Vehicle occupant safety system with variable support and method of operating the same

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Abstract

A vehicle occupant safety system having an airbag prevents an excessive force from acting upon the thorax of an occupant who has fastened the seat belt, in the event of an impact. The vehicle occupant safety system comprises an airbag, a sensor device for sensing at least one situation parameter and a control device for controlling the inflation and/or deflation and/or unfolding and/or positioning of the airbag in dependence of the at least one situation parameter. The unfolding, position or shape of the airbag and/or distribution of pressure within the airbag at the end of the filling phase, is directly or indirectly controlled in a targeted manner by a control device based on the at least one situation parameter. A modification of the shape of the airbag in the thorax region can be obtained in particular by a releasable constriction.
Fig. 2
VEHICLE OCCUPANT SAFETY SYSTEM WITH VARIABLE SUPPORT AND METHOD OF OPERATING THE SAME

BACKGROUND AND SUMMARY OF THE INVENTION


[0002] The present invention relates to a vehicle occupant safety system, and to an operating method, with at least one airbag, at least one sensor device for sensing one or more situation parameters and a control device for the directly or indirectly controlling inflation, deflation, and/or unfolding, and/or positioning of the airbag based on the at least one situation parameter. The present invention further relates to a method for operating a vehicle occupant safety system.

[0003] When conventional restraint systems are adjusted, it is necessary to find a good compromise for different accident situations (type, severity, impact, occupant type, belt state etc.) with requirements which are often quite different with regard to the occupant protection. This is so because some parameters of the airbag of the restraint system are fixed during development, cannot thereafter be changed, even if the accident situation is or will be known at least partially during or prior to an accident.

[0004] In addition to considering real accidents, legal requirements are particularly important during the design of restraint systems. For example, the legal requirements with regard to unfastened loads must be satisfied in the USA, so that the airbag must be designed in such a manner that it alone delays the occupant sufficiently, as the restraint by a belt is completely omitted. This is however often counterproductive for low occupant load in the fastened load cases (e.g., in so-called rating experiments), as the retaining forces of the belt and the airbag are added, which additionally takes place in a stepped manner.

[0005] This fundamental problem is increasingly approached by means of adaptive restraint systems. For this, inflow openings or the inflation degree of airbags and/or their size are e.g., adapted to different accident/occupant parameters. German patent document DE 196 10 833 A1, for example, discloses a device for controlling an occupant restraint system with sensors for sensing the position and weight of an occupant. A control unit accesses a ventilation device based on among other things, the occupant's position, his or her weight or the accident severity, to control the pressure of the gas in the airbag during its unfolding by controlling the gas amount guided away from the airbag via the ventilation device. The ventilation device is thus accessed prior to or during the ignition of the airbag.

[0006] German patent document DE 40 28 715 A1 further discloses an airbag which is provided with an outlet valve, which is activated by the destruction of a closing plate by means of a pyrotechnical priming charge 30 ms after the actuation of a pressurized gas source for the airbag. In the activated state, the outlet valve is adjusted to a predetermined differential pressure in the airbag and the surroundings.

[0007] It is disadvantageous with these adaptive restraint systems that, during the adaptation, only parameters of the airbag such as dampening (outflow opening) or airbag size are changed for the occupant seen as a unit. Improvements with the most important load cases are thus limited.

[0008] Furthermore, conventional airbags with a predetermined outflow and size are known, where the ignition time of at least one gas generator stage can take place in dependence on e.g., accident type, accident severity, belt state and seat occupancy. Further adaptation during or just prior to the accident, however, is no longer possible. In addition, especially with fastened load cases in particular for thorax loads, the problem exists that initially only the belt, and then additionally the airbag, apply their restraining force. An optimum load which is as even as possible is thus not possible in principle.

[0009] The automotive industry further has the problem that the restraint systems have to be designed differently for different country-specific requirements. This means that the restraint systems can be designed in a less universal manner and that additional logistics costs result by means of several airbag versions.

[0010] Finally, airbags adapted to different body regions are also known. The respective adaptation is however not adaptive.

[0011] German patent document DE 101 57 710 B4 discloses a method for accessing a ventilation device of a vehicle airbag where the ventilation device is brought into an operation-ready state at a predetermined time after triggering the gas generator. The ventilation device is opened when the pressure acting on the airbag which is sensed by the sensor exceeds a limit value. The ventilation is thus triggered by the pressure signal which is received by the pressure sensor. The predetermined time and the limit value for the pressure can be adjusted in dependence on the seat position or the weight of a vehicle occupant.

