

DIE CASTING OF COMPONENT HAVING INTEGRAL SEAL

BACKGROUND

This disclosure generally relates to die casting, and more particularly to die
5 casting components with integral seals.

Gas turbine engines generally include a compressor section, a combustor
section, and a turbine section circumferentially disposed about an engine centerline
axis. At least the compressor section and the turbine section include alternating rows
of rotating rotor blades and static stator vanes. As airflow is communicated through
10 the gas turbine engine, the rotor blades increase the velocity of the oncoming airflow.
The stator vanes convert the velocity into pressure and prepare the airflow for the next
set of rotor blades.

Gas turbine engine components can be manufactured in a number of ways
including machining operations, forging operations or casting operations. Gas turbine
15 engine components are often manufactured in an investment casting process.
Investment casting involves pouring molten metal into a ceramic shell having a cavity
in the shape of the component to be cast. An abradable seal, such as a honeycomb
seal, can be brazed onto the gas path side of a gas turbine engine component to
improve the seal between the gas turbine engine component and any surrounding
20 components.

SUMMARY

A method of die casting a component having an integral seal includes defining
a first portion of a die cavity of a die to include an open cell structure. A second
25 portion of the die is defined without the open cell structure. Molten metal is injected
into the die cavity, and the molten metal is solidified within the die cavity to form the
component having the integral seal.

In another exemplary embodiment, a die casting machine includes a die
comprised of a plurality of die elements that define a die cavity, a shot tube in fluid
30 communication with the die cavity, and a shot tube plunger moveable within the shot
tube. The die cavity includes a first portion having an open cell structure and a
second portion without the open cell structure. The shot tube plunger is moveable

within the shot tube to communicate a molten metal into the die cavity to die cast a component having an integral seal.

The various features and advantages of this disclosure will become apparent to those skilled in the art from the following detailed description. The drawings that
5 accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a simplified cross-sectional view of a standard gas turbine engine.

10 Figure 2 illustrates a cross-sectional view of a portion of the gas turbine engine depicted in Figure 1.

Figure 3 illustrates an example die casting system.

Figure 4 illustrates an example die for use with a die casting system.

Figure 5 illustrates an insert having an open cell structure that can be used
15 with the die of Figure 4.

Figure 6 illustrates another example die for use with the die casting system of Figure 3.

Figure 7 illustrates a component having an integral seal that can be cast using the die of Figure 4 or Figure 6.

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DETAILED DESCRIPTION

Figure 1 illustrates a gas turbine engine 10, such as a turbofan gas turbine engine, that is circumferentially disposed about an engine centerline (or axial centerline axis) 12. The gas turbine engine 10 includes a fan section 14, a compressor
25 section 15 having a low pressure compressor 16 and a high pressure compressor 18, a combustor 20, and a turbine section 21 including a high pressure turbine 22 and a low pressure turbine 24. This disclosure can also extend to engines without a fan, and with more or fewer sections.

As is known, air is compressed in the low pressure compressor 16 and the high
30 pressure compressor 18, is mixed with fuel and burned in the combustor 20, and is expanded in the high pressure turbine 22 and the low pressure turbine 24. Rotor assemblies 26 rotate in response to the expansion, driving the low pressure and high pressure compressors 16, 18 and the fan section 14. The compressorsection 15 and

the turbine section 21 may include alternating rows of rotating rotor blades 28 and static stator vanes 30.

It should be understood that this view is included simply to provide a basic understanding of the sections of a gas turbine engine 10 and not to limit the disclosure. This disclosure extends to all types of gas turbine engines 10 for all types of applications.

Figure 2 illustrates a portion of the gas turbine engine 10. In this example, the portion depicted is the high pressure turbine 22 of the gas turbine engine 10. However, this disclosure is not limited to applications within the high pressure turbine 22, and could extend to other sections of a gas turbine engine 10, including but not limited to, the low pressure turbine 24 and the compressor section 15. In addition, selected features of the high pressure turbine 22 are shown enlarged in order to illustrate specific details and are not shown to the scale they would be in operation.

