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Eljárás sajtolóedzéssel edzett alakos idom előállítására, valamint sajtolóedző szerszám

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmat az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.

Method for producing a press-hardened molded part, and press-hardening tool

The invention relates to a method for producing a press-hardened molded part having at least two regions that differ regarding their strength making use of a press-hardening tool in which a blank heated to a forming temperature is formed and held in the tool for the purpose of heat-treating, wherein, in order to set the strength in the at least one region of lower strength, this region is cooled more slowly than the regions to be adjusted with greater strength, wherein during the forming step, the entire blank and thus also the region(s) of the blank intended to be adjusted with lower strength are in contact with a molding surface of the tool and after the conclusion of the forming step, the tool surface in contact with the molded part is changed in such a way that the region(s) to be adjusted with lower strength have no tool contact during the cooling step that follows the forming step, wherein the tool surface assigned to the one or more regions of lower strength of the molded parts is formed by tool segments that can be adjusted relative to the remaining tool surface, and the tool segments for changing the tool surface are adjusted after the forming step. The invention furthermore relates to a press-hardening tool with a molding surface for producing a press-hardened molded part comprising at least two regions that differ regarding their strength, wherein the tool surface associated with the region(s) of lower strength of the molded part is formed by tool segments which can be adjusted in relation to the remaining tool surface of the lower tool and of the upper tool.

Press-hardening tools are tools for forming and hardening metal blanks. For the purpose of hardening, depending on the configuration of the method, an appropriately preheated blank is fed into the press-hardening tool, in which it is formed and for its hardening is sufficiently quickly cooled and thus hardened after the forming has been completed. Such press-hardening tools are for example used for producing structural components of motor vehicles. The blanks are normally sheet steel blanks.

There are numerous applications in which a structural component for a motor vehicle with different mechanical strength properties is desired. Such structural component can be the B-pillar of a motor vehicle, for example. For a B-pillar, it is sometimes desired for the column to have less strength in the region of the base and thus increased ductility compared to the connecting regions of higher strength and a correspondingly lower ductility.



Such B-pillar is known from EP 1 180 470 B1, which for the purpose of adjusting the different strengths is differently heated in regions prior to introducing the blank. For this purpose, it is provided that those regions of the blank in which the formed molded part must have regions of greater strength, these are heated to a higher temperature than those which are to have lower mechanical strength properties in this regard. The method known from EP 1 180 470 B1 uses a steel blank in which the regions of greater strength in the molded part, i.e. the B-pillar, is heated to austenitizing temperature, while those regions of the blank in which the regions of the formed molded part are to have lower strength are only heated to a temperature which is distinctly below the austenitizing temperature. In order to protect the regions that are to be heated to a lower temperature, EP 1 180 470 B1 proposes to insulate these regions. It has been shown, however, that this manner of handling the blanks is complicated. At the same time, it must be recognized that a certain amount of lack of definition of the dimensional accuracy in the delimitation of the regions of greater strength has to be accepted.

WO 2006/038868 A1 discloses an additional method of producing press-hardened molded parts with regions of different strength. In this known method, it is provided to configure the tool design such that those regions of the blank in which the formed molded part is to have a lower strength are located in a tool cavity. To be able to also hold the molded part in the tool in the regions where the strength is to be adjusted lower, support structures are incorporated into the cavity, which are supported on the molded part. The contact area between the molding surface of the tool and the molded part within such cavity amounts to less than 25% of the surface area. Even if it is possible to produce structural components having regions of different strength using the method described in this document and the press-hardening tool which is likewise described therein, wherein the blank was previously heated uniformly to its forming temperature, the dimensional accuracy of the molded parts produced with this method and/or with this tool is frequently not sufficient. Especially with such structural components in which seals are to be used, as is the case with a B-pillar, for example, the molded parts produced with this method do not meet the necessary tolerance requirements. In the methods which became known from the prior art, those regions of the molded part are moreover limited with respect to their size which have a lower strength throughout, since regions of greater strengths are formed in the contact areas.

DE 27 18 970 discloses a method for forming a brake disc. A heated blank is inserted into a

forming press tool, after which a central hub fitting portion and an outer peripheral portion are pressed and held. By moving parts of the press tool, the abovementioned portions are offset in the direction of the disc axis, while they are maintained pressed and held, wherein a portion between the hub fitting portion and the annular portion will be subjected to a pulling process. At the end of the pulling process, the intermediate portion is also pressed and the entire workpiece is quenched. This piece of prior art does not disclose that different strengths can be adjusted on the workpiece produced.

The post-published WO 2012/010418 A discloses a forming tool and a method for hot forming and partially press hardening a workpiece made of sheet steel, in which, for the purpose of partially hardening the formed workpiece, the forming tool is partially moved away from the region which is to have lower strength. Thus, the die part and punch part cooperating for this purpose contact the workpiece for a shorter time compared to the workpiece regions that are to have greater strength.

Based upon the discussed prior art, the object of the invention is therefore to develop a method named at the outset as well as a press-hardening tool named at the outset in such a manner that the advantages in handling of the method known from WO 2006/038868 A1 can be realized, wherein the dimensional accuracy of the molded parts produced with it is improved, nevertheless, the limitations regarding the size of the regions of lower strength do not have to be contended with and no losses in the surface quality have to be accepted.

