A tank for a reducing agent which forms ammonia or which includes ammonia, has a planar first tank volume and at least one elongate second tank volume. A motor vehicle has an internal combustion engine, an exhaust system with an SCR catalytic converter and a reducing agent metering device and a body with a roof. A tank with a planar first tank volume for the reducing agent is provided on the roof. A method for operating an SCR system of a motor vehicle which has at least two tank volumes, a reducing agent metering device and an SCR catalytic converter, is also provided.
TANK FOR A REDUCING AGENT, MOTOR VEHICLE HAVING A TANK FOR A REDUCING AGENT AND METHOD FOR OPERATING AN SCR SYSTEM OF A MOTOR VEHICLE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the priority, under 35 U.S.C. §119, of German Patent Application DE 10 2008 022 515.0, filed May 7, 2008; the prior application is herewith incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Field of the Invention

[0003] The present invention relates to a tank for a reducing agent. The tank has a planar first tank volume and at least one elongate second tank volume. The invention also relates to a motor vehicle having a tank for a reducing agent and to a method for operating an SCR system of a motor vehicle having at least two tank volumes for a reducing agent.

[0004] Due to the increased demands on the exhaust-gas purification systems of internal combustion engines, in particular of diesel engines, ever-increasing use is made of SCR systems in the exhaust systems of internal combustion engines in order to reduce the nitrogen oxides in an exhaust gas. In that case, the exhaust-gas or emissions regulations which have now been agreed to in many countries apply not only to on-road vehicles such as passenger vehicles and utility vehicles, but also apply even today, or will apply in the near future, to so-called off-road vehicles, that is to say for example to tractors and other agricultural vehicles.

[0005] In addition to the integration of such SCR systems during the development phase of vehicles, SCR systems which can be retrofitted in particular are of great significance, because the purchase costs of off-road vehicles are generally very high.

[0006] The retroactive integration of such SCR systems is generally difficult since the tank capacities for the reducing agent of an SCR system must be selected to be very large in order to obtain the longest possible service intervals and due to intensive utilization of the vehicles. Furthermore, in particular in agricultural machines, for example in tractors, there are many restrictions with regard to installation location, because the visibility of the front region in front of the body is particularly significant.

[0007] Furthermore, the system components of such an SCR system should be constructed to be very light with regard to their weight, and should have a low level of complexity with regard to freedom from maintenance. Furthermore, the production and operating costs must be reduced and, in particular, the least possible amount of additional energy of the internal combustion engine or of the electrical energy accumulator or energy generator should be consumed. In the case of a retroactive installation of such an SCR system into a motor vehicle, the modification measures required should also be as minor as possible.

[0008] From the above statements, it is clear that there are numerous requirements for the (retroactive) installation of SCR systems in motor vehicles in order to ensure long service lives and service intervals of the vehicle and to generate low servicing and production costs.

SUMMARY OF THE INVENTION

[0009] It is accordingly an object of the present invention to provide a tank for a reducing agent, a motor vehicle having a tank for a reducing agent and a method for operating an SCR system of a motor vehicle, which overcome the hereinafore-mentioned disadvantages and at least partially solve the problems of the heretofore-known devices and methods of this general type. In particular, it is an object to specify a tank for a reducing agent, in which the tank permits retroactive installation into a motor vehicle. It is also intended to specify a motor vehicle which at least partially solves the problems highlighted in the introduction and in particular specifies the configuration of a tank for a reducing agent, in which the configuration does not restrict the user with regard to the visibility of the body of the vehicle. Furthermore, it is intended to specify a method for operating an SCR system of a motor vehicle, in which the method permits simple operation of the SCR system and therefore permits considerable advantages with regard to servicing, production, operating costs and energy consumed.

