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United States Patent	12383954
Kind Code	B1
Date of Patent	August 12, 2025
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System and method of preparing a metal object for machining

Abstract

A system and method of preparing a metal object for machining, wherein the metal object comprises at least two working portions that are to be machined and that are connected to remote sides or ends of an intermediate portion of the metal object, the method comprising: inserting the intermediate portion into a casting mold, such that the at least two working portions protrude from the casting mold; pouring a liquid metal material into the casting mold so as to cover the intermediate portion; allowing the liquid metal to cool, thereby forming a cast bulk surrounding the intermediate portion of the metal object; and removing the casting mold, whereby the cast bulk enables machining of the at least two working portions to be carried out while the second cast segment is being held.

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Appl. No.: **19/039795**

Filed: **January 29, 2025**

Publication Classification

Int. Cl.: **B22D19/00** (20060101); **B22D25/02** (20060101); **B22D29/00** (20060101); **B23P15/02** (20060101); B22C9/22 (20060101); B22D17/20 (20060101); B22D19/10 (20060101)

U.S. Cl.:

CPC **B22D19/009** (20130101); **B22D25/02** (20130101); **B22D29/003** (20130101); **B23P15/02** (20130101); B22C9/22 (20130101); B22D17/2076 (20130101); B22D19/10 (20130101); Y10T29/49799 (20150115); Y10T29/49812 (20150115); Y10T29/49989 (20150115)

Field of Classification Search

CPC: B23P (15/02); B22D (17/2076); B22D (19/009); B22D (19/10); B22D (25/02); B22D (29/003); Y10T (29/49799); Y10T (29/49812); Y10T (29/49989); B22C (9/22)

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Background/Summary

FIELD OF THE INVENTION

(1) The present invention relates to machining of a metal object. More particularly, the present invention relates to systems and methods for preparing a metal object to enable machining of multiple parts of the metal object.

BACKGROUND OF THE INVENTION

(2) Metal fabrication or machining is a known process of shaping elements (e.g., elements made of alloys), and modification of their physical dimensions, by removing any unwanted material from the element, for instance by use of a sharp cutting tool.

(3) The goal of such a machining process is to produce an element that has a desired size and shape. For example, machining may be carried out by, e.g., drilling, turning, milling, and grinding.

(4) In order for machining to accurately shape delicate or small objects, it may be necessary for the delicate or small objects to be tightly gripped during this process in order to prevent movement of the object during machining. However, tight gripping may also cause damage to such delicate or small objects.

(5) Thus, a known process of encapsulation is applied in which a material having a low melting temperature encapsulates the delicate or small object, and it is the encapsulating material, rather than the object itself, that is then gripped during the machining process.