This object is solved according to the invention by a method having the features of claim 1.

This object is furthermore solved by a press-hardening tool having the features of claim 5.

In the previously described method – and the same applies also to the press-hardening tool described in claim 5 – a press-hardening tool is used whose tool surface can be changed. The changeability of the molding surface of the tool, i.e. the one surface that is in contact with the blank to be formed and/or the formed molded part, relates to its contact area with the molded part. The changeability of the molding surface is provided in such a way that a closed tool surface is provided for the forming step, which surface is in contact with the blank to be formed and/or the formed molded part. For the purposes of adjusting the regions of different strength,

the tool surface is changed subsequently to the forming step, namely in such a way that the tool surface effective for the forming step is retracted from those sections of the molded part surface which are in contact with the regions of the molded part that are to be adjusted with a lower strength during the cooling step. Consequently, these molded part surface sections are not or are at least temporarily not in contact with the molded part surface during the cooling step. Since the tool is cooled, the cooling process is significantly slower in those sections of the molded part in which the molded part is not in contact with the tool surface than in the other tool regions. What is used with this concept is that for adjusting the regions of the molded part with greater strength, a specific cooling rate must be adhered to. This cannot be achieved in those regions in which the molded part is not in contact with the tool surface during the cooling process, which is why these regions are not hardened and thus only have lower mechanical strength properties. The above-described concept thus ensures that the cooling process can be performed selectively in the different regions of the molded part in different ways. In those regions in which a lower strength is desired, the contact time of the molded part with the tool segment(s) is reduced during the cooling process relative to the regions of the molded part which are to be adjusted with greater strength. This does not mean that these regions of the molded part must not have any contact with the tool segment during the entire cooling process. What is decisive is that the tool segments, which are associated with the regions of the molded part of lower strength, are controlled with reference to the molded part surface which it contacts during the forming process in such a way that the cooling rate is reduced relative to the other regions of the molded part. Apart from the option to leave the tool segment(s) in a retracted position from the regions of the molded part to be adjusted with lower strength during the entire cooling process, it is also possible to retract them intermittently against the regions of the molded part once or even multiple times. This makes it possible to influence the cooling rate. In addition, such a measure assists the dimensional accuracy of these molded part regions. In addition, or even in place of the single or multiple retraction of the tool segment(s) from the molded part surface during the cooling process, the molded part regions of lower strength can also be calibrated in the described manner after the cooling process has been completed.

The molding surface of the side wall of the tool segment(s) in contact with the molded part for the forming process is larger than the region of the molded part to be adjusted by an adjustment of these tool segments with lower strength. In this embodiment, the side wall of the tool segment(s) is not only associated with the actual region of the molded part which is in contact

with said part during the forming process, but it is at least partially also associated with the connecting transition region in those regions of the molded part of greater strength. This concept permits the press-hardening tool to be configured such that the tool segments adjoin one another without any gaps. This is essential to prevent tool imprints on the upper side of the molded part in the course of the forming process.

Since the entire surface of the blank is in contact with a tool surface during the forming step and this is maintained right up to the end or at least until shortly before the forming step is completed, this results in the particular dimensional accuracy of the molded parts produced with this method and also with such a press-hardening tool.

The handling of such tool is uncomplicated and can also be controlled automatically. The tool surface regions, which are in contact with those regions of the blank and/or the molded part during the forming step, and which are to be adjusted with lower strength, are typically formed by tool segments that are moved like slide elements, for example. Such a process can be performed fully automatically. It is particularly not required to heat a blank differently over regions before it is formed.

Changing the effective tool surface between the forming step and the cooling step not only ensures a particularly high dimensional accuracy in the final geometry of the molded part, but also acute and especially repeatable reciprocal delimitation of the regions of different strength, as well as process stability.

This method and the described press-hardening tool can be used particularly advantageously for the press hardening of sheet steel blanks. In such a case the blank is brought to its austenitizing temperature before it is fed into the press-hardening tool for the purpose of forming and partially heat-treating.

A particular advantage with the method described and with the pressing tool described is also that one and the same structural component can be produced with regions of different strength or also without such regions. Tools which allow changing the tool surface in different regions of the tool surface, by activating or correspondingly not activating the tool segments referred to, make it possible to produce molded parts in which either the total number of the possible

regions have a lower strength, or only individual ones of same, or that the entire molded part is hardened uniformly. This allows using one and the same press-hardening tool for producing molded parts of the same geometry, in which different regions can have a lower hardness, however.

Additional advantages and embodiments of the invention result from the following description of exemplary embodiments in reference to the appended figures, which show the following:

- Fig. 1:** illustrates a part of a press-hardening tool with its lower tool and an already formed molded part bearing on it, with the lower tool for providing a first tool surface;
- Fig. 2:** illustrates the lower tool of Fig. 1 in a second position for providing a tool surface which differs from the tool surface of the position of Fig. 1.
- Fig. 3:** illustrates the press-hardening tool of Fig. 1 with a further position of its lower tool for providing a different tool surface compared to the tool surface of the tool of Fig. 2;
- Fig. 4:** illustrates the press-hardening tool which is designed in principle as the one of Fig. 1, pursuant to a further embodiment, and
- Fig. 5:** illustrates a further lower tool of a press-hardening tool.