[0010] With the foregoing and other objects in view there is provided, in accordance with the invention, a tank for a reducing agent forming ammonia or including ammonia. The tank comprises a planar first tank volume having a first height, a first mean base area and a first ratio of the first mean base area to the first height of greater than 500 cm, in particular 1,000 cm or even greater than 1,500 cm. At least one elongate second tank volume has a second height and a second mean base area. The at least one elongate second tank volume projects, protrudes or overhangs relative to the planar first tank volume.

[0011] It is, of course, possible to use a tank of this type to store a reducing agent which already includes ammonia and/or an ammonia precursor. However, in the SCR systems used in this case, an aqueous urea solution is preferable as a reducing agent. The aqueous urea solution is, for example, available under the trademark AdBlue. In this case, the solution is injected, sprayed or vaporized into the exhaust line upstream of an SCR catalytic converter, for example through the use of a dosing pump or an injector. Ammonia (NH₃) and water are generated from the aqueous urea solution in a hydrolysis reaction by using a catalyst (for example which is still outside of the exhaust gas) and/or as a result of contact with the hot exhaust gas. The ammonia which is generated in this way may react, in an SCR catalytic converter at a corresponding temperature, with the nitrogen oxides of the exhaust gas.

[0012] In this case, the consumption of aqueous urea solution is approximately 1% to 8% of the fuel (diesel fuel) which is used, depending on the untreated emissions of the internal combustion engine. It is therefore necessary precisely in this case for a correspondingly large tank volume to be carried on board.

[0013] The tank is shaped in such a way that a first tank volume has a planar construction, that is to say simultaneously has a comparatively large length and/or width, while having a small height. The first mean base area of the first tank volume is generated by averaging the tank cross-sectional area over the first height (that is to say perpendicularly thereto). In this case, the first height is preferably also the greatest height of the first tank volume, which is preferably for example a maximum of 10 cm or even only a maximum of
5 cm. The elongate second tank volume forms a direct continuation of the first tank volume, and is in particular non-detachably connected to the first tank volume. In this case, the second tank volume has, along its elongate extent, a second height which is comparatively large in relation to the length and width of the second tank volume. The second mean base area is generated, similarly to the first tank volume, by averaging the tank cross-sectional area of the second tank volume over the second height. In this case, the second height is preferably the averaged or even the smallest height of the second tank volume, which is preferably for example at least 20 cm or even at least 50 cm. The second tank volume is in particular formed relative to the first tank volume in such a way that the first height and the second height, and accordingly the second volume mean base areas, extend in each case in virtually the same direction (parallel). The first base area is preferably at least 0.5 m² or even at least 1 m².

In accordance with another feature of the invention, the tank is preferably constructed in such a way that a second ratio of the second mean base area and the second height is smaller than 2 cm, in particular smaller than 1.5 cm.

In particular, the ratio of the second height (H2) to the first height (H1) is greater than 3:1, that is to say

\[ \frac{H_2}{H_1} > 3. \]

If appropriate, the ratio may even be at least 5:1.

In accordance with a further feature of the invention, the at least one second tank volume is disposed directly in an edge region of the first tank volume, and in particular in a corner region of the first tank volume. In addition to the at least one second tank volume, the tank may also have further second tank volumes which are advantageously likewise disposed in the edge region of the first tank volume, particularly advantageously in the further corner regions of the first tank volume.

In accordance with an added feature of the invention, the first tank volume for holding the reducing agent preferably has a first volume of at least 90 l (liters) and the at least one elongated second tank volume preferably has a second volume which encompasses at most 10% of the first volume, and in particular at most 5%. If a plurality of elongate second tank volumes are to be provided, the respective volume of the second tank volumes should in particular be adapted to the number of second tank volumes, that is to say in the case of two second tank volumes being provided, the respective second volumes are at most 5% of the first volume, and in the case of three second tank volumes being provided, the respective second volumes are at most 3.3% of the first volume. In particular, the plurality of second tank volumes are directly connected to one another through the use of a collecting line, in such a way that the liquids which are contained in the second tank volumes can be exchanged with one another. In this case, the collecting lines are in particular connected to that end of the second tank volume which is disposed so as to face away from the first tank volume.

