the assembly 100. The assembly 100 has an outer shell 102, which includes an Inconel-720 alloy. The Inconel-720 alloy withstands higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material 103. The molding material 103 includes a molten metallic alloy that has a light-metal alloy. The light-metal alloy includes a magnesium alloy (for example). Other alloys, such as zinc, aluminum may be used as well.**

**According to a non-limiting variant, the assembly 100 includes a body 105 that is configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy that has a light-metal alloy.**

**FIG. 1B depicts the cross sectional view of the assembly 100 in accordance with a second non-limiting variant of the first non-limiting embodiment, in which the assembly 100 includes: (i) the outer shell 102, and (ii) an inner shell 104. The inner shell 104 is fitted within the outer shell 102. The inner shell 104 includes a corrosion-resistant alloy, which is (preferably) wear resistant. For example, the corrosion-resistant alloy may include a Stellite-12 alloy.**

**According to a non-limiting variant, the assembly 100 has the body 105 that is configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy that has a light-metal alloy. The body 105 has: (i) the outer shell 102 that includes an Inconel-720 alloy, and (ii) the inner shell 104 that is fitted within the outer shell 102. The inner shell 104 includes a corrosion-resistant alloy.**

**FIG. 2 is a schematic representation of the assembly 100, the system 200 and the system 202. The system 200 or the system 202 may include components that are known to persons skilled in the art, and these known components will not be described here; these known components are described, at least in part, in the following text books (by way of example): (i) “Injection Molding Handbook” by Osswald/Turner/Grannan (ISBN: 3-446-21669-2; publisher: Hanser), (ii) “Injection Molding Handbook” by Rosato and Rosato (ISBN: 0-412-99381-5; publisher: Chapman & Hill), and/or (iii) “Injection Molding Systems” 3rd Edition by Johannsen (ISBN 3-446-17733-7).**

**The system 200 (or the system 202) includes (for example): (i) a hopper 210, (ii) a feed throat 212, (iii) an extruder 208, and (iv) a clamp assembly 217. The hopper 210 is connected with the feed throat 212. The feed throat 212 is connected with a barrel assembly 106 of the extruder 108. The extruder 108 may be: (i) a reciprocating-screw (RS) extruder, or (ii) a two-stage extruder that has a shooting pot configuration. A molding material (in the form of chips of solidified magnesium, for example) is received in the hopper 210, and then the molding material is conveyed to the interior of the barrel assembly 106 of the extruder 108 via the feed throat 212. A screw 107 is received in the interior of the barrel assembly 106. The screw 107 is used to move or convey the molding material. A screw actuator 109 is attached to one end of the screw 107. The screw actuator 109 is used to actuate movement of the screw 107. A controller 111 is operatively coupled with the screw actuator 109. The controller 111 is used to control the screw actuator 109. The screw actuator 109 is used to rotate the screw 107, so that the chips of...**
molding material that are received in the barrel assembly 106 may be conveyed along the barrel assembly 106 from the feed throat 212 toward an exit of the barrel assembly 106. Heaters 117 are coupled to the outer surface of the barrel assembly 106. As the chips are conveyed along the barrel assembly 106, the heaters 117 are used to melt the chips into either a semi-solid state or a liquid state (as may be required). A check valve (not depicted, but known) is mounted with a tip of the screw 107, and the check valve is used to collect a shot of molten molding material in an accumulation zone of the barrel assembly 106. The accumulation zone is located at the exit port of the barrel assembly 106. Once the controller 111 issues an injection command to the screw actuator 109, the screw actuator 109 linearly translates the screw 107 so as to push the molten molding material out from the accumulation zone of the barrel assembly 106.

[0021] According to a non-limiting arrangement (which is depicted in FIG. 2), a mold 114 is used to mold articles, and the mold 114 includes or defines multiple mold cavities. For this case, a hot runner 216 is used, and a nozzle assembly 110 is connected with: (i) the exit port of the barrel assembly 106, and (ii) a hot sprue 112. The hot sprue 112 is held or supported in a fixed or stationary position by a stationary platen 152. The mold 114 is attached with the hot runner 216. The hot runner 216 is attached with the hot sprue 112, so that the molten molding material may be conveyed from the barrel assembly 106, to the nozzle assembly 110, to the hot sprue 112, to the hot runner 216, and then to the mold cavities of the mold 114, accordingly.