Fig. 1 shows the lower tool 1 of a press-hardening tool which is otherwise not illustrated in greater detail. On its molding surface 2 it bears an already formed blank, a molded part 3, namely such as this has been arranged on the molding surface 2 following the forming process. In addition to the lower tool 1, also an upper tool, which is not represented in the figures, is associated with the press-hardening tool. The upper tool is designed in the same manner as the lower tool 1, which is subsequently described in greater detail.

The lower tool 1 is composed of multiple tool components. These include a basic tool body 4. The basic tool body 4 is cooled in a manner which is not illustrated in greater detail. In addition

to the basic tool body 4, the lower tool 1 has multiple tool segments 5.1, 5.2, 5.3 and 5.4, which are adjustable with respect to the basic tool body 4, namely in a manner so that their forming area on the tool segment 5.1, which is marked with the reference symbol 6.1, which is facing towards the molded part 3, can be retracted with respect to the molding surface 2 of the basic tool body 4. The tool segment 5.1 is located in the vicinity of the base of the molded part 3; the tool segments 5.2, 5.3 and 5.4 in the vicinity of a flange 7. The upper tool that is not represented in the figures is partitioned accordingly, so that on the positions opposite the tool segments 5.1 - 5.4 of the molded part 3, such tool segments are also provided that can likewise be retracted and which are shaped complementary with respect to their molding surface.

Fig. 1 shows the molding surface 2 provided by the lower tool 1, said surface being used for forming a steel sheet blank that has been heated to its austenitizing temperature.

The described press-hardening tool with its lower tool 1 and its upper tool (not shown) is used for producing a molded part, which in the illustrated embodiment is a B-pillar with regions of different strength for a motor vehicle. The regions of different strength in the molded part 3 are adjusted in that the following is done after the forming step, i.e.: only after the lower tool 1 and the upper tool have performed their press movement for forming the steel sheet blank, those tool segments are retracted from the surface of the molded part 3, which surface is in contact with those areas of the molded part that are to be set to a lower strength during the forming step. It will be appreciated that the press-hardening tool with its lower tool 1 and its upper tool is designed in such a manner that the tool segments are located at those positions which are in contact with regions of the molded part that are to be adjusted with lower strength.

Fig. 2 for example illustrates a position of the tool segments 5.2, 5.3 and 5.4, in which a section of the flange 7 of the molded part is to be adjusted with lower strength due to a change in the molding surface. Consequently, the tool segments 5.2, 5.3 and 5.4 with their molding surface 6.2, 6.3, 6.4 are retracted from the respective sections of the flange 7 after the forming step and after changing the tool surface by retraction of the tool segments 5.2, 5.3 and 5.4 from the surface of the flange 7. This flange section 7 is therefore located within the still-closed press-hardening tool in a cavity filled with air. This results in that the cooling rate of this section of the flange 7 because of the significantly lower thermal conductivity of air compared to the thermal conductivity of the tool steel of the basic tool body 4 and of the tool segment 5.1

likewise still in contact with its forming area 6.1 on the molded part 3. The areas of the molded part 3 which bears upon the effective molding surface of the lower part of the tool will be cooled at a rate required for the desired hardening process (heat-treating). Therefore, in these areas of the molded part 3 a higher strength is adjusted by the cooling in the form of quenching than in those areas of the molded part 3 which do not have any tool contact during the cooling step, as is the case with the illustrated embodiment with respect to a part of the flange 7.

Fig. 3 illustrates the lower tool 1 of the press-hardening tool with another embodiment of its effective molding surface for adjustment and of areas of different strength. In contrast to the embodiment of the effective tool surface provided for the cooling step in the embodiment Fig. 2, the embodiment of Fig. 3 provides retracting the tool segments 5.1 and 5.2 from the surface of the molded part 3.1. Consequently, in an embodiment of the cooling surface of the lower tool 1, as illustrated in Fig. 3, in the vicinity of the base of the B-pillar formed by the molded part 3.1, a region of lower strength is adjusted same as in a short section of the flange 7.1.

The tool segments 5.1, 5.2, 5.3 and 5.4 of the bottom part of the tool 1 are adjustable in the vertical direction relative to the basic tool body 4 as indicated by the arrows in Figs. 2 and 3, in a manner which is not illustrated in greater detail.

Fig. 4 shows the lower tool 1.1 of a press-hardening tool which is otherwise not illustrated in greater detail. In principle, this is constructed like the lower tool 1 of Figs. 1 to 3. The lower tool 1.1 differs from what is described above in that only one tool segment 5.5 is arranged in the vicinity of the flange 7. This can be adjusted in the horizontal direction for the retraction of its forming area 6.5 from the surface of the molded part 3 which bears on the lower tool 1.1.

Fig. 5 shows still a further lower tool 1.2 of a press-hardening tool which is otherwise not illustrated in greater detail. With this lower tool 1.2, it is provided to adjust regions of reduced strength in the vicinity of a flange 7.1 to be developed, in order to carry out spot welding thereon. For this reason, the lower tool 1.2 has individual tool segments 5.6 on those positions on which spot welds are to be performed on the molded part 3.2 to be produced. These are illustrated in Fig. 5 with their forming area retracted from the surface of the molded part 3.2.