(6) For example, a material with a melting temperature of 150-200 degrees Celsius can be poured in liquid form to encapsulate a metallic object for machining, while keeping out of the encapsulation material the specific portion of the metallic object that is to be machined.
(7) Once the desired form of the encapsulation surrounding the object is achieved, the material can be cooled until the encapsulation material is solidified, so as to enable the hardened encapsulation material to be gripped while the portion of the object outside the encapsulation is being machined.
(8) After machining is completed, heat may be applied to the encapsulation to liquefy the material in order to remove the object therefrom.
(9) Currently, as described below, separate molds are required for machining different parts of an object, since a different mold would be needed for each portion of the object that is intended to undergo machining.
(10) Reference is made to FIGS. **1**A and **1**B, which show illustrations of prior art encapsulation of a metal object **10**. Some portions of the metal object **10** can be intended for machining, such as portions **11** and **12**, while other portions of the metal object **10** are intended for other uses without machining, such as intermediate portion **13**. FIGS. **1**A and **1**B illustrate the two stages during which portions **11** and **12** of object **10** can be machined.
(11) FIG. **1**A shows the first stage encapsulation of the metal object **10**, such that portion **12** is available for machining. As shown in FIG. **1**A, prior art methods for machining the metal object **10** include encapsulating portions **11** and **13** of the metal object **10** by a dedicated material **20**, such that the encapsulation material **20** surrounds portions **11** and **13** of the metal object **10**.
(12) The dedicated material may be, for example, a metal with a low melting point temperature.
(13) A portion **12** of the metal object **10** that is to be machined is kept outside of the encapsulation material **20** in order to allow machining (e.g., by an external tool not shown in FIG. **1**A) of portion **12**.
(14) In order for accurate machining of portion **12** to be enabled, the encapsulation **20** may be tightly held by an external tool (not shown in FIG. **1**A) so as to prevent movement of portion **12** during the machining process.
(15) Portions **11** and **13** of the metal object **10** are unchanged during the machining process, since they are encased within encapsulation material **20**, and the encapsulation **20** is tightly held during the machining process, thereby protecting portions **11** and **13** of the metal object **10**.
(16) Once the machining of portion **12** is completed, the encapsulation material **20** may be removed from around portions **11** and **13** of metal object **10**.
(17) For instance, in one embodiment, the encapsulation material **20** may be removed by heating it to its melting point, such that the liquid material **20** can be removed, leaving only the unencased metal object **10**.
(18) FIG. **1**B shows the second stage encapsulation of the metal object **10**, such that portion **11** is available for machining. In one embodiment, as shown in FIG. **1**B, once the machining of portion **12** is completed, and the encapsulation **20** shown in FIG. **1**A is removed, portions **12** and **13** of the metal object **10** are encased by low melting point temperature material **21**, such that a new encapsulation **21** surrounds portions **12** and **13** of the metal object **10**.
(19) At this stage, portion **11** of the metal object **10** that is to be machined is kept outside of the encapsulation material **21** to allow it to be machined (e.g., by an external tool not shown in FIG. **1**B).
(20) In order for accurate machining of portion **11** to be enabled, the encapsulation **21** may be tightly held by an external tool (not shown in FIG. **1**B) so as to prevent movement of portion **11** during the machining process.
(21) Portions **12** and **13** of the metal object **10** are unchanged during the machining process, since they are encased within encapsulation material **21**, and the encapsulation **21** is tightly held during the machining process, thereby protecting portions **12** and **13** of the metal object **10**.
(22) Once the machining of portion **11** is completed, the encapsulation material **21** may be removed

from around portions **12** and **13** of metal object **10**.
(23) For instance, in one embodiment, the encapsulation material **21** may be removed by heating it to its melting point, such that the liquid material **21** can be removed, leaving an unencased metal object **10**, after machining of both portions **11** and **12**.
(24) As illustrated in FIGS. **1**A and **1**B, a process of machining separate portions of an object requires performing a separate encapsulation for each of the portions to be machined. This process is costly, time consuming and cumbersome. Accordingly, another solution is required in order to reduce the costs and time for such machining.
(25) It would be desirable to provide a system and method for preparing a metal object to enable machining of multiple parts of the metal object.

SUMMARY OF THE INVENTION

(26) There is thus provided in accordance with some embodiments of the invention, a method of preparing a metal object for machining, wherein the metal object includes at least two working portions, i.e., portions that are to be machined, that are connected to opposite or remote sides or ends of an intermediate portion of the metal object, including: inserting the intermediate portion into a casting mold, such that the at least two working portions protrude from the casting mold, pouring a liquid metal material into the casting mold so as to cover the intermediate portion, allowing the liquid metal to cool, thereby forming a cast bulk surrounding the intermediate portion of the metal object, wherein the cast bulk includes a first cast segment that is adjacent to and surrounds the intermediate portion and a second cast segment that is remote from the intermediate portion, and removing the casting mold.
(27) In some embodiments, the cast bulk enables machining of the at least two working portions of the object to be carried out while the second cast segment is being held.
(28) In some embodiments, the cast bulk is configured such that heating of the cast bulk back into the liquid metal will allow the liquid metal to be removed from the intermediate portion.
(29) In some embodiments, the intermediate portion of the metal object maintains structural integrity during machining of the at least two portions.
(30) In some embodiments, the metal object is an airfoil.
(31) In some embodiments, the liquid metal is a Cerrotru alloy.
(32) In some embodiments, machining is carried out on the at least two working portions.
(33) In some embodiments, machining of the at least two working portions is configured to be carried out simultaneously.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanied drawings. Embodiments of the invention are illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like reference numerals indicate corresponding, analogous or similar elements, and in which:
(2) FIGS. **1**A and **1**B show illustrations of prior art encapsulation of a metal object;
(3) FIG. **2** shows an illustration of a cross-section view of a metal object that is being prepared for machining, according to some embodiments of the invention;
(4) FIGS. **3**A-**3**E show an illustration of the metal object, within a cast bulk, that is being prepared for machining, according to some embodiments of the invention; and
(5) FIG. **4** shows a flowchart for a method of machining at least two metal objects, according to

