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(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2019/0283115 A1**
Di Serio et al. (43) **Pub. Date: Sep. 19, 2019**(54) **METHOD FOR MANUFACTURING A PART
CONSISTING AT LEAST PARTIALLY OF A
METAL ALLOY, AND OPTIMISATION
METHOD**(30) **Foreign Application Priority Data**

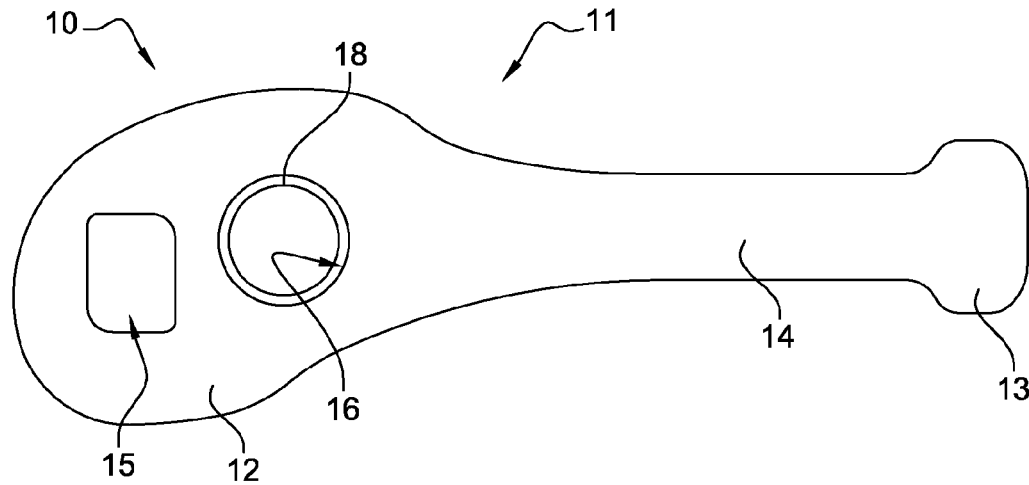
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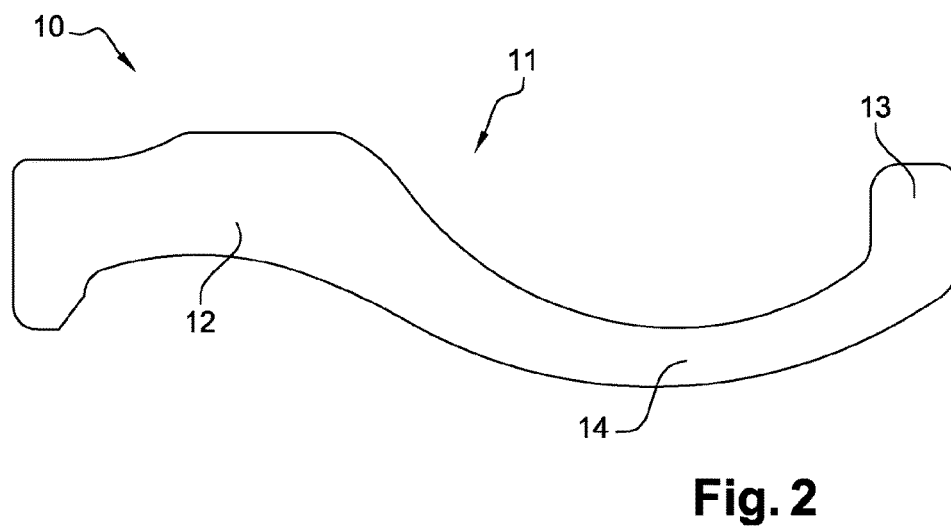
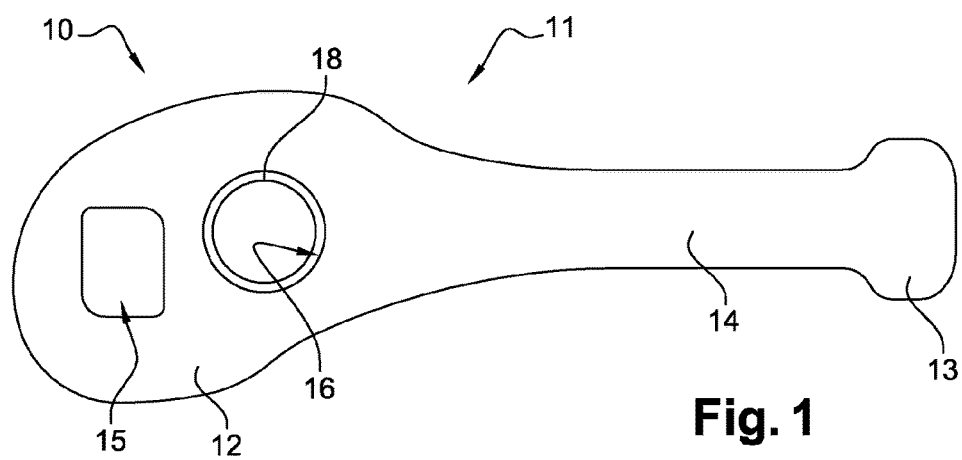
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(2) Date: **Nov. 19, 2018**(57) **ABSTRACT**