Using tools of the type described above, molded parts can be produced in which the regions of greater strength comprise tensile strengths (R_m) of 1300 to 1950 MPa and yield points ($R_{p0.2}$) of 950 to 1520 MPa. The regions of reduced strength on the molded part can be realized, so that these comprise tensile strengths (R_m) from 550 to 750 MPa and a yield point ($R_{p0.2}$) of 350 to 600 MPa. It will be appreciated that this data is exemplary. It also depends on the material used for the blank. The exemplary data refers to a molded part made of sheet steel. The difference in the mechanical strength properties makes it clear that the described method as well as the described press-hardening tools are suitable for adjusting regions of different strength with a high contrast in the strength.

The sidewall of a tool segment is typically greater all-around than that region in which the lower strength is to be adjusted. This takes into account that a certain transition zone exists between the regions of higher strength and those of lower strength.

List of Reference Numerals

1, 1.1, 1.2	Lower tool
2	Molding surface
3, 3.1, 3.2	Molded part
4	Basic tool body
5.1, 5.2, 5.3, 5.4, 5.5, 5.6	Tool segment
6.1, 6.2, 6.3, 6.4	Molding area
7, 7.1	Flange

ELJÁRÁS SAJTOLÓEDZÉSSSEL EDZETT ALAKOS IDOM ELŐÁLLÍTÁSÁRA, VALAMINT SAJTOLÓEDZŐ SZERSZÁM

SZABADALMI IGÉNYPONTOK

1. Eljárás sajtolóedzéssel edzett, szilárdságát tekintve legalább két különböző területtel rendelkező alakos idom (3, 3.1, 3.2) sajtolóedző szerszám alkalmazásával történő előállítására, amiben egy alakítási hőmérsékletre felmelegített félkész darabot alakítunk, és nemesítés céljából a szerszámban tartunk, amelynek során a szilárdságnak legalább egy kisebb szilárdságú területen való beállítása végett ezt a területet a nagyobb szilárdságúra beállítandó területekhez képest lassabban hűtjük le, amelynél az alakítási lépés alatt az egész félkész darab és ezáltal annak egy vagy több kisebb szilárdság beállítására tervezett területe is felfekszik a szerszám (1, 1.1, 1.2) formafelületére (2), és az alakítási lépés befejezte után az alakos idommal (3, 3.1, 3.2) érintkezésben álló szerszámfelületet megváltoztatjuk olyan módon, hogy az alakítási lépéshez csatlakozó lehűtési lépés alatt a kisebb szilárdságúra beállítandó egy vagy több területnek ne legyen érintkezése a szerszámmal, és amelynél az alakos idom (3, 3.1, 3.2) egy vagy több kisebb szilárdságú területéhez hozzárendelt szerszámfelületet a többi szerszámfelülethez képest állítható szerszámszegmensekkel (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) hozzuk létre, és az alakítási lépés után a szerszámfelület (2) megváltoztatása végett a szerszámszegmenseket (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) elállítjuk, **azzal jellemezve**, hogy az alakítási folyamathoz az egy vagy több szerszámszegmensnek (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) az alakos idomra (3, 3.1, 3.2) felfekvő formafelülete nagyobb, mint az alakos idomnak egy ilyen szerszámszegmenshez (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) hozzárendelt, kisebb szilárdságúra beállítandó területe, és hogy a szerszámszegmensek (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) egymás mellett hézagmentesen helyezkednek el.

2. Az 1. igénypont szerinti eljárás, **azzal jellemezve**, hogy a szerszámfelületet olyan módon változtatjuk meg, hogy a lehűtési folyamat alatt az alakos idom (3, 3.1, 3.2) kisebb szilárdság beállítására tervezett egy vagy több területe egy szerszámüregben található.

3. Az 1. vagy 2. igénypont szerinti eljárás, **azzal jellemezve**, hogy a félkész darabot egy-egyes alakítási hőmérsékletre felmelegítjük, mielőtt ezt az alakítási hőmérsékletén lévő félkész darabot alávetjük a sajtolóedzési folyamatnak.



4. Az 1-3. igénypont egyike szerinti eljárás, **azzal jellemezve**, hogy félkész darabként ausztenitesítési hőmérsékletre felmelegített acéllemez félkész darabot, például acéllemez terítékdarabot alkalmazunk.

5. Sajtolóedző szerszám, amelynek van egy alakadó felülete (2) sajtolóedzéssel edzett, szilárdságát tekintve legalább két különböző területtel rendelkező alakos idom (3, 3.1, 3.2) előállítására, amely sajtolóedző szerszám rendelkezik egy alsó szerszámmal (1) és egy felső szerszámmal, amely sajtolóedző szerszámnál az alakos idom egy vagy több kisebb szilárdságú területéhez hozzárendelt szerszámfelület (6.1, 6.2, 6.3, 6.4, 6.5) az alsó szerszám (1) és a felső szerszám többi szerszámfelületéhez képest állítható szerszámszegmensekkel (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) van létrehozva, **azzal jellemezve**, hogy az alakítási folyamathoz az egy vagy több szerszámszegmensnek (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) az alakos idomra (3, 3.1, 3.2) felfekvő formafelülete (6.1, 6.2, 6.3, 6.4, 6.5) nagyobb, mint az alakos idomnak egy ilyen szerszámszegmense (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) szilárdságon keresztül rendre kisebb keménységűre beállítható területe, és hogy a szerszámszegmensek (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) egymás mellett hézagmentesen helyezkednek el.