[0022] According to another non-limiting arrangement (which is not depicted), the mold 114 includes or defines a single mold cavity. For this case, the hot runner 216 not is used, and the nozzle assembly 110 is connected with: (i) the exit port of the barrel assembly 106, and (ii) the hot sprue 112. The mold 114 is attached with the hot sprue 112.

[0023] The clamp assembly 217 includes: (i) a movable platen 150, (ii) the stationary platen 152, (iii) clamp units 154, (iv) rods 156, and (v) nuts 158. The movable platen 150 is movable relative to the stationary platen 152, so that the mold 114 may be closed. The clamp units 154 are fixedly mounted to respective corners of the stationary platen 152. The clamp units 154 are used to apply a clamping force to the mold 114. The nuts 158 are mounted to respective corners of the movable platen 150. The rods 156 are coupled with respective clamp units 154. The rods 156 extend from the respective clamp units 154 to respective nuts 158. The nuts 158 are used to lock the rods 156 relative to the movable platen 150, so that the clamping force may be transmitted from the clamp units 154 to the movable platen 150. As well, the nuts 158 are used to unlock the rods 156 relative to the movable platen 150, so that the movable platen 150 may be moved relative to the stationary platen 152.

[0024] The mold 114 includes: (i) a movable mold portion 140 (hereafter referred to as the “portion 140”), and (ii) a stationary mold portion 142 (hereafter referred to as the “portion 142”). The portion 140 is mounted to the movable platen 150, so that the portion 140 faces the stationary platen 152. The portion 142 is mounted to the hot runner 216, and the hot runner 216 is mounted to the stationary platen 152, so that the portion 142 faces the portion 140.

[0025] According to an alternative arrangement (not depicted), the hot runner 216 is not used, and the portion 140 is mounted to the movable platen 150, and the portion 142 is mounted to the stationary platen 152, so that the portion 142 faces the portion 140.

[0026] In operation, the movable platen 150 is moved (by a mold-stroking actuator, which is not depicted) toward the stationary platen 152 so that the portion 140 may be closed against the portion 142. The nuts 158 lock the platens 150, 152 together, so that the clamp units 154 may be actuated so as to transmit the clamping force to the mold 114. The clamping force is used to prevent the mold 114 from inadvertently releasing (also known as flashing) the molding material from the mold 114 as the mold 114 is filled (under pressure) with the molten molding material that was prepared and injected by the extruder 108. Once the shot of molding material has been collected in the accumulation zone of the barrel assembly 106, the screw actuator 109 is actuated so as to linearly translate the screw 107 forwardly (which causes the check valve to close so as to prevent a backflow of the molten molding material toward the feed throat 212), and in this manner the shot of molten molding material may then be ejected (under pressure) from the barrel assembly 106, through the nozzle assembly 110, and either: (i) directly (as depicted in FIG. 2) to the hot sprue 112, and then to the hot runner 216 and then to the mold cavities of the mold 114, or (ii) directly (which is not depicted) to the hot sprue 112 and then to the mold cavity defined by the mold 114.

[0027] Once the molded article 204 is formed and solidified in the mold cavity of the mold 114, the clamp units 154 stop applying the clamping force, the nuts 158 are unlocked so that then the mold 114 may be broken apart (by application of a mold break force to the mold 114); and then the movable platen 150 may be moved away from the stationary platen 152, so that the molded article 204 may be removed from the mold 114 (either manually or by robot).

[0028] According to a non-limiting variant, the outer shell 102 is included in any one of: (i) the barrel assembly 106, (ii) the nozzle assembly 110, (iii) the hot sprue 112, (iv) the mold 114, (v) components of the hot runner 216, (vi) the screw 107, and/or any combination and permutation thereof.

[0029] According to another non-limiting variant, the outer shell 102 and inner shell 104 are included in any one of: (i) the barrel assembly 106, (ii) the nozzle assembly 110, (iii) the hot sprue 112, (iv) the mold 114, (v) components of the hot runner 216, (vi) the screw 107, and/or any combination and permutation thereof.