The present invention concerns a method for manufacturing a part consisting at least partially of a metal alloy. The method includes a metallurgical manufacturing step a1) consisting of manufacturing the body of the part. The method subsequently includes a reinforcing step a2) consisting of forming a local reinforcement directly on the body, in an area of the part that is under stress. The invention also concerns a method for optimising a part.





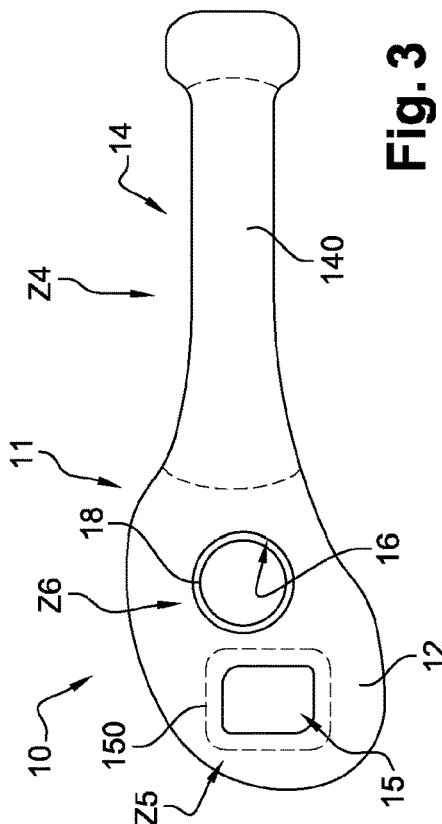


Fig. 3

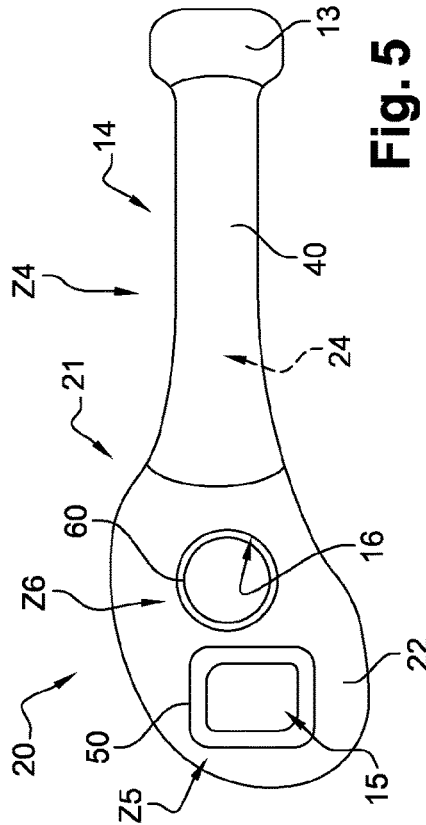


Fig. 5

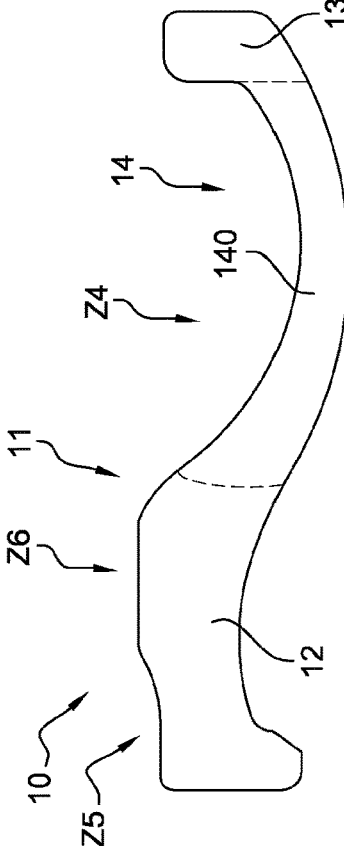


Fig. 4

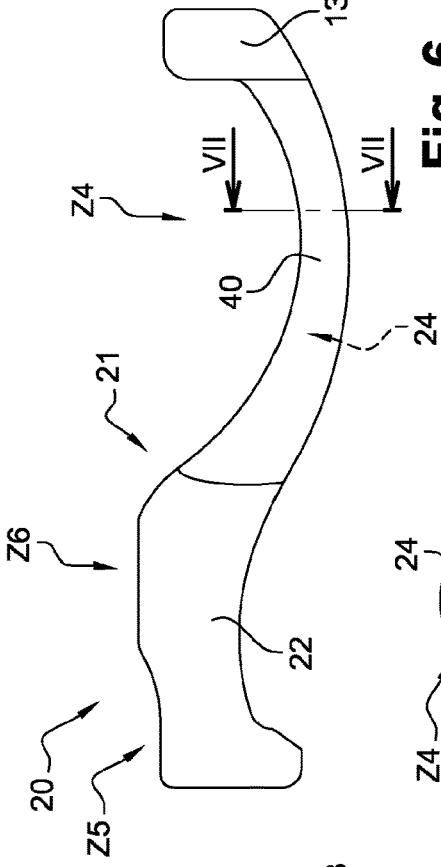


Fig. 6

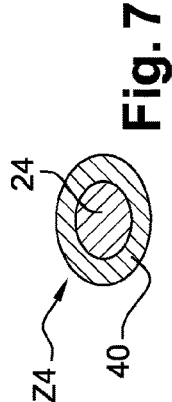
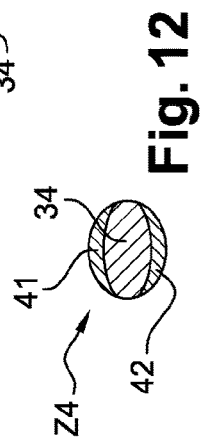
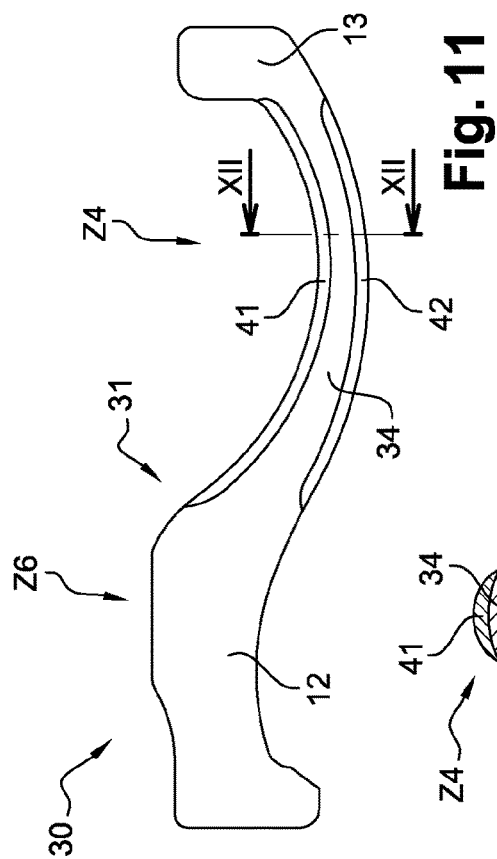
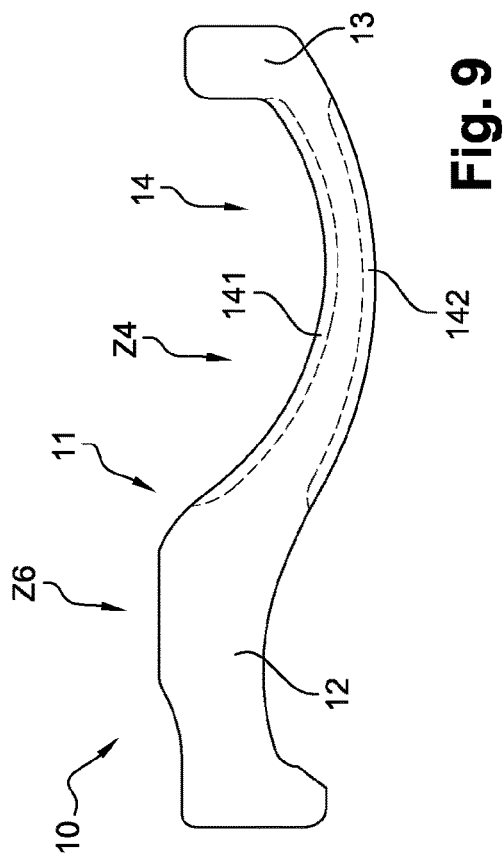
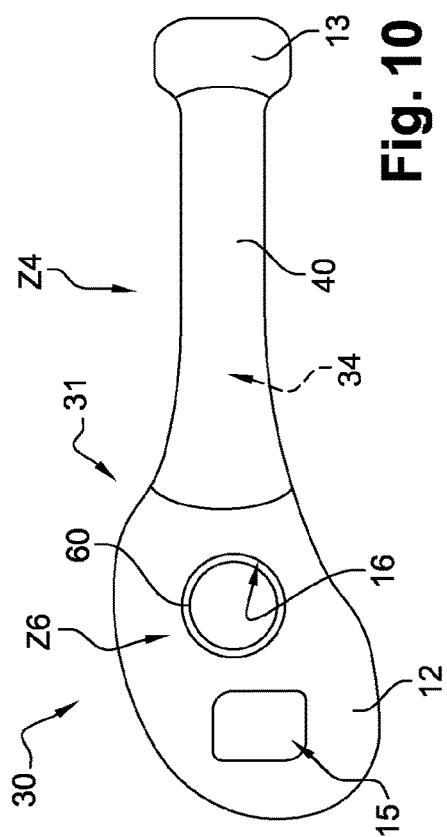
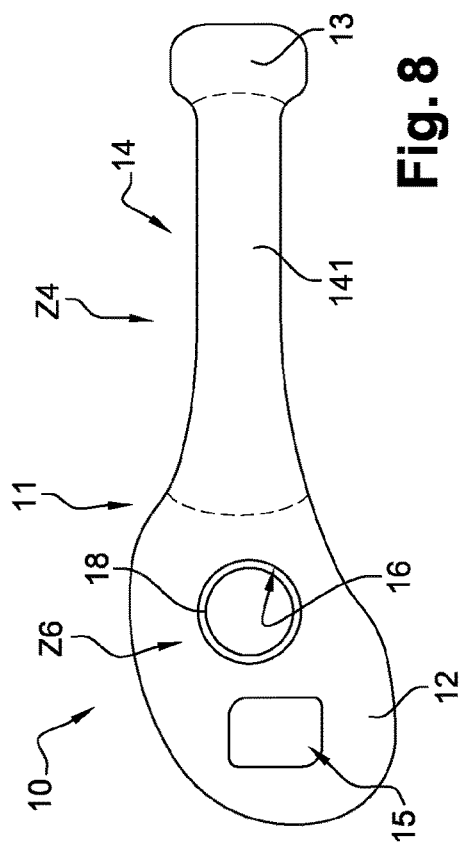