6. Az 5. igénypont szerinti sajtolóedző szerszám, **azzal jellemezve**, hogy az egy vagy több szerszámszegmens (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) formafelülete (6.1, 6.2, 6.3, 6.4, 6.5) minden oldalon nagyobb, mint az alakos idomnak (3, 3.1, 3.2) az alakítási lépés végén vele érintkezésben álló kisebb szilárdságúra beállítandó területe.

7. Az 5. vagy 6. igénypont szerinti sajtolóedző szerszám, **azzal jellemezve**, hogy a sajtolóedző szerszám (1, 1.1, 1.2) egy vagy több szerszámszegmense (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) rendre tolóka módjára a szerszámon belül elállítható.

8. Az 5-7. igénypont egyike szerinti sajtolóedző szerszám, **azzal jellemezve**, hogy a sajtolóedző szerszám egymással együttműködő szerszámfelei a bennük található alakos idomhoz képest egymással szemköztí pozíciókban állítható szerszámszegmensekkel rendelkeznek.

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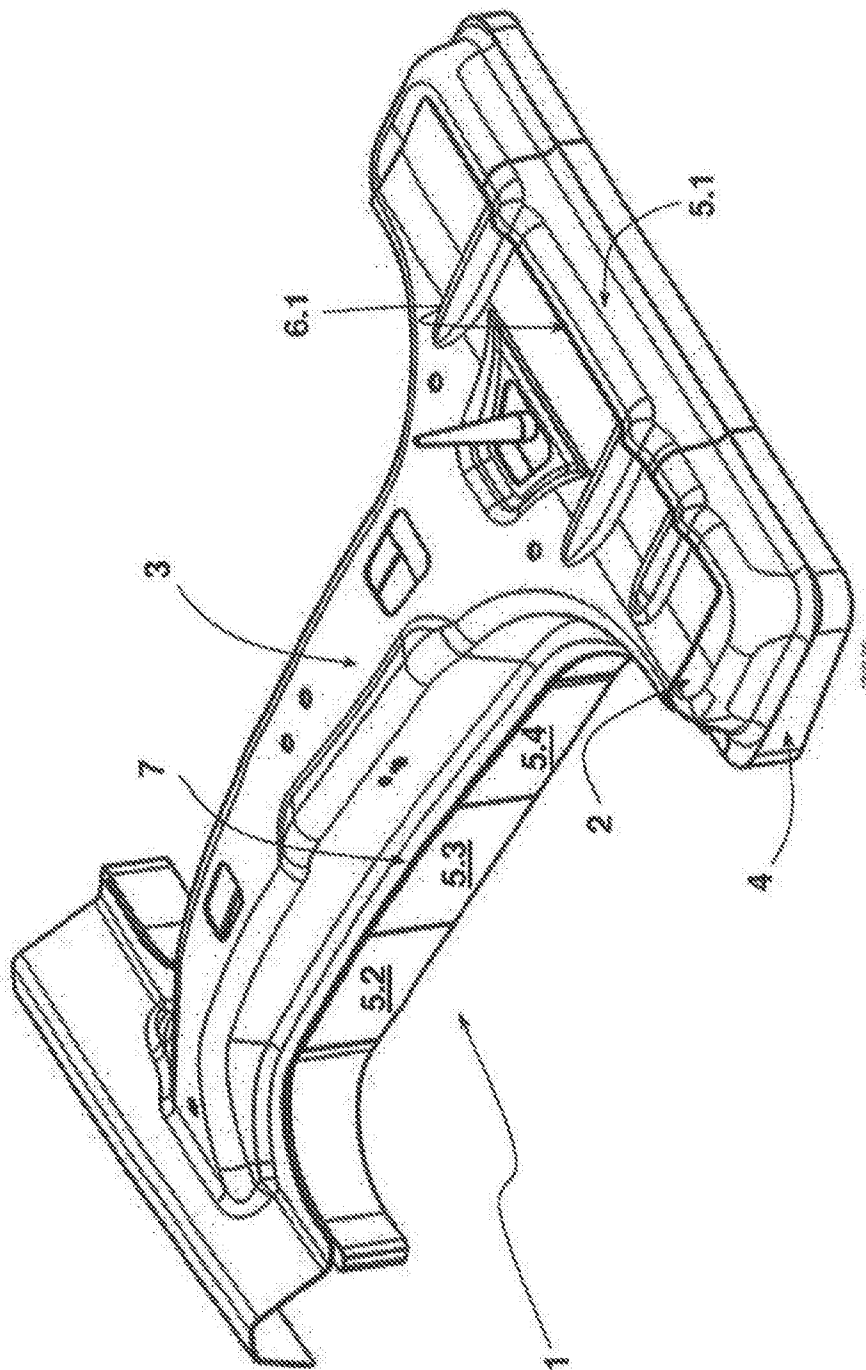