[0030] The description of the non-limiting embodiments provides non-limiting examples of the present invention; these non-limiting examples do not limit the scope of the claims of the present invention. The non-limiting embodiments described above may be: (i) adapted, modified and/or enhanced, as may be expected by persons skilled in the art, for specific conditions and/or functions, without departing from the scope of the claims herein, and/or (ii) further extended to a variety of other applications without departing from the scope of the claims herein. It is to be understood that the non-limiting embodiments illustrate the aspects of the present invention. Reference herein to details and description of the non-limiting embodiments is not intended to limit the scope of the claims of the present invention. Other non-limiting embodiments, which may not have been described above, may be within the scope of the appended claims. It is understood that: (i) the scope of the present invention is limited by the claims,
(ii) the claims themselves recite those features regarded as essential to the present invention, and (ii) preferable embodiments of the present invention are the subject of dependent claims. Therefore, what is to be protected by way of letters patent are limited only by the scope of the following claims:

1. A metal-molding conduit assembly, comprising:
   a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy having a light-metal alloy.

2. The metal-molding conduit assembly of claim 1, wherein:
   the body includes:
   an Inconel-720 alloy.

3. The metal-molding conduit assembly of claim 1, wherein:
   the light-metal alloy includes a magnesium alloy.

4. The metal-molding conduit assembly of claim 1, wherein:
   the body includes:
   an outer shell, including:
   an Inconel-720 alloy.

5. The metal-molding conduit assembly of claim 1, wherein:
   the body includes:
   an inner shell being fitted within an outer shell, the inner shell, including:
   a corrosion-resistant alloy.

6. The metal-molding conduit assembly of claim 1, wherein:
   the body includes:
   an inner shell being fitted within an outer shell, the inner shell, including:
   a corrosion-resistant alloy, the corrosion-resistant alloy includes:
   a Stellite-12 alloy.

7. The metal-molding conduit assembly of claim 1, wherein:
   the body is included in a barrel assembly of an extruder.

8. The metal-molding conduit assembly of claim 1, wherein:
   the body is included in a nozzle assembly.

9. The metal-molding conduit assembly of claim 1, wherein:
   the body is included in a hot sprue.

10. The metal-molding conduit assembly of claim 1, wherein:
    the body is included in a screw.

11. The metal-molding conduit assembly of claim 1, wherein:
    the body is included in a mold.

12. The metal-molding conduit assembly of claim 1, wherein:
    the body is included in a hot runner.


14. A metal-molding conduit assembly, comprising:
    a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy having a light-metal alloy, the body includes:
    an outer shell, including:
    an Inconel-720 alloy; and
    an inner shell being fitted within the outer shell, the inner shell, including:
    a corrosion-resistant alloy.

15. The metal-molding conduit assembly of claim 14, wherein:
    the light-metal alloy includes:
    a magnesium alloy.

16. The metal-molding conduit assembly of claim 14, wherein:
    the corrosion-resistant alloy includes a Stellite-12 alloy.

17. The metal-molding conduit assembly of claim 14, wherein:
    the outer shell is included in a barrel assembly of an extruder.

18. The metal-molding conduit assembly of claim 14, wherein:
    the outer shell is included in a nozzle assembly.

19. The metal-molding conduit assembly of claim 14, wherein:
    the outer shell is included in a screw.

20. The metal-molding conduit assembly of claim 14, wherein:
    the outer shell is included in a mold.

21. The metal-molding conduit assembly of claim 14, wherein:
    the outer shell is included in a hot runner.

22. A metal-molding system incorporating the metal-molding conduit assembly of claim 14.


25. A metal-molding conduit assembly, comprising:
    a body being configured to withstand higher temperatures, from approximately 30 to approximately 40 degrees Centigrade above approximately 650 degrees Centigrade for processing a molding material, and the molding material includes a molten metallic alloy having a light-metal alloy, the body includes:
    an outer shell, including:
    an Inconel-720 alloy; and
    an inner shell being fitted within the outer shell, the inner shell, including:
    a corrosion-resistant alloy, a Stellite-12 alloy, wherein the outer shell and the inner shell are included in any one of:
    a barrel assembly of an extruder,
    a nozzle assembly,
    a hot sprue,
    a screw,
    a mold, and
    a hot runner.

* * * * *