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[0001] The invention relates to a method for the surface treatment of a lightweight gas canister or cylinder made of dual-phase steel, in which the gas cylinder is blast-cleaned to a minimum roughness depth of 30 µm, then powder-coated with paint and finally heat-treated in a furnace at a temperature ranging
5 between 150°C and 250°C.

[0002] Liquefied petroleum gas cylinders, in particular propane gas cylinders, are used in many different ways for commercial and private purposes, in particular also for the operation of barbecue stations. These are portable, refillable, welded
10 steel cylinders capable of withstanding a test pressure of 30 bar and, for example, have a diameter of 300 mm with a capacity of between 12.5 and 27.2 l, for example. Such gas cylinders are available on the market as owned or hired-out cylinders, are refillable in many cases and require regular maintenance and checks to verify their operational safety.

[0003] Especially in the event of smaller filling volumes, the deadweight of the gas cylinder accounts for a considerable part of the total weight. This has a detrimental effect on cylinder handling and transportability.

[0004] With a view to reduce the deadweight of LPG cylinders a number of measures have been taken. For example, the valve protection collars have been converted to plastic and, at the same time, the metal handles integrated into the plastic collar. However, the large proportion of the deadweight results from the metal
20 body of the gas cylinder itself.

[0005] Remedial action has been taken in this context by utilizing a new steel quality, the so-called dual-phase steel. Dual-phase steel or DP steel are steels whose microstructure consists of a ferritic matrix in which a predominantly martensitic second phase is embedded. While the ferritic matrix has a rather soft
25 quality, the martensitic second phase with a proportion of about 20%, for example, causes the tensile strength to increase. DP steels are considerably stronger than conventional steels and thus enable thinner sheet metal to be used without loss of strength in a variety of applications, for example in automotive engineering, but also in the manufacture of gas cylinders.

[0006] For example, dual-phase steels are available from ThyssenKrupp and ArcelorMittal under the brand name DP 600. In publication WO 2011/039463 A1 reference is made to a gas cylinder of double-phase or complex-phase steel comprising two half-shells joined by welding.

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[0007] Conventional gas cylinders, are made, for example, of P 310 quality steel sheets having a thickness of 2.3 mm. For gas cylinders manufactured of DP-600 steel, sheet metal of 1.6 mm thickness can be employed resulting in a weight saving of approx. 30%.

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[0008] Gas cylinders are produced by cold forming (deep drawing) from sheets appropriately cut to size. DP steel offers advantages in that excellent cold formability is achieved with hardening and improvement of the mechanical properties which are important for the gas cylinder. In comparison with the initial steel material, the yield strength, in particular, is improved.

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[0009] Especially the outside of gas cylinders must be protected against corrosion, and, for that reason, the cylinders are usually provided with a paint coat. The coating must be capable of withstanding a standardized salt spray test for 480 hours (corrosion protection category C4). However, gas cylinders made of DP steel have to meet salt spray test requirements for an even longer period of 720 h. This cannot be achieved with a single coating as it is used for standard gas cylinders (polyester lacquer coating). As a rule, this requires a higher film thickness of the paint coat or even a multi-layer coating system.

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[0010] Corrosion resistance is also difficult to attain in view of the fact that conventional paint material does not adhere well to the very smooth DP steel surfaces. This situation must also be taken into account.

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[0011] It is thus the objective of the invention to make available a surface treatment method by means of which liquefied petroleum gas cylinders made of dual-phase steel can be provided with a permanent and corrosion-resistant coating.

[0012] This objective is achieved by a method in accordance with claim 1. Advantageous embodiments of the invention will arise from the subclaims. Powder coatings in particular are used for the coating systems.

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[0013] In practice, it has been shown that the coating method with a final heat treatment leads to a product that is also further improved in terms of steel quality. Measurements have shown that heat treatment in the range of 150 to 250°C (object
5 temperature) applied over a defined period of time further improves the mechanical strength of the steel used. In the DP 600 steel grade in particular, such a subsequent heat treatment results in so-called bake hardening, i.e. a further increase in strength.

[0014] The method proposed by the present invention for the surface
10 treatment and hardening and tempering of lightweight gas cylinders made of dual-phase steel involves roughening the surface in a first step. A minimum roughness depth of 30 µm, preferably 40 µm, must be achieved in order to enable a durable coating to be applied that meets the requirements of the prescribed salt spray test. For roughening, a blast cleaning process with coarse-grained steel particles (GK
15 blasting) is used in particular, which covers all parts of the cylinder surface that come into contact with the paint.

[0015] After blast cleaning of the surface, at least one paint coat layer is applied, preferably at least two. For this purpose, the application of a primer and
20 subsequently a finishing paint coat has proven its worth. As primer coat, an epoxy powder coating is particularly suitable, which offers significantly improved adhesion compared to a polyester powder coating. After application, the epoxy powder coating is first gelatinized at an elevated temperature before the finishing coat is applied. The finishing paint material employed is preferably a polyester powder
25 coating. The two layers of paint are then subjected to a heat treatment at 150°C to 200°C, with it being important that the object (the gas cylinder) reaches this temperature as well. Preferably, this thermal treatment takes place at a temperature ranging between 170°C and 220°C for 15 to 30 minutes and in particular at about 180°C for a period of 20 minutes. At this temperature setting, the hardening effect
30 has also been shown for the steel shell of the gas cylinder.