some embodiments of the invention.
(6) It will be appreciated that, for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE INVENTION

(7) In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details.
(8) In other instances, well-known methods, procedures, and components, modules, units and/or circuits have not been described in detail so as not to obscure the invention.
(9) Some features or elements described with respect to one embodiment may be combined with features or elements described with respect to other embodiments.
(10) For the sake of clarity, discussion of same or similar features or elements may not be repeated.
(11) Although embodiments of the invention are not limited in this regard, discussions utilizing terms such as, for example, “processing”, “computing”, “calculating”, “determining”, “establishing”, “analyzing”, “checking”, or the like, may refer to operation(s) and/or process(es) of a computer, a computing platform, a computing system, or other electronic computing device, that manipulates and/or transforms data represented as physical (e.g., electronic) quantities within the computer's registers and/or memories into other data similarly represented as physical quantities within the computer's registers and/or memories or other information non-transitory storage medium that may store instructions to perform operations and/or processes.
(12) Although embodiments of the invention are not limited in this regard, the terms “plurality” and “a plurality” as used herein may include, for example, “multiple” or “two or more”.
(13) The terms “plurality” or “a plurality” may be used throughout the specification to describe two or more components, devices, elements, units, parameters, or the like. The term set when used herein may include one or more items.
(14) Unless explicitly stated, the method embodiments described herein are not constrained to a particular order or sequence. Additionally, some of the described method embodiments or elements thereof may occur or be performed simultaneously, at the same point in time, or concurrently.
(15) Reference is now made to FIG. **2**, which shows an illustration of a cross-section view of a metal object **100** that is being prepared for machining, according to some embodiments of the invention.
(16) Since many objects for which machining may be needed may be fragile and cannot be tightly held for the machining process without being damaged, an improved method and system are provided to protect the object while reducing the required costs and working time.
(17) According to some embodiments, metal objects may be produced (e.g., in a factory) as a single unit including multiple portions of which machining is subsequently needed (referred hereinafter as “working portions”), for instance in order to reduce costs and working time for production.
(18) Such a metal object **100** may include at least two working portions **110**, **120** that are to be machined, wherein the at least two working portions **110**, **120** may be connected to different, e.g., remote, ends of an intermediate portion **130** of the metal object **100**.
(19) In some embodiments, as discussed hereinbelow, metal object **100** may include an airfoil, e.g., used for a jet engine. An airfoil is a thin metal sheet with defined and/or precise geometry. Clamping of an airfoil for the purpose of machining may require special tools or materials, while clamping of a simple surface may require simple clamping tools. In some embodiments, after machining of the at least two working portions **110**, **120**, those at least two working portions **110**, **120** may be removed for other uses, while the intermediate portion **130** remains to be utilized for an airfoil.