Fig. 1

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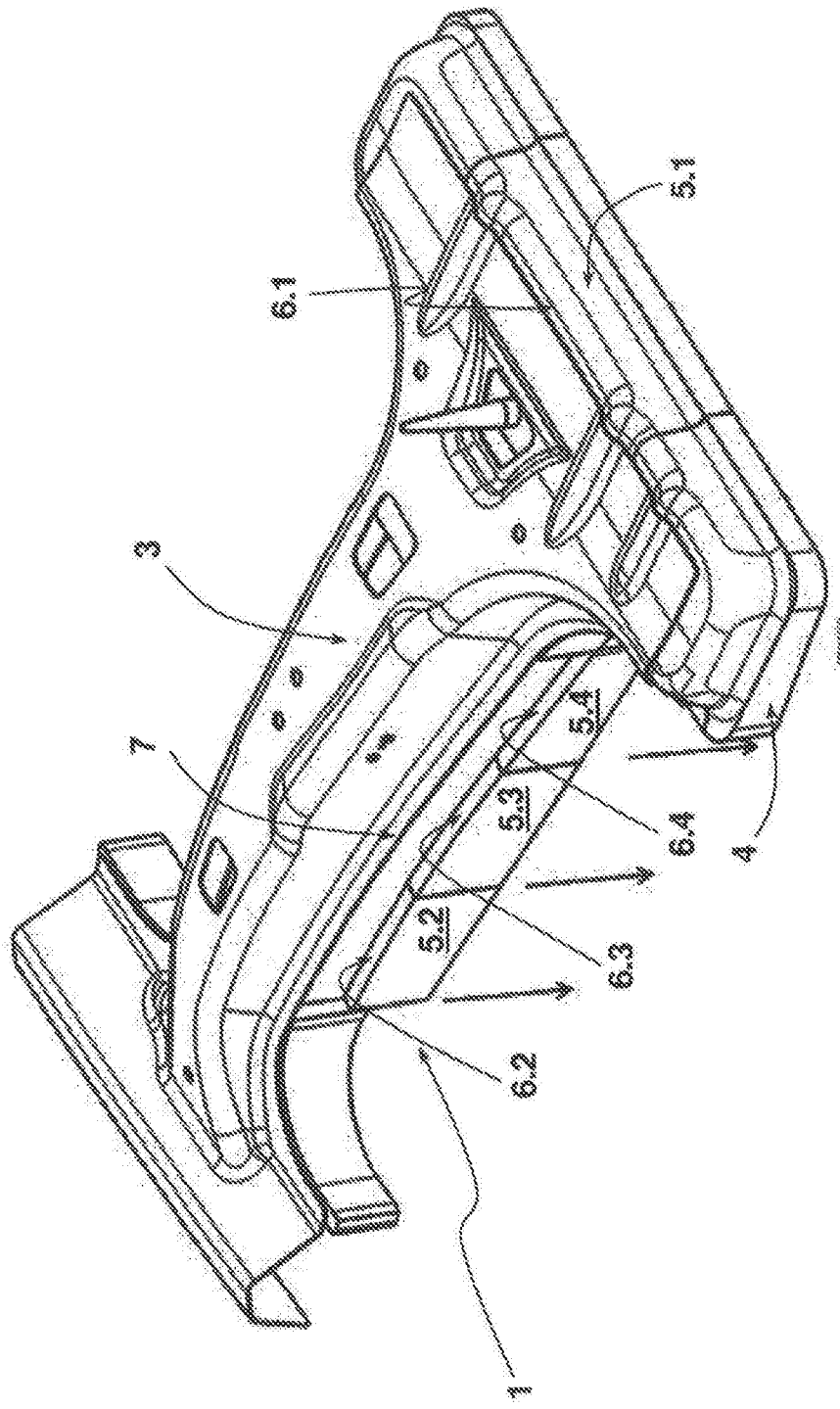
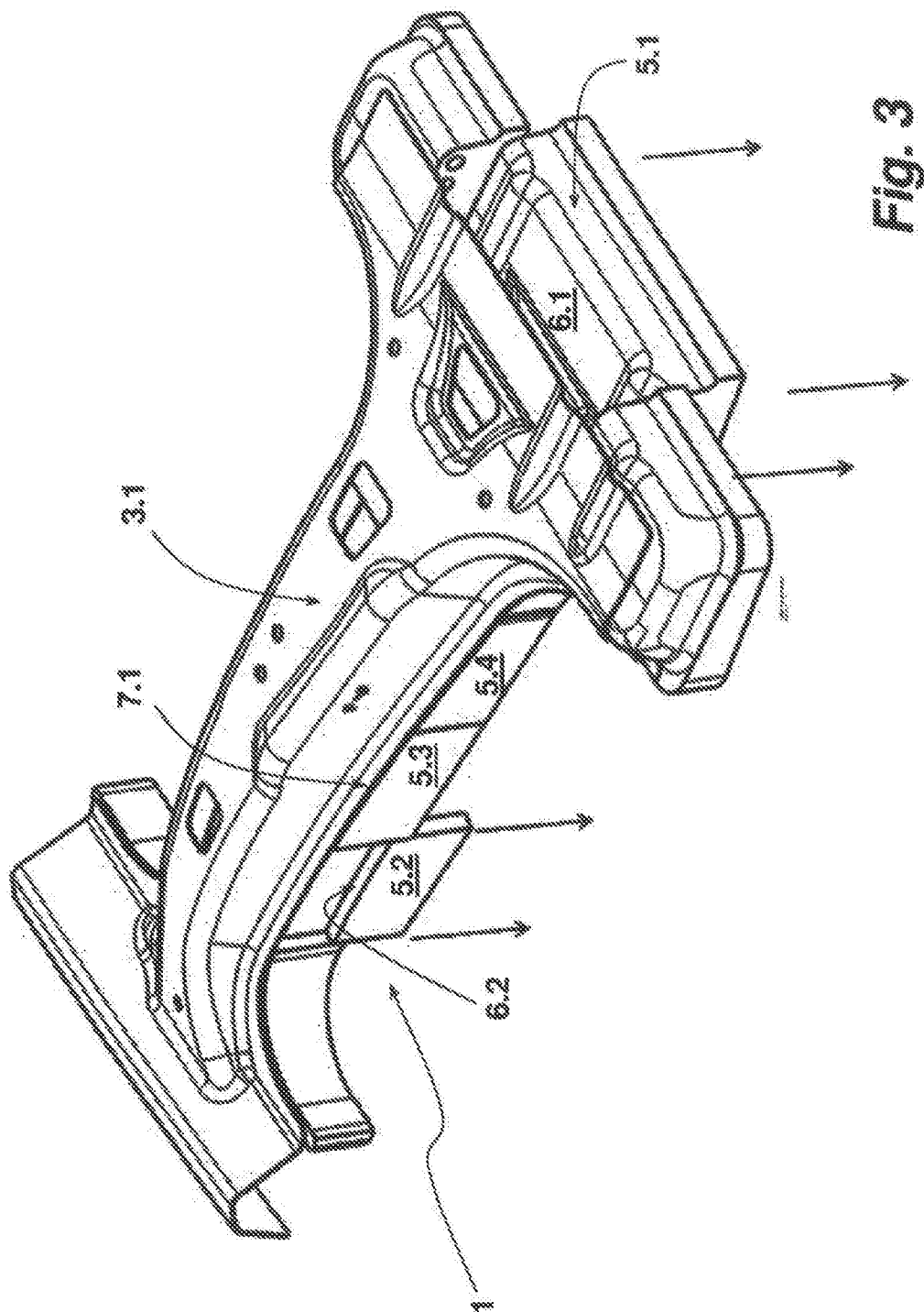