The high pressure turbine section 22 includes a rotor assembly 26 having a plurality of rotor blades 28 (one depicted) extending outwardly from the circumference of the rotor assembly 26. The rotor blades 28 extend between a rim 27 of the rotor assembly 26 and a blade tip 40.

An outer casing 42 extends circumferentially about the high pressure turbine section 22 at a position radially outward from the rotor blades 28. The outer casing 42 includes a plurality of blade outer air seals (BOAS) 44 positioned between the blade tips 40 of the rotor blades 28 and the outer casing 42. The BOAS 44 includes an integral seal 46, such as an abradable seal, that interacts with the rotor blades 28 to mitigate gas leakage. During operation, the rotor blades 28 rotate about the engine centerline axis 12 and at least partially wear away a portion of the integral seal 46 to seal and mitigate gas leakage around the components within the high pressure turbine section 22. In the illustrated example, a portion 45 has been partially worn away by the rotor blade 28.

Figure 3 illustrates a diecasting system 48 for die casting a component, such as the BOAS 44 or other seals. However, this disclosure is not limited to the die casting of BOAS, and it should be understood that any aeronautical or non-aeronautical component can be die cast with an integral seal according to the example methodologies of this disclosure.

The die casting system 48 includes a reusable die 50 having a plurality of die elements 52, 54 that function to cast the component. Although two die elements 52, 54 are depicted in Figure 3, it should be understood that the die 50 could include more or fewer die elements, as well as other parts and configurations.

5 The die 50 is assembled by positioning the die elements 52, 54 together and holding the die elements 52, 54 at a desired position via a mechanism 56. The mechanism 56 could include a clamping mechanism of appropriate hydraulic, pneumatic, electromechanical and/or other configurations. The mechanism 56 also separates the die elements 52, 54 subsequent to casting.

10 The die elements 52, 54 define internal surfaces that cooperate to define a die cavity 58. A shot tube 53 is in fluid communication with the die cavity 58 via one or more ports 60 located in the die element 52, the die element 54 or both. A shot tube plunger 62 is received within the shot tube 53 and is moveable between a retracted and injected position (in the direction of arrow A) within the shot tube 53 by a
15 mechanism 64. The mechanism 64 could include a hydraulic assembly or other suitable mechanism, including, but not limited to, pneumatic, electromechanical or any combination thereof.

 The shot tube 53 is positioned to receive a molten metal from a melting unit 66, such as a crucible, for example. The melting unit 66 may utilize any known
20 technique for melting an ingot of metallic material to prepare molten metal for delivery to the shot tube 53, including but not limited to, vacuum induction melting, electron beam melting and induction scald melting. The molten metal is melted by the melting unit 66 at a location that is separate from the shot tube 53 and the die 50. In this example, the melting unit 66 is positioned in relatively close proximity to the
25 shot tube 53 to reduce the required transfer distance between the molten metal and the shot tube 53.

 Example molten metals capable of being used to die cast a component include, but are not limited to, nickel base super alloys, cobalt alloys, titanium alloys, high temperature aluminum alloys, copper based alloys, iron alloys, molybdenum,
30 tungsten, niobium, or other refractory metals. This disclosure is not limited to use of the disclosed alloys, and it should be understood that any high melting temperature material may be utilized to die cast a component. As used herein, the term “high

melting temperature material” is intended to include materials having a melting temperature of approximately 1500°F/815°C and higher.

The molten metal is transferred from the melting unit 66 to the shot tube 53 in a known manner, such as pouring the molten metal into a pour hole 55 in the shot tube 53, for example. A sufficient amount of molten metal is communicated into the shot tube 53 to fill the die cavity 58. The shot tube plunger 62 is actuated to inject the molten metal under pressure from the shot tube 53 into the die cavity 58 to cast the component. Although the casting of a single component is depicted, the die casting system 48 could be configured to cast multiple components in a single shot.