(20) The metal object **100** may be inserted into a dedicated casting mold (not shown in FIG. **2**) such that the intermediate portion **130** is within the casting mold but the at least two working portions **110**, **120** are without, e.g., protrude from, the casting mold.
(21) A metallic material, with a low melting point temperature, may be poured, while in liquid form, into the casting mold, so as to surround intermediate portion **130** of metal object **100** (that is within the casting mold), i.e., for encapsulation.
(22) Once the metallic material is cooled and solidifies around intermediate portion **130**, a cast bulk **200** may be formed by the cooled metallic material in the shape of the casting mold.
(23) The cast bulk **200** may include a first cast segment **210** that is adjacent to and surrounds the intermediate portion **130**, and a second cast segment **220** that is remote from the intermediate portion **130**. In some embodiments, the second cast segment **220** is configured to be held by an external tool.
(24) In some embodiments, the size and/or shape of the first cast segment **210** may be different from the size and/or shape of the second cast segment **220** to allow access to the at least two working portions **110**, **120** of metal object **100** for machining.
(25) In some embodiments, the size and/or shape of the first cast segment **210** may be adapted for various shapes and/or sizes of the intermediate portion **130**, such that the entire intermediate portion **130**, but not working portions **110**, **120** that protrude from intermediate portion **130**, is surrounded by, and is protected by, the first cast segment **210** during machining.
(26) For example, intermediate portion **130** may maintain structural integrity during machining of the at least two working portions **110**, **120** of metal object **100** due to the protection of the first cast segment **210**.
(27) Once the metallic material has cooled and has solidified around intermediate portion **130**, the casting mold (not shown in FIG. **2**) may be removed, allowing cast bulk **200** to be held (e.g., by an external tool not shown in FIG. **2**) for machining of the at least two working portions **110**, **120**.
(28) For example, the casting mold (not shown in FIG. **2**) may be removed by mechanical means.
(29) Thus, there is no need to use separate molds for different parts of the metal object **100** that have different sizes and/or shapes, since use of a cast bulk **200** is applicable to all shapes and/or sizes that can fit within the particular casting mold. For example, a size difference of only 5 millimeters between two different metal objects may normally cause a significant difference in structural integrity during machining if mold is in the wrong size for these objects. Accordingly, the external size and/or shape of the cast bulk **200** is unchanged for different sizes of a metal object that can fit within the particular casting mold.
(30) In some embodiments, the external size and/or shape of the cast bulk **200** is unchanged for different types of metal object **100**, while the external opening that accommodates the intermediate portion **130** of the metal object **100** may vary. For example, two different cast bulks may be used for two different intermediate portion such as intermediate portion **130**.
(31) According to some embodiments, the at least two working portions **110**, **120** may be machined simultaneously, while the cast bulk **200** is being held by an external tool.
(32) In some embodiments, the at least two working portions **110**, **120** may be machined separately and at different times, while the cast bulk **200** is being held by an external tool.
(33) Reference is now made to FIGS. **3**A-**3**E, which show an illustration of the metal object **100**, within the cast bulk **200**, that is being prepared for machining, according to some embodiments of the invention.
(34) FIG. **3**A shows the metal object **100** to be prepared for machining. The metal object **100** includes at least two working portions **110**, **120** at opposite ends of the intermediate portion **130**.
(35) As shown in FIG. **3**B, cast bulk **200**, which encapsulates intermediate portion **130** but not working portions **110**, **120**, may be created by a casting mold **300**, shown in FIG. **3**C. When the metal object **100** is placed within the casting mold **300**, the at least two working portions **110**, **120** may protrude outward from casting mold **300** (in order to be accessible for machining at a later