[0012] Conventional approaches of adaptive systems thus change the restraining effect of airbags or belts shortly prior to or during an accident in dependence on the above-mentioned parameters (e.g., in dependence on the belt state). The occupant is thereby however usually viewed as a unit. The desired decoupling of optimization measures with regard to their effect for accidents with different boundary conditions is thus restricted. In addition, there exists the problem with many previous approaches of adaptive airbags that the sensor system for decisive improvements is not sufficient or at least expensive.

[0013] It is thus one object of the present invention to provide an improved vehicle occupant safety systems (in particular, restraint systems) in which the effective forces are distributed as optimally as possible during accidents; that is, e.g., the thorax is not strained excessively. Furthermore, a corresponding method for operating a vehicle occupant safety system shall be suggested.

[0014] This and other objects and advantages are achieved by the occupant safety system according to the invention, which has at least one airbag, at least one sensor device for sensing one or more situation parameters and at least one control device for controlling inflation and deflation, unfolding and/or a positioning of the airbag in dependence on the at least one situation parameter. The shape of the airbag or the distribution of pressure in the airbag can be controlled directly or indirectly in a targeted manner by the control device in dependence on the one or more situation parameters.

[0015] A method for operating a vehicle occupant safety system with an airbag is further provided according to the
invention, by sensing at least one situation parameter and controlling an inflation and/or deflation and/or unfolding and/or a positioning of the airbag in dependence on the at least one situation parameter, wherein the shape of the airbag and/or the distribution of pressure in the airbag is controlled in a targeted manner in dependence on the situation parameter.

[0016] A variable airbag support in dependence on environment parameters can thus be ensured in an advantageous manner. A reduction of the load on the thorax (e.g., of the thorax indentation with EU NCAP experiments or the thorax acceleration with US NCAP experiments) can thus be achieved. A realization can usually be achieved without an additional sensor system. A situation parameter, which is sensed by a sensor unit, preferably represents an accident type, an accident severity, an impact direction, a type of occupant an occupant weight, an occupant size, an occupant contour, an occupant position, an occupant kinematics and/or a belt state. The belt state can for example in particular be determined by a belt buckle sensor.

[0017] The present invention can in principle be applied to different types of airbags as e.g., conventional airbags, which are only supported by the filling gas, support structure airbags or mechanical airbags.

[0018] According to one further development, an imminent or occurred accident can be detected with the sensor device and the shape of the airbag and/or the distribution of pressure in the airbag prior to and/or during the accident can be changed with the control device. The risk of injury can be reduced considerably with the corresponding adaptation.

[0019] In a further embodiment, the control device can control the shape of the airbag in such a manner that, if the sensor device recognizes a closed belt, a region of the airbag meant for the support of the thorax of an occupant supplies less support force than in the case of a belt which is not closed. Thereby, the thorax is not excessively strained by the airbag, if high forces already act thereon by the belts.

[0020] The shape of the airbag can be adapted differently in several regions to a predetermined and/or predicted contour. Thus, a suitable support can respectively take place for example for the head region, the neck region, the shoulder region and the thorax region of the occupant.

[0021] The airbag can further have several segments, which are separated from each other and which can be filled with pressure independently of each other. A support dependent on the body region can also be achieved thereby.

[0022] In a further embodiment, the control device has active and/or passive elements for changing the shape of the airbag and/or the distribution of pressure in the airbag. The pressure in the airbag can thus for example be influenced in a purely passive manner dependent on the speed according to the principle of Bernoulli. Rebound straps controlled by ignition tablet(s), gas generator(s) and/or electromagnet(s) can e.g., be used as active elements.

[0023] Furthermore, a means for the releasable or temporary constriction of the airbag can be arranged thereon. In particular, a releasable rebound strap can reduce the volume of the airbag at least in a first release stage. The constriction can be released, but this is not necessary.

[0024] In an advantageous further development of the invention, a multi-stage gas generator is provided for inflating the airbag, wherein the control device for a first release stage of the gas generator leaves the constriction of the airbag and releases the constriction for a second release stage. The airbag volume can thereby be adapted to the inflation volume of the respective gas generator stage. The release of the constriction can take place not only directly via the release stage, but also indirectly, e.g., via the pressure increase by the ignition of a further generator stage. A release stage of a gas generator stage can also contain the function of a control device or be connected thereto. It is e.g. possible that a rebound strap is released for the constriction of an airbag by the release of a second generator stage (e.g. severed).

[0025] Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. 1 is a schematic diagram of the support of a vehicle occupant with a fastened seat belt, by an airbag with rebound strap; and

[0027] FIG. 2 shows the support of a vehicle occupant with an unfastened seat belt, by an airbag with released rebound strap.