In accordance with an additional feature of the invention, a third tank volume is connected through a connecting line to the first tank volume and/or to the at least one second tank volume. In this case, the third tank volume should be matched in terms of its shape to the spatial conditions in the vehicle. The volume of the third tank volume however corresponds in particular to that of the at least one second tank volume, that is to say encompasses for example at most 10% of the first volume. According to a further advantageous refinement, the third tank volume is significantly smaller than the at least one second tank volume. The third tank volume thus has a third volume which corresponds in particular to at most 1% of the first volume.

In accordance with yet another feature of the invention, at least one second tank volume and/or the third tank volume of the tank preferably includes a heater. In this case, the heater is in particular an electrical heater, which can for example be connected to electrical accumulators or electrical generators of a motor vehicle. The heating power can in particular be automatically activated on demand and/or regulated and should be at least 500 W in order to make a freezing agent having a freezing point of at least −50 °C boil at atmospheric pressure.

In accordance with yet a further feature of the invention, at least the first tank volume has a housing composed of plastic. High-grade steel or plastic tanks are particularly suitable for reducing agents, in particular for an aqueous urea solution. The present embodiment of the tank, however, plastic is preferable since it has a lower weight than a construction using high-grade steel and has a certain expansion capability. It is very particularly preferable in this case to use polyurethane as a material, for example a high-pressure-resistant polyurethane. At least the first tank volume of the tank has heat insulation. The heat insulation is in particular constructed so as to encompass only a partial region of the first tank volume.

With the objects of the invention in view, there is also provided a motor vehicle, comprising an internal combustion engine, an exhaust system having an SCR catalytic converter and a reducing agent metering device, a body with a roof, and a tank, in particular a tank according to the invention, disposed on the roof and having a planar first tank volume for a reducing agent.

The reducing agent metering device includes, for example, an injector or an injection nozzle and a dosing pump which supplies the reducing agent from a tank volume to the exhaust system.

The body of the motor vehicle includes all of the structural parts of the motor vehicle and a roof which is disposed above a driver’s cab. The planar first tank volume is disposed on the roof, in particular in such a way that a driver or user (that is to say any other persons present in the driver’s cab) of the vehicle is not restricted in terms of their freedom of movement by the first tank volume. In particular, the first tank volume may be disposed above the roof, below the roof or else within the roof. The roof, or any other roof shape, or other profiles which are adapted firstly to the construction of the roof and/or to the freedom of movement of the driver or user. In this case, the tank preferably extends over virtually the entire area of the roof and therefore, through the use of the largest possible base area and the smallest possible height, utilizes the greatest possible first tank volume. Likewise, any other desired shape of the first tank volume equally falls within the scope of this construction of the vehicle according to the invention in this case.

In accordance with another feature of the invention, the tank of the motor vehicle preferably has a planar first tank volume and at least one elongate second tank volume. The at least one elongate second tank volume is formed so as to
project, protrude or overhang in relation to the planar first tank volume and the at least one second tank volume is disposed along a roof beam of the body. The first tank volume is thus distinguished in particular in that the greatest possible length and width of the tank are provided so as to utilize the roof area, and the smallest possible first height is provided in such a way that, as far as possible, the user or the driver is not restricted. The at least one elongate second tank volume has the smallest possible width and length, but has a large height along the elongate extent of the second tank volume, in such a way that the at least one second tank volume can run along a roof beam of the body. Through the use of as narrow a construction of the second tank volume as possible, which is possibly also profiled, it is sought firstly to provide a sufficiently large volume in the second tank volume, and secondly to provide that the freedom of movement of the user and/or driver is as far as possible not restricted, and that a reduction of the visibility of the body of the vehicle is avoided as far as possible. In this case, the second tank volume should be disposed geodetically (with regard to its height position) below the first tank volume.