Although not necessary, at least a portion of the example die casting system 48 can be positioned within a vacuum chamber 70 that includes a vacuum source 72. A vacuum is applied in the vacuum chamber 70 by the vacuum source 72 to render a vacuum die casting process. The vacuum chamber 70 provides a non-reactive environment for the die casting system 48 that reduces reaction, contamination or other conditions that could detrimentally affect the quality of the cast component, such as excess porosity of the cast component that occurs as a result of exposure to oxygen. In one example, the vacuum chamber 70 is maintained at a pressure between 1×10^{-3} Torr and 1×10^{-4} Torr, although other pressures are contemplated. The actual pressure of the vacuum chamber 70 will vary based upon the type of component being cast, among other conditions and factors. In the illustrated example, each of the melting unit 66, the shot tube 53 and the die 50 are positioned with the vacuum chamber 70 during the die casting process such that the melting, injecting and solidifying of the metal are all performed under vacuum. In another example, the vacuum chamber 34 is backfilled with an inert gas, such as Argon, for example.

The example die casting system 48 depicted in Figure 3 is illustrative only and could include more or less sections, parts and/or components. This disclosure extends to all forms of die casting, including but not limited to, horizontal, inclined or vertical die casting systems.

Figure 4 illustrates an example die 150 for use with a die casting system, such as the die casting system 48 depicted in Figure 3. In this disclosure, like reference numerals signify like features, and reference numerals identified in multiples of 100 signify slightly modified features. Moreover, select features of one example embodiment may be combined with selected features of other example embodiments.

The die 150 may be used to die cast a component, such as a BOAS having an integral seal, or any other component.

The die 150 includes a die cavity 158 that is defined by a plurality of die elements 152, 154. The die cavity 158 includes a first portion 80 and a second portion 82. In the illustrated example, the first portion 80 and the second portion 82 are openings within the die 150. Although the example die cavity 158 is depicted as including two portions, it should be understood that more or less portions may define the die cavity 158. Also, the size of shape of the first portion 80 and the second portion 82 will vary depending upon design specific parameters including, but not limited to, the type of component being cast.

In this example, the first portion 80 of the die cavity 158 is configured to receive an insert 84. The insert 84 is generally sized and shaped similar to the first portion 80. In the example embodiment, the insert 84 is a honeycomb seal made of a Nickel Alloy or other high melting temperature material that includes an open cell structure 85 that defines walls 87 having openings 88 therebetween, such as diamond shaped openings (See Figure 5). Other inserts having different structures are contemplated as being within the scope of this disclosure. The insert 84 is positioned within the first portion 80 of the die cavity 158 either manually or automatically, such as with a robot, for example.

The second portion 82 of the die cavity 158 does not include the open cell structure. Therefore, the second portion 82 represents a void or opening within the die 150 that is sized and shaped to correspond to the component being cast. The second portion 82 of the die cavity 158 receives molten metal M from a die casting system, such as the die casting system 48 detailed above. Molten metal M is injected into the die cavity 158 via the shot tube 53 and the shot tube plunger 62 and is solidified within the die cavity 158. The molten metal M locally bonds with the insert 84 at an interface I during solidification of the molten metal M to cast a component having an integral seal. In other words, the component is die cast against the insert 84, thereby overcasting the component (the portion solidified in the second portion 82) having an integral seal (the locally bonded insert 84 located in the first portion 80) in a single operation.

Figure 6 illustrates another exemplary die 250 that may be used with a die casting system, such as the die casting system 48 depicted above. The die 250 is

utilized to die cast a component having an integral seal, such as a BOAS having a honeycomb seal, for example. Other aeronautical and non-aeronautical components may also be cast using the die 250.

The die 250 includes a die cavity 258 defined by a plurality of die elements 252, 254. The die cavity 258 defines a first portion 280 and a second portion 282, although more or fewer portions may be defined within the die cavity 258. Also, the size of shape of the first portion 280 and the second portion 282 will vary depending upon design specific parameters including, but not limited to, the type of component being cast.

In this example, the first portion 280 of the die cavity 258 is pre-defined with an open cell structure 285 that corresponds to a desired structure of an integral seal. That is, the first portion 280 of the die cavity 258 is formed with design features, such as a honeycomb, open cell structure, that are automatically form corresponding features within a cast component once molten metal is injected into the die cavity 258, i.e., no inserts are required. The open cell structure 285 may be formed within the first portion 280 of the die cavity 258 in any known manner. The first portion 280 defines the integral seal on the cast component.