DETAILED DESCRIPTION OF THE DRAWINGS

[0028] The embodiments described in more detail in the following represent preferred embodiments of the present invention.

[0029] According to the invention, the airbag is no longer designed or adapted to an occupant as a unit, but according to the situation to individual body regions and/or impact directions. The airbag can be adapted specially prior to or during an accident for individual regions (e.g., head, thorax) in dependence on boundary conditions (as e.g., accident type, accident severity, impact direction, type of occupant, belt state, etc.) corresponding to the necessary restraining effect. A decision or adaptation algorithm can possibly also consider several boundary conditions and put them in relation to each other.

[0030] With the vehicle occupant safety system according to the invention, an even more targeted division of the restraining effect of the airbag on individual body regions in dependence on different boundary conditions or situations is possible. As the optimization measures can be decoupled in a better manner for this for the different boundary conditions, these optimizations are partially actually only possible for the first time. It is for example conceivable for fastened load cases that the airbag or airbag only supports the head, so as to enable a reduction of the thorax load. For prevalent unfastened load cases, the support by means of the airbag is however needed.

[0031] A vehicle occupant safety system according to the present invention can for example be realized in the following embodiments:

[0032] According to a first embodiment, the shape of the airbag is adapted to individual body regions according to the situation. These include for example the omission of regions, which shall be not be restrained or only be restrained in a reduced manner by the airbag. According to a second embodiment, the shape of the airbag adapts to the impact direction in such a manner that a larger part of the airbag lies between the occupant and the possible impact surface in the vehicle interior, as would be the case without adaptation.

[0033] In a third embodiment, the airbag is segmented for individual body regions. At least one of the regions resulting in this manner can be adapted according to the situation prior to or during the restraint. A segment can thereby for example have an inner pressure, which is different from the other
[0034] The characteristics of the three embodiments which have just been introduced can also be combined with each other, if this is sensible. The adaptation can further take place in a passive manner (self-adaptive) and/or in an active manner (e.g., switchable).

[0035] A concrete embodiment of a vehicle occupant safety system is introduced in the following by means of FIGS. 1 and 2.

[0036] A vehicle occupant, a passenger in this case, sits in his seat 2 while being fastened with a seat belt. One part of the belt 3 passes over the thorax of the occupant 1. During an impact, the belt 3 exerts a force $F_G$ on the thorax of the occupant 1, so as to restrain him. As the airbag 4 was also released during the impact, it additionally exerts a pressure $F_{AD}$ on the thorax. The two forces $F_{AD}$ and $F_G$ are added together. In order that this force does not exceed a predetermined threshold, a releasable rebound strap 5 is arranged in the airbag 4. This rebound strap 5 slightly constricts the airbag 4 in the region of the thorax of the vehicle occupant 1, such that the force $F_{AD}$ exerted from the airbag on the thorax is reduced.

[0037] In the present case, it was recognized by a belt buckle sensor 6 that the vehicle occupant 1 is fastened with a seat belt. This sensor signal is guided as a situation parameter to a control device 7, which serves for releasing the airbag 4. The control device 7 thereby determines a fastened load case, and a holding device 8 accessed thereby holds the rebound strap 5 for example at the panel 9. The airbag can thereby not unfold completely in the thorax region and only exerts a reduced force $F_{AD}$ on the thorax. The airbag 4 is supported on the windscrean 10. In the region of the head of the head 1, the airbag is however not constricted. A force $F_{AD1}$ thus acts on the head. No other force acts on the head, so that only the airbag is responsible for the restraining of the head.

[0038] By means of the constriction of the airbag 4 in the thorax region, it mainly acts in the head region when the occupant 1 is fastened by a seat belt. The restraining force acting on the thorax can thus be adjusted in a clearly more even or restrained manner. If a similar ratio of gas filling amount per volume unit is to be achieved for the cases with/without rebound strap, this can e.g., be achieved by the “redistribution” of the airbag volume. For this, several rebound straps can possibly be useful. (E.g., for the omission of occupant regions and for the release of division volumes). A further example with multi-stage gas generators is listed below.

[0039] In the example of FIG. 2, the occupant 1 is not fastened by a seat belt. During the impact it is thus necessary that the airbag does not only restrain the head, but also the thorax region of the occupant 1 without the help of the belt 3. The belt buckle sensor 6 has recognized that the occupant is not fastened by a seat belt. It delivers a corresponding sensor signal (situation parameter) to the control device 7. This determines the unfastened load case and releases the holding device 8 when impacting. The airbag or the airbag 4 is thereby not constricted by the rebound strap 5 and exerts an increased force $F_{AD}$ on the thorax of the occupant 1. This increased force $F_{AD}$ can approximately correspond to the sum of the reduced airbag force $F_{AD}$ and the belt force $F_G$ from the example of FIG. 1.