[0025] It may thus also be possible, for example, for the first tank volume and/or the second tank volume to be an integral part of the body and/or of a driver’s cab. This applies in particular to applications in which the tank is already installed during the production of the motor vehicle. In this connection, “integral” means in particular that the first tank volume and/or the second tank volume can be removed with (partial) deformation and/or destruction of the body.

[0026] In accordance with a further feature of the invention, a third tank volume is connected through a connecting line to at least one second tank volume or to the first tank volume, and at least the first tank volume is connected through the third tank volume to a reducing agent metering device.

[0027] A second tank volume therefore need not necessarily be provided in this case. The third tank volume is thus supplied with the reducing agent directly from the first tank volume. The third tank volume is disposed in particular outside the driver’s cab, in the vicinity of the dosing pump or of an injector of the reducing agent metering device. The third tank volume is in particular disposed in such a way that the waste heat of the engine or the exhaust line can be utilized as heating power for the third tank volume. Accordingly, the third tank volume is in particular at least partially heat-insulated with respect to the environment, in such a way that freezing of the reducing agent is prevented, or thawing of the reducing agent is accelerated.

[0028] The third tank volume is preferably disposed geodetically below the at least one second tank volume and may, in the case of a plurality of second tank volumes, be connected to each of the plurality or preferably to a collecting line which connects the plurality of second tank volumes. The collecting line is preferably connected to those ends of the second tank volumes which face away from the first tank volume.

[0029] The third tank volume is in particular disposed outside a driver’s cab of the motor vehicle, in particular in the direct vicinity of a delivery pump of the SCR system for the reducing agent. If a third tank volume is not provided, the at least one second tank volume is connected through a connecting line (which, if appropriate, is flexible, for example formed by a hose) to a reducing agent metering device. The connecting line may also be connected to a collecting line of the plurality of second tanks, as already described above.

[0030] In accordance with an added feature of the motor vehicle of the invention, a reducing agent metering device is connected to at least one second tank volume which can be filled under gravitational force, or to a third tank volume which can be filled under gravitational force. In this case, the reducing agent metering device includes, for example, at least one pump and an injection configuration or an injector and is supplied with the reducing agent from the at least one second tank volume or from the third tank volume. In this case, at least one second tank volume is filled with reducing agent from the first tank volume as a result of gravitational force. The third tank volume is filled with reducing agent either from the first tank volume and/or from the at least one second tank volume. Such a configuration of the tank volumes makes it possible to dispense with additional supply pumps, and also to prevent insufficient filling of a tank volume as a result of the motor vehicle traveling long distances in (oblique) awkward positions. This is obtained in particular by providing a further second tank volume or the third tank volume, wherein the second tank volumes can additionally be connected to one another through the use of a collecting line for the equalization of the second tank volumes.

[0031] In accordance with an additional feature of the motor vehicle of the invention, a roof region of the motor vehicle has heat insulation, such that at least the first tank volume of the tank is at least partially insulated with respect to the external environment by the heat insulation. In this case, the (in particular non-metallic) heat insulation serves in particular to protect the first tank volume from climatic influences of the environment, such that freezing of the reducing agent within the first tank volume is prevented as far as possible, but at the same time a liquefaction of the reducing agent can be accelerated as a result of the first tank volume not being heat-insulated with respect to the interior space of the cabin of the motor vehicle.

[0032] With the objects of the invention in view, there is concomitantly provided a method for operating an SCR system of a motor vehicle having at least two tank volumes, a reducing agent metering device and an SCR catalytic converter. The method comprises storing a reducing agent for the SCR system in one of the tank volumes,

[0033] during operation of the motor vehicle, automatically filling at least one further of the tank volumes with the reducing agent from the one tank volume, and forming a reservoir for the reducing agent metering device with the at least one further tank volume. The method is proposed in particular for operating a motor vehicle according to the invention, and the motor vehicle has in particular a tank according to the invention.