Fig. 2



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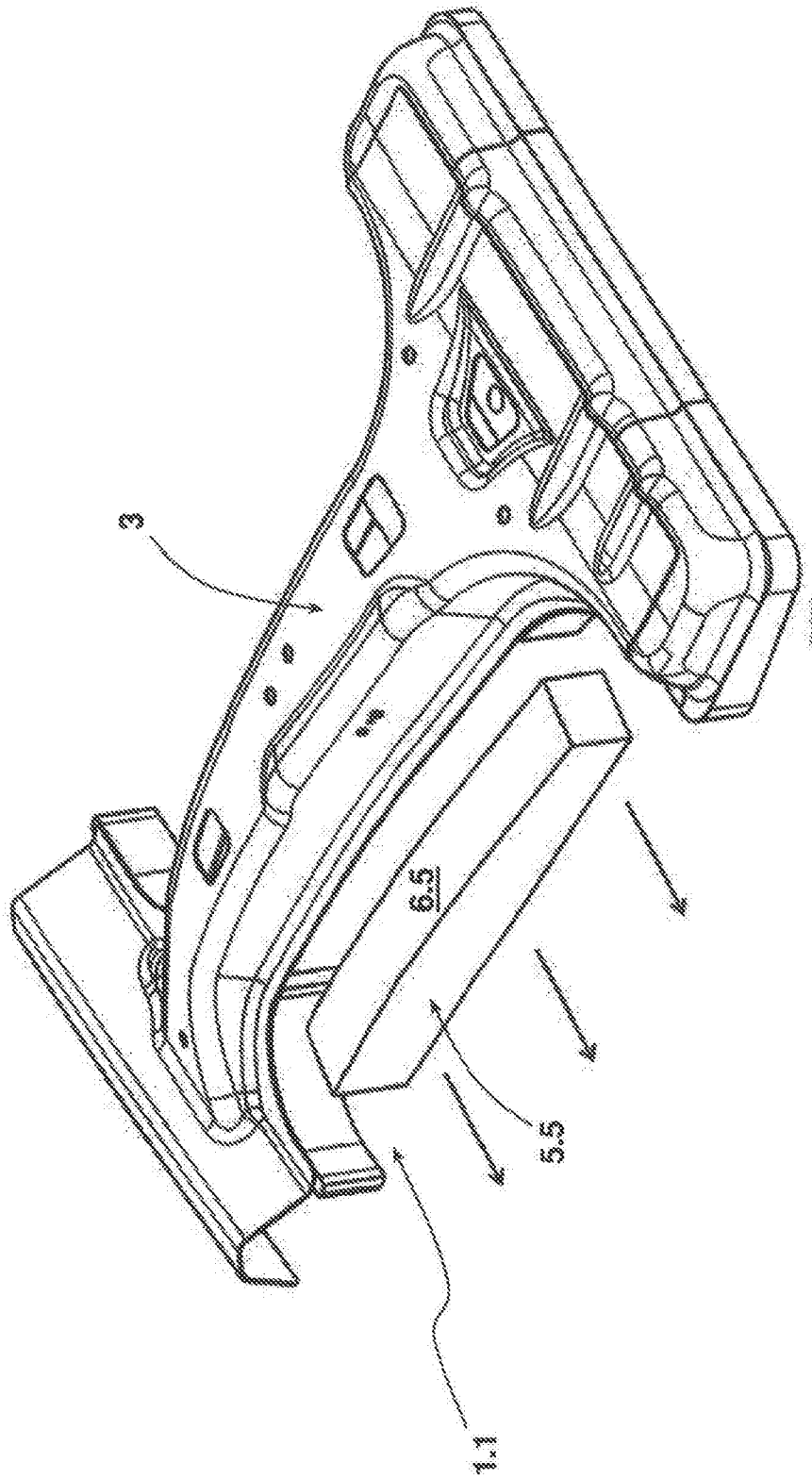