Fig. 7



METHOD FOR MANUFACTURING A PART CONSISTING AT LEAST PARTIALLY OF A METAL ALLOY, AND OPTIMISATION METHOD

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a manufacturing method for a part constituted at least partially of a metal alloy. The invention also relates to an optimization method for a part.

[0002] The field of the invention is that of manufacturing of parts constituted in whole or in part of a metal (ferrous or nonferrous) alloy, where said manufacturing includes successive foundry and forge operations.

BACKGROUND OF THE INVENTION

[0003] Saint-Jean Industries developed the COBAPRESS (trademark) method for aluminum and alloys thereof over 30 years ago. This technology consists of forging a foundry preform in a single forge operation, as described in particular in the documents EP0119365, EP0586314 and EP2877353.

[0004] The COBAPRESS method has proven to be very effective in suspension applications at most automobile manufacturers. In particular, compared with the conventional foundry, a notable improvement of the mechanical properties and especially decrease assistance is possible with this method. Also, this method is competitive compared to the forge in terms of costs and achievable geometric complexity.

[0005] EP0586314 describes the positioning of inserts in a foundry preform and then striking the preform to get the final part. The inserts are fixedly and permanently integrated by deformation of the material, thus defining locally reinforced areas. The inserts are formed aside and then added onto the body of the part constituted by the preform; that is what the present invention aims to avoid.

[0006] Today reducing the weight of structures, in the automotive, aeronautic and industrial fields, is a necessity connected to developments in safety, environmental and other standards.

[0007] The weight objectives for structures are perpetually decreasing with an increase of the stresses thereon and a cost objective compatible with the market. In the majority of cases today, these constraints lead to a compromise involving the choice of materials, processes, weights and costs.

[0008] As an example, if a particular area of the part is subject to large stresses, the material for this part overall is going to be driven by this area and lead to higher costs related to the choice of this material.

SUMMARY OF THE INVENTION

[0009] The objective of the present invention is to propose an improved manufacturing method.

[0010] In this regard, the invention concerns a manufacturing method for a part constituted at least partially of a metal alloy, wherein the method comprises a metallurgical manufacturing step a1) consisting of manufacturing the body of the part, characterized in that the method next comprises a reinforcement step a2) consisting of forming a local reinforcement on the body, in an area under stress of the part.

[0011] Thus, the mechanical properties of the part, for example the fatigue resistance or hardness thereof can be locally improved with the invention, while keeping the mass of the reinforced part the lowest possible and without using a part that is added on. As an alternative or a complement, a section of the part can be reduced locally because of the invention resulting in space savings. Further, the overall performance of the part, for example the stiffness thereof, can be improved with the invention.