[0016] If only one coat of paint is applied, the film thickness in particular is 120 to 180 µm, in case two paint coats are applied the film thickness is 40 to 60 µm for the priming coat and 50 to 100 µm for the finishing coat.

[0017] The invention enables a lightweight gas cylinder to be manufactured from a dual phase steel provided with a corrosion resistant coating as described hereinbefore. For this anti-corrosion coating, at least one coat of paint is applied to a roughened surface having a minimum roughness depth of 30 μm , preferably 40 μm . Preferably, the gas cylinder is provided with a priming and a finishing coat of paint, with the primer coat consisting of an epoxy lacquer layer and the finishing coat being a polyester lacquer layer. Due to the heat treatment of the powder-coated lightweight gas cylinder the strength of the DP steel employed for the manufacture of the gas cylinder is additionally increased.

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[0018] The making of a gas cylinder consisting of DP steel is explained below in more detail.

[0019] Out of initial steel material from the company of ArcelorMittal round blank sheets are cut having a sheet thickness of 1.6 mm which are wetted with a conventional drawing oil. By means of a draw punch and a die ring the round blanks are cold-formed into a calotte. After cold forming, the calotte edge is evened out and the edge of every second calotte is additionally beaded. The calottes serve to form the upper and lower portion of the gas cylinder, with the bead facilitating the positioning of the components in relation to each other and serving as weld pool backing.

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[0020] Subsequently, the calotte used for the upper part is transported into a piercing tool and prepared for mounting the valve device. Moreover, a seat accommodating the plastic cap and for the neck ring is formed in the upper part. The drawing oil is then washed away from the calottes.

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[0021] After preparation and cleaning, welding work is carried out. A screwed coupling is attached by welding, with a tapered female thread being provided to accommodate the valve. If necessary or recommendable, a steel collar and steel handles are welded on, unless a plastic collar is used to secure the valve in which case, the handles can be integrated into the plastic collar.

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[0022] After welding on the valve seating assembly, the upper part, lower part and foot ring of the cylinder are connected with each other by welding. Conventional steel grades can be used here for the foot rings. In the case of gas cylinders

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provided with plastic collars, the manufacturing data are stamped into the foot ring, otherwise they are shown on the carrying handles or the steel collar.

5 **[0023]** Before the coating system is applied, the blanks of the gas cylinders are prepared by blast cleaning to a minimum roughness depth of approx. 40 µm. For blast cleaning a GK process using steel particles is employed. The tightness of the gas cylinder is then tested, preferably with air, up to a pressure of 30 bar.

10 **[0024]** A customary powder coating process is used to apply the paint system, providing for an epoxy powder layer to be applied first to the gas cylinders. This powder layer is gelatinized in a furnace at relatively low temperature to improve the application and adhesion of a finishing coat of paint. As finishing layer, a polyester powder coating is applied. Both paint coat layers are then cross-linked in an oven at a temperature of 180°C (object temperature) for a period of approx. 20 minutes.

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[0025] As a result of the heat treatment process at 180°C, the strength of the DP 600 material is further increased through so-called bake hardening.

20 **[0026]** During final assembly, the gas cylinders are completed by mounting a plastic collar, a valve, the safety sticker, if necessary a screen print with customer logo and an imprint providing information on deadweight and date of manufacture.

25 **[0027]** It goes without saying that in some products it is possible to deviate from this exemplified method. For example, gas cylinders may be provided with only one paint coat or more than 2 coats of paint. In the event that only one coat of paint is required, this is preferably an epoxy coating.

PATENTKRAV

1. Fremgangsmåde til overfladebehandling af en letvægtsgasflaske fremstillet under anvendelse af et bifasestål (dual-phase steel), ved hvilken fremgangsmåde gasflasken
5 pulverblæses til en minimal ruhedsdybde på 30 µm, efterfølgende pulverbelægges med lak, og endelig varmebehandles i en ovn ved en temperatur på fra 150°C til 250°C.
2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** den minimale ruhedsdybde er
40 µm.
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3. Fremgangsmåde ifølge enten krav 1 eller krav 2, **kendetegnet ved, at** ruhedsdybden genereres ved grovkornet pulverblæsning.
4. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved** påføringen
15 af først et primerlag og efterfølgende en topbelægningslak.
5. Fremgangsmåde ifølge krav 4, **kendetegnet ved, at** en epoxypulverlak anvendes til primerbelægningen, hvilken lak geleres ved en forhøjet temperatur.
- 20 6. Fremgangsmåde ifølge enten krav 4 eller 5, **kendetegnet ved, at** en polyesterpulverlak anvendes til topbelægningslakken, hvilken lak påføres den gelererede epoxypulverlak.
7. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved, at** lak-
25 belægningen hærdes ved en temperatur på fra 170°C til 220°C i 15 til 30 minutter.