[0034] It is also the case herein that the reducing agent metering device includes for example an injector or a delivery pump and an injection nozzle for dispensing the reducing agent into the exhaust line. The method is distinguished in that, during the operation of the motor vehicle, the reducing agent is delivered from a first tank volume into at least one further tank volume as a result of gravitational force, in such a way that the at least one further tank volume forms an in particular permanently filled reservoir for the reducing agent metering device. A reservoir therefore refers to a volume which is permanently filled in particular in awkward positions of the vehicle and when the further tank volumes which are provided are partially filled, and which can be emptied through the reducing agent metering device only once the further tank volumes have emptied.
[0035] Other features which are considered as characteristic for the invention are set forth in the appended claims, noting that the features specified individually in the dependent claims may be combined with one another in any desired technologically expedient manner, and define further refinements of the invention. Although the invention is illustrated and described herein as embodied in a tank for a reducing agent, a motor vehicle having a tank for a reducing agent, and a method for operating an SCR system of a motor vehicle, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

[0036] The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0037] FIG. 1 is a diagrammatic, perspective view of a tank;
[0038] FIG. 2 is a side-elevational view of a vehicle having a tank;
[0039] FIG. 3 is a diagrammatic and schematic view showing details of a motor vehicle which are important to the invention; and
[0040] FIG. 4 is a view similar to FIG. 3 showing a further view of details of a motor vehicle which are important to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0041] Referring now in detail to the figures of the drawings, which show particularly preferred embodiment variants of the invention, without the invention being restricted thereto and first, particularly, to FIG. 1 thereof, there is seen a diagrammatic, perspective view of a tank 1 having a housing 17 and a first tank volume 3 with a first mean base area GF1, a first height H1 and a corresponding first volume V1. The first tank volume 3 is connected to a second tank volume 7 of the tank 1 having a second mean base area GF2, a second height H2 and a corresponding second volume V2. In this case, the second tank volume 7 is disposed in an edge region 21 of the first tank volume 3. The tank 1, in this case, may also have further second tank volumes 7 which, if appropriate, are connected to one another through the use of a collecting line 23 that is connected to those ends of the second tank volumes 7 which face away from the first tank volume 3. The collecting line 23, or the at least one second tank volume 7, is connected through a connecting line 10 to a reducing agent metering device 13, through the use of which a reducing agent 2 is supplied to an exhaust system 14, seen in FIGS. 2, 3 and 4. Furthermore, if appropriate, the second tank volumes 7 have a heater 16 which is preferably disposed in the region of a tank outlet 24 of the second tank volume 7.

[0042] FIG. 2 is a diagrammatic side view which shows a motor vehicle 5 with an exhaust system 14 and a body 22 with a roof 6 and a roof beam 8. In this case, a tank 1 for a reducing agent 2 has a first tank volume 3 disposed in a roof region 4 of the motor vehicle 5.

[0043] FIG. 3 diagrammatically shows details of a motor vehicle 5 which are important to the invention, in particular an internal combustion engine 15 with an exhaust system 14 connected thereto, in which the exhaust system 14 includes at least one SCR catalytic converter 11. The reducing agent 2 is supplied from a first tank volume 3 of a tank 1 and from a second tank volume 7 through a connecting line 10 to a reducing agent metering device 13, which supplies the reducing agent 2 to the exhaust system 14 through an injection configuration or an injector. In this embodiment, an SCR system 19, denoted in FIG. 3 by a dashed line, includes at least the two tank volumes, that is the first tank volume 3 and the second tank volume 7, as well as the reducing agent metering device 13 and the SCR catalytic converter 11. The tank 1 is disposed with its first tank volume 3 in the region of the roof 6 and is in particular at least partially integrated into the roof, with the housing 17 of the tank 1, in particular of the first tank volume 3, being at least partially insulated with respect to the external environment through the use of heat insulation 18. The second tank volume 7 extends downward from an edge region 21 of the first tank volume 3 along a roof beam 8, and has, at its lower end, a tank outlet 24 in the vicinity of which a heater 16 is disposed if appropriate.