[0012] According to a first embodiment, the metallurgical manufacturing step a1) comprises a foundry operation a11) consisting of manufacturing a foundry preform, and then a forge operation a12) consisting of forging the foundry preform to obtain the body of the part. This metallurgical manufacturing step a1) corresponds to the implementation of the COBAPRESS method.

[0013] According to a second embodiment, the metallurgical manufacturing step a1) includes a foundry operation a11) consisting of manufacturing the body of the part. This foundry operation a11) is not followed by a forge operation a12).

[0014] According to a third embodiment, the metallurgical manufacturing step a1) includes a forge operation a12) consisting of manufacturing the body of the part. This forge operation a12) is not preceded by a foundry operation a11).

[0015] The invention also concerns a method for optimization of the design of an existing part, comprising a metal alloy body, wherein the optimization method comprises the following successive phases:

[0016] b1) identify an area under stress of the existing part, for example by numerical simulation;

[0017] b2) define an optimized part comprising a modified body, by providing at least one local reinforcement formed on the body in the stressed area;

[0018] b3) define metallurgical manufacturing tools conforming to the body of the optimized part;

[0019] b4) manufacture the body of the optimized part with the tools;

[0020] b5) form a local reinforcement directly on the body, in the area of the optimized part under stress.

[0021] According to other advantageous features of the invention, considered alone or in combination:

[0022] The part is a structural part for car (in particular a part for pivot type suspension, direction arm, suspension arm, under frame structural part, etc.), aeronautic, industrial equipment or medical device.

[0023] The local reinforcement has a surface arranged at least 50% in contact with the body of the part.

[0024] The local reinforcement substantially marries the body of the part.

[0025] Several local reinforcements are formed on the body, in one or more areas under stress of the part.

[0026] The method comprises a step of preparation of the surface of the area to be reinforced, between the metallurgical manufacturing step a1) and the reinforcement step a2).

[0027] The method comprises a step of finishing the part in the reinforced area, after the reinforcement step a2).

[0028] The method comprises a step of surface treatment, applied at least on a portion of the body, between the steps a1) and a2).

- [0029] The method comprises a step of surface treatment, applied at least on a portion of the part, after step a2).
- [0030] The body and the local reinforcement are made of different metal alloys.
- [0031] The body is made of a metal alloy, whereas the local reinforcement is made of a composite material.
- [0032] The body is made of a metal alloy, whereas the local reinforcement is made of a ceramic material.
- [0033] The local reinforcement is formed by cold spraying.
- [0034] The local reinforcement is formed by micro-arc oxidation.
- [0035] The local reinforcement is formed by adhering a composite assembly taking the final shape thereof on the body of the part.
- [0036] The local reinforcement is formed by baking a resin.
- [0037] The local reinforcement is formed by additive manufacturing.
- [0038] The local reinforcement is substituted for an original portion of the body of the existing part.
- [0039] The local reinforcement is substituted for an insert fitted, overmolded or pressed on the body of the existing part.
- [0040] The optimized part has substantially the same dimensions as the existing part.
- [0041] The optimized part has dimensions that are locally reduced compared to the existing part.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0042] The invention will be better understood upon reading the following description, given solely as a non-limiting example, and made with reference to the accompanying figures wherein:
- [0043] FIG. 1 is a top view of a part conforming to the state of the art, comprising a metal alloy body, manufactured according to a foundry operation and then a forge operation;
- [0044] FIG. 2 is a side view of the part from FIG. 1;
- [0045] FIGS. 3 and 4 are views analogous to FIGS. 1 and 2 showing an optimization method for the design of the part;
- [0046] FIGS. 5 and 6 are views analogous to FIGS. 1 and 2 showing a part optimized according to the invention, comprising local reinforcements formed on the body in stressed areas;
- [0047] FIG. 7 is a section along the line VII-VII in FIG. 6; and
- [0048] FIGS. 8 to 12 are views analogous to FIGS. 3 to 7 showing a second embodiment of a part optimized according to the invention.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

- [0049] A part 10 is shown in FIGS. 1 to 4 comprising a single piece body 11 and a tubular insert 18 fitted in the body 11. As an example, part 10 is a car suspension part.
- [0050] The body 11 is made of a metal alloy, for example aluminum alloy, according to two successive foundry and forge operations. The body 11 comprises a main portion 12, an end portion 13 and a long portion 14 connecting the portions 12 and 13. Two through openings 15 and 16 are

arranged in the portion 12. The opening 15 has a substantially rectangular section, whereas the opening 16 has a circular section.