The second portion 282 is defined without an open cell structure. Therefore, the second portion 282 represents a void or opening within the die 250 that is sized and shaped to correspond to the component being cast. The second portion 282 of the die cavity 258 is made larger by a distance X to define the first portion 280, which forms the integral seal portion of the cast component. That is, enlarging the second portion 282 of the die cavity 258 by a distance X allows the integral seal to be die cast as a feature of the component during the die casting process.

Subsequent to melting, molten metal M is injected into the die cavity 258 and is communicated to both the first portion 280 and the second portion 282 of the die cavity 258. The molten metal solidifies within the die cavity 258 to form a component having an integral seal. Because the first portion 280 is defined with an open cell structure, once solidified, the molten metal forms a component having an integral seal with a desired structure, such as a honeycomb seal structure, for example.

Figure 7 illustrates a component 29 that may be die cast using the example dies 150, 250 described above. The component 29 includes a body portion 31 and an integral seal 33. Each of the body portion 31 and the integral seal 33 may be made

from nickel based super alloys, cobalt alloys, titanium alloys, high temperature aluminum alloys, copper based alloys, iron alloys, molybdenum, tungsten, niobium, other refractory metals, or any combination of such materials. Any high melting temperature material may be utilized to die cast the component 29. In this example,
5 the component 29 is a seal having an integral seal 33 with an open cell structure 35, although other components may also be cast using the example dies 150, 250, including but limited to BOAS, inner air seals and 1-2 seals. The integral seal 33 is a honeycombabradeable seal such that contact with a rotor blade partially wears away the integral seal 33.

10 The foregoing description shall be interpreted as illustrative and not in any limiting sense. A worker of ordinary skill in the art having the benefit of this disclosure would recognize that certain modifications could come within the scope of the disclosure. For these reasons, the following claims should be studied to determine the true scope and content of this disclosure.

CLAIMS

1. A method of die casting a component with an integral seal, comprising the step of:
 - 5 (a) defining a first portion of a die cavity of a die to include an open cell structure;
 - (b) defining a second portion of the die cavity without the open cell structure;
 - (c) injecting molten metal into the die cavity;
 - 10 (d) solidifying the molten metal within the die cavity to form the component with the integral seal.
2. The method as recited in claim 1, wherein said step (a) includes:
positioning an insert that defines the open cell structure within the first portion
15 of the die cavity.
3. The method as recited in claim 2, wherein said step (d) includes:
locally bonding the insert with the component to provide the component with
the integral seal.
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4. The method as recited in claim 2, wherein the insert is a honeycomb
abradeable seal.
5. The method as recited in claim 1, wherein said step (a) includes:
25 pre-defining the open cell structure in the first portion of the die cavity.
6. The method as recited in claim 5, wherein said step (a) includes:
forming honeycomb design features within the first portion of the die cavity.
- 30 7. The method as recited in claim 1, wherein said step (c) includes:
melting an ingot of material to prepare the molten metal;
communicating the molten metal into a shot tube; and
injecting the molten metal into the die cavity with a shot tube plunger.

8. The method as recited in claim 1, wherein the component is a seal having an integral honeycomb abraadeable seal.
9. The method as recited in claim 1, comprising the step of:
- 5 (e) positioning the die within a vacuum chamber.
10. The method as recited in claim 1, wherein the first portion and the second portion of the die cavity are openings within the die, and the first portion defines the integral seal and the second portion defines the component.
- 10 11. A die casting system, comprising:
- a die comprised of a plurality of die components that define a die cavity, wherein a first portion of said die cavity includes an open cell structure and a second portion of said die cavity is without said open cell structure;
- 15 a shot tube in fluid communication with said die cavity; and
- a shot tube plunger moveable within said shot tube to communicate a molten metal into said die cavity to cast a component that includes an integral seal.
12. The system as recited in claim 11, wherein said component includes one of an
- 20 outer seal and an inner seal.
13. The system as recited in claim 11, wherein said integral seal is a honeycomb abraadeable seal.
- 25 14. The system as recited in claim 11, wherein said die casting system is positioned within a vacuum chamber.
15. The system as recited in claim 11, comprising an insert received within said first portion of said die cavity, wherein said insert defines said open cell structure.