Fig. 4

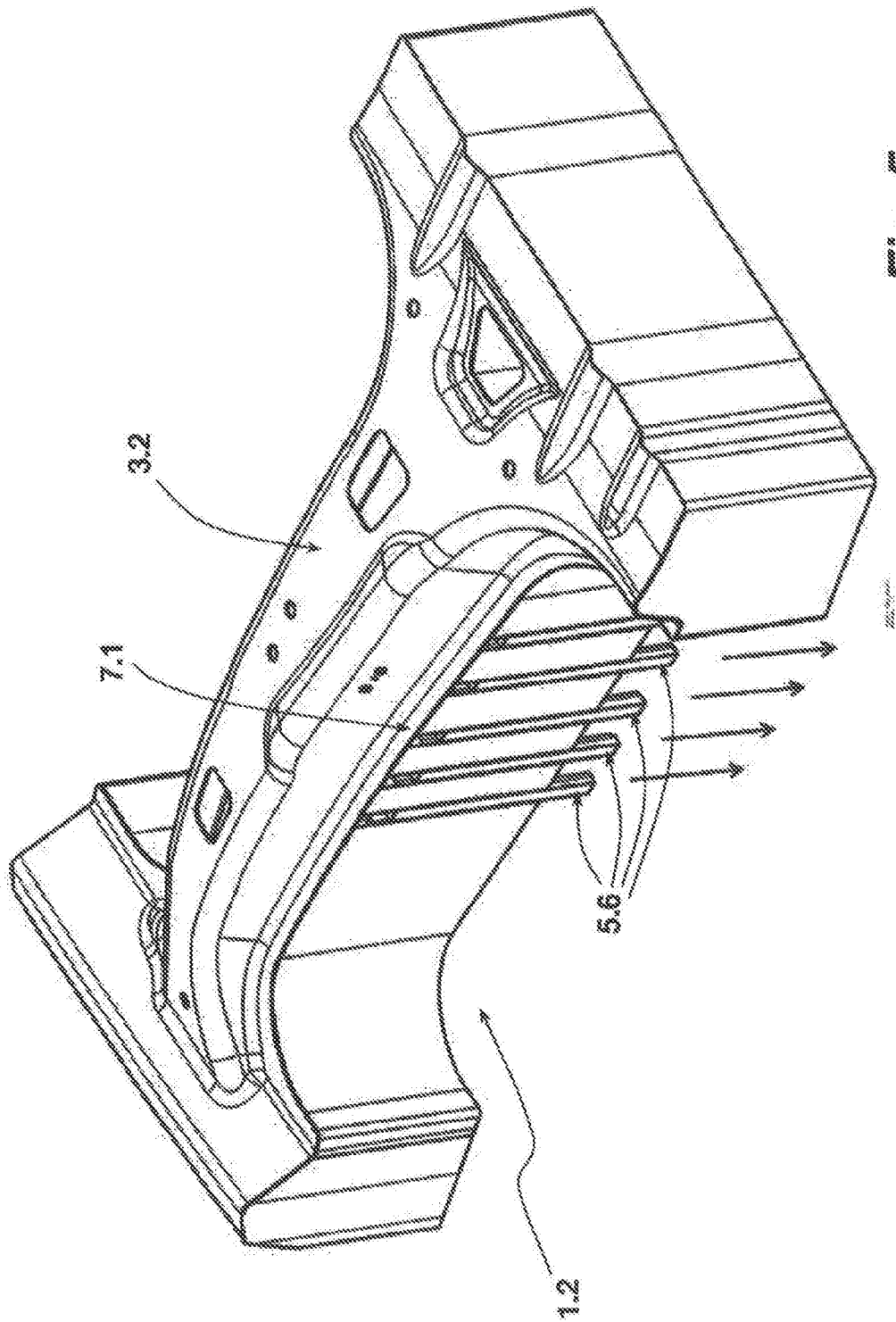


Fig. 5