[0051] The insert 18 is made of metal alloy, for example steel, and then fitted, overmolded or pressed (in particular by COBAPRESS) in the opening 16 formed in the body 11. The insert 18 provides various functions between the body 11 and an element not shown arranged through the opening 16: thermal connection, friction resistance, lubrication, etc.

[0052] Areas under stress Z4, Z5 and Z6 of part 10, corresponding respectively to elements 14, 15 and 16, are shown in FIGS. 3 and 4.

[0053] In the context of the present invention, an area under stress of part 10 is defined as being an area subject to large mechanical, thermal, friction and/or abrasion stresses when the part 10 is in service. These stresses are called large, in so far as they require specific attention for preserving the operating integrity of the part because of the environment thereof (mechanical system in which the part is incorporated, external factors, etc.).

[0054] As examples:

[0055] The mechanical stresses can be caused by forces of flexion, torsion, traction and/or compression experienced by this area;

[0056] The thermal stresses can be caused by a permanent or temporary local temperature increase experienced by this area;

[0057] The frictional constraints caused by an electric cable which extends along the part and which could rub against the surface of the part in this area;

[0058] The abrasion constraints can be caused by spraying of materials against this area from the ground on which the car equipped with the part is traveling.

[0059] In practice, the areas Z4, Z5 and Z6 of the part 10 are not subject to the same stresses in service.

[0060] In the area Z4, reduced weight of the portion 14 made of metal alloy is sought without reducing the mechanical performance thereof. For this purpose, an external portion 140 of this portion 14 can be replaced by a composite material.

[0061] In the area Z5, improved resistance of the part 10 is sought in the area of the opening 15 without changing the material making up the body 11. For this purpose, a portion 150 located around the opening 15 can be replaced by a metal alloy that is more resistant than that of the body 11.

[0062] In area Z6, reduced weight of the portion 12 is sought without reducing the performance of the part 10 in the area of the opening 16. For this purpose, the steel insert 18 can be replaced by a covering formed in the opening 16 by cold spraying of a powder comprising metal particles (alloys of aluminum, copper, cobalt, nickel, molybdenum, aluminum quasi-crystals, etc.).

[0063] Of course, other solutions can be selected depending on the specifications document to be satisfied.

[0064] A part 20 according to the invention is shown in FIGS. 5 to 7. The part 20 is an optimized version of the part 10 shown in FIGS. 1 to 4. The part 20 has a function and dimensions similar to the part 10.

[0065] Some constituent elements of the part 20 are comparable to those of part 10 described above and, for purposes of simplification, bear the same numeric references. Other constituent elements of the part 20 have differences from the part 10 and have numeric references increased by 10.

[0066] The part 20 comprises a body 21, and also various local reinforcements 40, 50 and 60 formed directly on the body 21, respectively in areas Z4, Z5 and Z6 of part 10.

[0067] As mentioned before, these areas Z4, Z5 and Z6 are not subject to the same stresses in service. Under these conditions, the choice of materials constituting the body 21 and the local reinforcements 40, 50 and 60 is a compromise in terms of performance, weight and cost.

[0068] The body 21 is made of a metal alloy, for example aluminum alloy, according to two successive foundry and forge operations. The body 21 comprises a main portion 22, an end portion 13 and a long portion 24 connecting the portions 22 and 13. Two through openings 15 and 16 are arranged in the portion 22.

[0069] In the area Z4, the body 21 includes a long portion 24 provided as local reinforcement 40. The portion 24 is made of metal alloy, while the reinforcement 40 is made of composite material. For example, the reinforcement 40 is formed by layers of carbon, glass or thermoplastic (in particular poly(p-phenyleneterephthalamide) known under the brand name Kevlar) fibers, precoated with resin, having a nearly finished state. The reinforcement 40 comes in the form of a composite element adhered onto the body 21 and taking its final shape directly on the body 21. The reinforcement 40 is substituted for the portion 140 of the body 11 such that the portions 14 and 24 have substantially the same dimensions. With the reinforcement 40, the part 20 can be made lighter in the area Z4 without reducing the mechanical performance thereof.

[0070] In the area Z5, a reinforcement 50 is substituted for the portion 150 of the body 11. The opening 15 is formed through this reinforcement 50 in the portion 22. The opening 15 has the same dimensions for the parts 10 and 20. The reinforcement 50 is made of stronger metal alloy than that of the body 11, for example by cold spraying. The strength of the part 20 is improved near the opening 15 compared to the part 10, without changing the material of the body 21 compared to the body 11.

[0071] In area Z6, the insert 18 is replaced by a coating 60 formed by cold spraying in the opening 16. The portion 22 of the part 20 can be made lighter with the coating 60 without reducing the performance thereof near the opening 16.

[0072] The body 21 makes up the majority of the volume of the part, in comparison with the reinforcements 40, 50 and 60.