[0044] FIG. 4 diagrammatically shows a further view of details of a motor vehicle 5 which are relevant to the invention. In this case, similarly to FIG. 3, a tank 1 is disposed with its first tank volume 3 in a roof 6 of a motor vehicle 5 and extends downward with a second tank volume 7 along a roof beam 8. The second tank volume 7 is connected through a connecting line 10 to a third tank volume 9 which, if appropriate, has a heater 16 within the third tank volume 9 in the vicinity of a tank outlet 24. The reducing agent 2 is metered to the exhaust system 14 upstream of an SCR catalytic converter 11 from the third tank volume 9 through the use of a reducing agent metering device 13. In this case, the third tank volume 9 serves as a reservoir 20 for the reducing agent metering device 13. In particular, the reservoir 20 is supplied with the reducing agent 2 from the other tank volumes (3, 7) under gravitational force 12, in such a way that all of the other tank volumes (3, 7) are emptied before the reservoir 20.

1. A tank for a reducing agent forming ammonia or including ammonia, the tank comprising:
   a planar first tank volume having a first height, a first mean base area and a first ratio of said first mean base area to said first height of greater than 500 cm; and
   at least one elongate second tank volume having a second height and a second mean base area, said at least one elongate second tank volume projecting relative to said planar first tank volume.

2. The tank according to claim 1, wherein a second ratio of said second mean base area to said second height is smaller than 2 cm.

3. The tank according to claim 1, wherein said first tank volume has an edge region, and said at least one second tank volume is disposed directly in said edge region of said first tank volume.

4. The tank according to claim 1, wherein said first tank volume has a first volume of at least 90 liters for holding the reducing agent, and said at least one elongate second tank volume has a second volume encompassing at most 10% of said first volume.

5. The tank according to claim 1, which further comprises a third tank volume, and a connecting line connected between said first tank volume and at least one of said first tank volume or said at least one second tank volume.
6. The tank according to claim 5, wherein at least one of said at least one second tank volume or said third tank volume includes a heater.

7. The tank according to claim 1, wherein at least said first tank volume has a housing composed of plastic.

8. The tank according to claim 1, wherein at least said first tank volume has heat insulation.

9. A motor vehicle, comprising:
   an internal combustion engine;
   an exhaust system communicating with said internal combustion engine and having an SCR catalytic converter and a reducing agent metering device;
   a body with a roof; and
   a tank disposed on said roof, communicating with said exhaust system and having a planar first tank volume for a reducing agent.

10. The motor vehicle according to claim 9, wherein said body has a roof beam, and said tank has at least one elongate second tank volume, said at least one elongate second tank volume being disposed along said roof beam and projecting relative to said planar first tank volume.

11. The motor vehicle according to claim 10, which further comprises a third tank volume, and a connecting line connected between said third tank volume and at least one of said at least one second tank volume or said first tank volume, at least said first tank volume being connected through said third tank volume to said reducing agent metering device.

12. The motor vehicle according to claim 10, wherein said reducing agent metering device is connected to said at least one second tank volume which can be filled under gravitational force.

13. The motor vehicle according to claim 11, wherein said reducing agent metering device is connected to said third tank volume which can be filled under gravitational force.

14. The motor vehicle according to claim 9, which further comprises a roof region having heat insulation, at least said first tank volume of said tank being at least partially insulated by said heat insulation.

15. A method for operating an SCR system of a motor vehicle having at least two tank volumes, a reducing agent metering device and an SCR catalytic converter, the method comprising the following steps:
   storing a reducing agent for the SCR system in one of the tank volumes;
   during operation of the motor vehicle, automatically filling at least one further of the tank volumes with the reducing agent from the one tank volume; and
   forming a reservoir for the reducing agent metering device with the at least one further tank volume.

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