stage), while the intermediate portion **130** is covered by the cast bulk **200**.
(36) FIG. **3**C shows the metal object **100** positioned within the cast bulk **200** in casting mold **300**. As seen in FIG. **3**D, the cast bulk **200** includes a first cast segment **210** that is adjacent to and surrounding the intermediate portion **130**, and a second cast segment **220** that is remote from the metal object **100**.
(37) The machining process of two distinct portions of object **100** becomes more efficient, even when the at least two working portions **110**, **120** will be machined separately, since there is no longer a need for multiple encapsulation/decapsulation processes of the multiple portions of the metal object when different parts need to be machined.
(38) Once the machining of the at least two working portions **110**, **120** is completed, the cast bulk **200** may be removed from around the intermediate portion **130** of metal object **100**, as described above.
(39) In some embodiments, the metallic material is recyclable and, once melted and separated from the metal object **100**, may be used again for the next unit in liquid form.
(40) For example, the metallic material may include a Cerrotru alloy having a melting point temperature of 138 degrees Celsius (281° Fahrenheit).
(41) FIG. **3**D shows the metal object **100** positioned within the cast bulk **200**, wherein a portion of the prepared metal object **350**, which is the prepared version of metal object **100** after machining has been completed positioned within the cast bulk **200** after machining of working portions **110**, **120** has been completed, and FIG. **3**E shows the prepared metal object **350** after the cast bulk **200** has been removed.
(42) For instance, in one embodiment, the metallic material of the cast bulk **200** may be removed by heating it to its melting point, such that the liquid material may be removed, leaving only the prepared metal object **350**.
(43) Once the machining of the at least two working portions **110**, **120** is completed, as shown in FIG. **3**E, the prepared metal object **350** has prepared portions **310**, **320** that result from the machining of working portions **110**, **120**, respectively, which are portions of the prepared metal object **350** that may be utilized separately, or alternatively utilized as a single unit. For example, the prepared portions **310**, **320** of the prepared metal object **350** may be utilized in manufacturing of additional objects (e.g., such as airfoils).
(44) Reference is made to FIG. **4**, which shows a flowchart for a method of preparing a metal object for machining, according to some embodiments of the invention.
(45) The at least two working portions **110**, **120** of the metal object **100** may be connected to opposite sides or ends of an intermediate portion **130** of the metal object **100** (e.g., as shown in FIG. **2**).
(46) In some embodiments, the metal object **100** may be inserted **401** into a casting mold, such that the at least two working portions protrude from the casting mold. Then, a liquid metallic material may be poured **402** into the casting mold such that the intermediate portion **130** is covered by the liquid metallic material but such that the at least two working portions **110**, **120** are not covered by the liquid metallic material.
(47) The liquid metallic material may cool **403**, thereby forming a cast bulk **200** surrounding the intermediate portion **130**, wherein the cast bulk **200** includes a first cast segment **210** that is adjacent to and surrounds the intermediate portion **130** and a second segment **220** that is remote from the intermediate portion.
(48) The casting mold may be then removed **404**, and the second cast segment **220** of the cast bulk **200** may be held by an external tool to enable machining of the at least two working portions **110**, **120** of the metal object **100** that protrude from the cask bulk **200**.
(49) In some embodiments, the machining may be carried out while the second cast segment **220** is being held by an external tool.
(50) In some embodiments, the machining of the two portions **110**, **120** may be carried out

simultaneously while the second cast segment **220** is being held.
(51) According to some embodiments, such machining method may reduce working time and costs by a significant factor since several steps are no longer required, such as application of the cast bulk on second portion of the unit as with previous solutions.
(52) For example, using this method the processing time to complete the machining of the working portions of the metal object may be reduced by 16 minutes compared to similar result with previous solutions.
(53) While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents may occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes.
(54) Various embodiments have been presented. Each of these embodiments may of course include features from other embodiments presented, and embodiments not specifically described may include various features described herein.

Claims

1. A method of preparing a metal object for machining, wherein the metal object comprises at least two working portions that are to be machined and that are connected to remote sides or ends of an intermediate portion of the metal object, the method comprising: inserting the intermediate portion into a casting mold, such that the at least two working portions protrude from the casting mold; pouring a liquid metal material into the casting mold so as to cover the intermediate portion; allowing the liquid metal to cool, thereby forming a cast bulk surrounding the intermediate portion of the metal object, wherein the cast bulk comprises a first cast segment that is adjacent to and surrounds the intermediate portion and a second cast segment that is remote from the intermediate portion; and removing the casting mold; whereby the cast bulk enables machining of the at least two working portions to be carried out while the second cast segment is being held, and wherein the metal object is an airfoil.
2. The method of claim 1, wherein the cast bulk is configured such that heating of the cast bulk back into the liquid metal will allow the liquid metal to be removed from the intermediate portion.
3. The method of claim 1, wherein the intermediate portion of the metal object maintains structural integrity during machining of the at least two working portions.
4. The method of claim 1, wherein the liquid metal is a Cerrotru alloy.
5. The method of claim 1, further comprising machining of the at least two portions.
6. The method of claim 5, wherein machining of the at least two portions is configured to be carried out simultaneously.