[0073] A variant of part 10 from FIGS. 3 and 4 is shown in FIGS. 8 and 9. Areas under stress Z4 and Z6 of part 10, corresponding respectively to elements 14 and 16, are shown in this variant. In the zone Z4, two external portions 141 and 142 of the portion 14 can be replaced by a composite material. In area Z6, the steel insert 18 can be replaced by a coating formed by cold spraying in the opening 16.

[0074] A part 30 according to the invention is shown in FIGS. 10 to 12. The part 30 is an optimized version of the part 10 shown in FIGS. 8 and 9. The part 30 has a function and dimensions similar to the part 10.

[0075] Some constituent elements of the part 30 are comparable to those of part 10 described above and, for purposes of simplification, bear the same numeric references. Other constituent elements of the part 30 have differences from the part 10 and have numeric references increased by 10.

[0076] The part 30 comprises a body 31, and also various local reinforcements 41, 42 and 60 formed directly on the body 31.

[0077] The body 31 is made of a metal alloy, for example aluminum alloy, according to two successive foundry and forge operations. The body 31 comprises a main portion 12, an end portion 13 and a long portion 34 connecting the portions 32 and 13. Two through openings 15 and 16 are arranged in the portion 12.

[0078] In the area Z4, the body 31 includes a long part 34 provided with the two local reinforcements 41 and 42. The part 34 is made of metal alloy, while the reinforcements 41 and 42 are made of composite material. The reinforcements 41 and 42 are substituted for the respective portions 141 and 142 of the body 11 such that the portions 14 and 34 have substantially the same dimensions. With the reinforcements 41 and 42, the part 30 can be made lighter in the area Z4 without reducing the mechanical performance thereof.

[0079] In area Z6, the insert 18 is replaced by the coating 60 formed by cold spraying in the opening 16. The portion 22 of the part 20 can be made lighter with the coating 60 without reducing the performance thereof near the opening 16.

[0080] Moreover, the part 10/20/30 can be shaped differently than in FIGS. 1 to 12 without departing from the scope of the invention.

[0081] In the examples from FIGS. 5 to 7 and 10 to 12, each of the reinforcements 40/41/42/50/60 marries the body 21/31 of the part 20/30. In other words, each of the reinforcements 40/41/42/50/60 has a surface arranged completely in contact with the body 21/31.

[0082] As a variant not shown, the surface of the reinforcement in contact with the body can be arranged at least 50% in contact with the body (and up to 100%). Preferably, the surface of the reinforcement is arranged at least 90% in contact with the body.

[0083] Whatever the embodiment of the invention, the part 20/30 is at least partially constituted of a metal alloy and includes:

[0084] a metal alloy body 21/31 manufactured by a metallurgical manufacturing step a1); and

[0085] at least one local reinforcement formed directly on the body 21/31 in an area under stress of the part 20/30 during a reinforcement step a2) subsequent to the metallurgical manufacturing step a1).

[0086] The body 21/31 constitutes most of the volume of the part 20/30 in comparison with the reinforcements. The body 21/31 could be constituted of one functional part all alone, whereas the characteristics of this part can be locally improved by the reinforcements. Each reinforcement has a volume that is less than 20% of the volume of the body 21/31 and preferably less than 10%.

[0087] In the context the invention, the local reinforcement can be formed by cold spray, micro-arc oxidation, additive manufacturing, baking of a resin in a mold, adhering a composite assembly (which takes the final shape thereof on the body of the part when the adhesive dries), or any other suitable technique.

[0088] The invention excludes reinforcement by parts added onto the body, for example by welding, screwing or pressing.

[0089] The invention also excludes reinforcement parts integrated with the body by overmolding.

[0090] A goal the invention is also a manufacturing method for a part 20/30 constituted at least partially of a metal alloy.

[0091] The method comprises the following successive steps a1) and a2):

[0092] a1) a metallurgical manufacturing step consisting of manufacturing the body 21/31 of the part 20/30; and

[0093] a2) a reinforcement step consisting of forming a local reinforcement directly on the body 21/31, in an area under stress of the part 20/30.

[0094] According to a first embodiment, the step a1) comprises a foundry operation and then a forge operation, according to the COBAPRESS method.

[0095] According to a second embodiment the step a1) includes only a foundry operation.

[0096] According to a third embodiment the step a1) includes only a foundry operation.

[0097] The method can comprise a step of preparation of the surface of the area to be reinforced, between the steps a1) and a2), depending on the technique used in step a2). As nonlimiting examples, this surface preparation step can include brushing, degreasing, shot blasting, machining or depositing. In the case of a composite reinforcement, the depositing can consist of applying an adhesive on the body 21/31 of the part 20/30.