[0040] The force $F_{AD1}$ is exerted on the head of the occupant 1. In order to adapt this force—especially with the ratio to the force $F_{AD1}$—it can be sensible that (e.g., together with

-the release of the rebound strap) the damping action of the airbag is changed, e.g., by opening an additional outflow surface.

[0041] The airbag 4 has a different shape in the example of FIG. 2, in which the constriction is ineffective, at the end of the unfolding or filling phase compared to the example of FIG. 1, in which the constriction acts. According to the situation, the airbag 4 has a shape which is suitable for this situation in its completely inflated state (maximum inflation state) at the end of the unfolding or inflation period. The possibly necessary constriction can thereby also take place by several rebound straps and/or by (releasable) hold of an airbag region. The differentiation of the different situations can advantageously take place as in the above example by means of serial sensors, as the belt buckle switch here.

[0042] The described airbag with a releasable constriction can be combined advantageously with a multi-stage (e.g., two-stage) gas generator. For this, the airbag volume can additionally be adapted to the inflation volume of the release stage of the gas generator. This is not the case in this manner with conventional airbags. The delayed build-up of the internal airbag pressure, which is usual with multi-stage airbags, can further be avoided with the constriction during the restraining phase during the ignition of not all stages, can be accelerated, and an airbag volume which is not necessary can be avoided. With this special solution, it would even be conceivable in a simple embodiment that the fastening of the constriction is for example blown (with a pyrotechnical stage) or torn (with a pressurized gas stage or with a pyrotechnical stage) by means of the ignition of the second stage while using the energy resulting therefrom. A mechanical release while using e.g., the released energy is also possible. (E.g., releasing a locking device by inflow by means of the gas).

[0043] The improved vehicle occupant safety system according to the invention altogether permits the use of a conventional airbag system with only slight additions, changes or additional costs. Possibly, only a releasable constriction with a triggering algorithm is additionally necessary to obtain an adaptive airbag system. The remaining components such as the sensor system, actuator system, cabling etc. are often already present in the series-production.

[0044] The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.

1.10. (canceled)

11. A vehicle occupant safety system comprising:

- at least one airbag;

- at least one sensor device for sensing at least one situation parameter; and

- at least one control device for controlling at least one of:

- inflation, unfolding, positioning, and deflation of the airbag based on at least one situation parameter;

wherein, at least one of the form of the airbag, its unfolding or positioning, and a distribution of pressure in the airbag are controlled by the control device in a targeted manner, based on the situation parameter.

12. The vehicle occupant safety system according to claim 11, wherein the situation parameter characterizes at least one of an accident type, accident severity, an impact direction, a
type of occupant, occupant weight, occupant size, occupant contour, occupant position, occupant kinematics and a belt state.

13. The vehicle occupant safety system according to claim 11, wherein:
   The sensor device is operable to detect an imminent or current accident; and
   at least one of the shape, unfolding, positioning, and pressure of the airbag can be changed directly or indirectly by the control device prior to or during the accident.

14. The vehicle occupant safety system according to claim 11, wherein the control device controls at least one of the shape, unfolding, positioning, and pressure of the airbag directly or indirectly in such a manner that, if the sensor device recognizes a closed belt, a region of the airbag predetermined for the support of the thorax of an occupant delivers less support force than in the case of a belt which is not closed.

15. The vehicle occupant safety system according to claim 11, wherein the shape of the airbag can be adapted to a predetermined or predicted contour in several regions in a different manner.

16. The vehicle occupant safety system according to claim 11, wherein the airbag has a plurality of segments that are separated from each other and can be inflated with pressures that are different from each other or adapted with damping behaviors that are different from each other.

17. The vehicle occupant safety system according to claim 11, further comprising active or passive elements for directly or indirectly changing the shape, unfolding, or positioning of the airbag, or the distribution of pressure in the airbag.

18. The vehicle occupant safety system according to claim 11, further comprising means for releasably constricting the airbag.

19. The vehicle occupant safety system according to claim 18, further comprising a multi-stage gas generator for inflating the airbag; wherein the control device for a first release stage of the gas generator leaves the constriction of the airbag and releases the constriction for a second release stage.

20. A method for operating a vehicle occupant safety system with an airbag, said method comprising:
   sensing at least one situation parameter; and
   controlling at least one of inflation, deflation, unfolding, positioning of the airbag depending on the at least one situation parameter;
   wherein at least one of the shape, unfolding, the positioning, and distribution of pressure within the airbag is controlled in a targeted manner depending on the at least one situation parameter.

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