[0098] The method can also comprise a step of finishing the part 20/30 in the reinforced area, after the reinforcement step a2). As nonlimiting examples, this finishing step may include machining, polishing or surface treatment.

[0099] The method can also include a surface treatment step. The surface treatment can be applied at least on a portion of the body 21/31 between steps a1) and a2), or at least on a portion of the surface of the part after step a2).

[0100] The invention also concerns a method for optimization of the design of an existing part 10, comprising a metal alloy body 11. Initially, this body 11 is made for example following a foundry operation and or a forge operation.

[0101] The optimization method comprises the following successive phases b1, b2, b3, b4 and b5:

[0102] b1) Identify one or more stressed areas Z4/Z5/Z6 of the existing part 10, for example by numerical simulation.

[0103] b2) Define an optimized part 20/30 comprising a modified body 21/31, by providing at least one local reinforcement 40, 41, 42, 50 and/or 60 formed on the body 21/31 in the stressed area Z4/Z5/Z6.

[0104] b3) Define metallurgical manufacturing tools (generally foundry and/or forge) for manufacturing the body 21/31 of the optimized part 20/30. The manufacturing tools for the body 21/31 of the part 20/31 are different from the manufacturing tools for the original body 11 of the part 10. In some cases, the foundry molds and forge mother molds that had been used for manufacturing the body 11 can be simply modified to be used for manufacturing the body 21/31.

[0105] b4) Manufacture the body 21/31 of the optimized part 20/30 with the tools. This phase may include a foundry operation and then a forge operation, according to the implementation of the COBAPRESS method. Alternatively, this phase can include only a foundry operation.

[0106] b5) Form the local reinforcement 40, 41, 42, 50, 60 directly on the body 21/31, in the area under stress Z4/Z5/Z6 of the optimized part 20/30.

[0107] The technical characteristics of the various embodiments and variants mentioned above can be, in whole or for some of them, combined with each other. Thus, the part 20/30 may be adapted in terms of cost, functionality and performance.

1. A manufacturing method for a part constituted at least partially of a metal alloy, wherein the method comprises a metallurgical manufacturing step a1) consisting of manufacturing the body of the part, wherein the method next comprises a reinforcement step a2) consisting of forming a local reinforcement directly on the body, in an area under stress of the part.

2. The method according to claim 1, wherein the metallurgical manufacturing step a1) comprises a foundry operation a11) consisting of manufacturing a foundry preform, and then a forge operation a12) consisting of forging the foundry preform to obtain the body of the part.

3. The method according to claim 1, wherein the metallurgical manufacturing step a1) comprises a foundry operation a11) or a forge operation a12) consisting of manufacturing the body of the part.

4. The method according to claim 1, wherein the local reinforcement has a surface arranged at least 50% in contact with the body of the part.

5. The method according to claim 1, wherein the local reinforcement substantially marries the body of the part.

6. The method according to claim 1, wherein several local reinforcements are formed on the body, in one or more areas under stress of the part.

7. The method according to claim 1, further comprising a step of preparation of the surface of the area to be reinforced, between the metallurgical manufacturing step a1) and the reinforcement step a2).

8. The method according to claim 1, further comprising a step of finishing the part in the reinforced area, after the reinforcement step a2).

9. The method according to claim 1, wherein the body and the local reinforcement are made of different metal alloys.

10. The method according to claim 1, wherein the body is made of a metal alloy, whereas the local reinforcement is made of a composite material.

11. The method according to claim 9, wherein the local reinforcement is formed by cold spraying.

12. The method according to claim 9, wherein the local reinforcement is formed by micro-arc oxidation.

13. The method according to claim 10, wherein the local reinforcement is formed by adhering a composite assembly taking the final shape thereof on the body of the part.

14. The method according to claim 10, wherein the local reinforcement is formed by baking a resin.

15. The method according to claim 1, wherein the local reinforcement is formed by additive manufacturing.

16. A method for optimization of the design of an existing part, comprising a metal alloy body, wherein the optimization method comprises the following successive phases:

b1) identifying an area under stress of the existing part;

b2) defining an optimized part comprising a modified body, by providing at least one local reinforcement formed on the body in the stressed area;

b3) defining metallurgical manufacturing tools conforming to the body of the optimized part;

b4) manufacturing the body of the optimized part with the tools; and

b5) forming the local reinforcement directly on the body, in the area under stress of the optimized part.

17. The method according to claim **16**, wherein the local reinforcement is substituted for an original portion of the body of the existing part.

18. The method according to claim **16**, wherein the local reinforcement is substituted for an insert fitted, overmolded or pressed on the body of the existing part.

19. The method according to claim **13**, wherein the local reinforcement is formed by baking a resin.

* * * * *