INNOVATIVE TECHNICAL VERSION OF THE INDUSTRIAL CONTAINER

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The present article deals with a technical design of industrial containers for bulk and piece materials. The introductory section of the article introduces several alternatives of the container types and describes their applications. The following section presents the original technical design of an industrial container, based on the theory, followed by a description of a newly developed design of an industrial container for bulk and piece materials, equipped with a hinged lid and a right-angled arm. The article also contains relevant drawing documentation.

KEYWORDS

industrial container, hinged lid, innovated design, lid opening

1 INTRODUCTION

Special containers, sound-insulated containers, as well as other types of containers are typically designed based on customer requirements. Containers are currently designed on the basis of a 3D model, which enables customers specify positions and sizes of all openings, structural details, technology placement and view a visualisation of the complete design of a container [Dyadyura 2021].

Each container design is based on static calculations. The use of containers is variable and universal. They are characterized by simplicity in transportation and assembly, they are mostly undemanding in preparing the base and connecting to distribution or communication networks, which facilitates their installation. They enable functional, efficient and quick construction of short- or long-term purpose-built facilities. They enable the construction of larger units by connecting several containers. The container is monitored by temperature sensors, humidity sensors, door contacts, motion sensors, flooding sensors, etc., as needed, power supply can be provided using power generators, backup sources, etc. [Murcinkova 2013].

However, residues of industrial chemicals found in containers can negatively affect the health of personnel. The results obtained using rapid tests are quite often false positive or false negative [Baur 2007]. The results show that accurate monitoring devices are suitable for quick signalling of risk and thus for initiating security measures. However, there is a need for optimization in terms of false positive results, which need to be eliminated due to unnecessary aeration and laborious test measurements [Pivarciova 2019]. From the prevention point of view, dangerous containers of this type must be entered, especially with closed ventilation slots, after exclusion of contamination by toxic substances using appropriate measuring devices and, if necessary, after sufficient ventilation and accurate measurement.

For example, a company Denios has developed a design for a technical storage container. With a useful area of 7 m² and an integrated collection tank, this container meets the key requirements for a warehouse unit. Despite the fact that the fire resistance of the warehouse was not mandatory, the warehouse insulation was made of an incombustible material (insulation panels compliant with the EI 120 standard), including the rear part. The warehouse insulation facilitates maintaining a constant indoor temperature of 20°C, even when the outdoor temperature ranges from -15°C to +35°C. This was achieved by using a heating, ventilation and air conditioning unit [Szabo 2020, Rimar 2022].

Storage of lithium-ion batteries should be carried out in an appropriate storage area. In order to ensure that the warehouse meets the requirements, the design had to be developed in cooperation with an Austrian company Kraftfahrzeuge Trunkenpolz Mattighofen and the battery manufacturer due to the absence of relevant legal regulations governing Li-ion accumulators. It was also necessary to take into consideration the thermal management requirement to avoid loss of the accumulator power during storage [Tothova 2014a, Kuznetsov 2020, Szabo 2020].

The aim of the presented research is therefore to present the modification of the industrial container in order to eliminate selected aforementioned risks [Baklouti 2001, Hœrle 2004, Jiang 2022]. The technical solution is also subject to intellectual property protection.

2 DESCRIPTION AND METHODOLOGY

With regard to the fact that a possibility of the formation of combustible gases during accumulator charging or in the event of a failure was absolutely excluded by the battery manufacturer, it was unnecessary to use the Ex-version for the internal equipment of the warehouse. Other technical features of the warehouse include door locking, fire extinguishing technology, drive-up ramp, potential balancing, and a bar grate with small cells for better mobility of pallet trucks (Figure 1).

Figure 1. Warehouse of Li-ion accumulators

For example, in one of the methods, the container/ILU must be either weighed directly on the shipping scales, where the resultant weight is the verified gross mass (VGM) of the loaded container/ILU, or weighed on a vehicle/vehicle combination using two weight measurements, while the weight is measured for the vehicle/vehicle combination with a loaded container/ILU and the vehicle/vehicle combination without the container/ILU. For the latter, the VGM value is calculated as follows [Kotus 2013]:

$$VGM = mt\,(V/\mathrm{VC}+LC) - mt\,(V/\,\mathrm{VC}) \quad (1)$$

$$VGM \leq MGM \quad (2)$$

wherein:

VGM if the gross mass of the loaded container/ILU in kg;

mt (V/VC+LC) is the total mass of the vehicle/vehicle combination with a loaded container/ILU in kg, measured by weighing;
mt (V/VC) is the total mass of the vehicle/vehicle combination without the container/ILU in kg, measured by weighing [Kotus 2013];
MGM is the maximum gross mass of the container in kg; for the container it is stated on the Safety Approval Plate in compliance with the International Convention for Safe Containers (CSC) and usually also on the container.
Verification of the total mass of the loaded container/ILU is carried out by measuring the mass of the whole cargo in the container on the vehicle/vehicle combination and by adding the mass of the empty container/ILU to the total mass of the load while using the shipping scales specified in the Methodological Guidance, by applying the following equations:

$$VGM = mt\ (V/\text{VC+LC}) - mt\ (\text{V/VC+C}) + m\text{C} \quad (3)$$

$$VGM \leq MGM \quad (4)$$

$$m\text{t}\ (V/\text{VC+LC}) \leq mmax\ (V/\text{VC}) \quad (5)$$

wherein:
VGM is the gross mass of the loaded container/ILU in kg;
mt (V/VC+LC) is the gross mass of the vehicle/vehicle combination with a loaded container/ILU in kg; measured by weighing;
mt (V/VC+C) is the gross mass of the vehicle/vehicle combination with an empty container/ILU in kg; measured by weighing;
$mmax$ (V/VC) is the maximum permitted gross mass of the vehicle/vehicle combination, as specified in Annex 1 to the Government Regulation no. 349/2009 Coll.;
mC is the mass of the empty container/ILU (TARE) in kg; for the container it is displayed on the container;
MGM is the maximum gross mass of the container in kg; for the container it is stated on the Safety Approval Plate in compliance with the International Convention for Safe Containers (CSC) and usually also on the container [Tothova 2014b, Panda 2018].
The present technical design relates to containers intended for the transport of bulk and piece materials, and it may be categorised as the design for transport operations.

2.1 *Original technical design for industrial containers*

The existing containers are typically produced in Asian countries and in sizes based on the Anglo-American metric system. These containers are of a unified height of 8 feet and 6 inches (2.59 m) and a width of 8 feet (2.44 m). This means that they only differ in length, whereas there are 5 different length options: 20 feet (6.1 m); 40 feet (12.2 m); 45 feet (13.7 m); 48 feet (14.6 m); and 53 feet (16.2 m). Containers are most frequently designed with the lengths of 20 and 40 feet. The inner sheath is made of steel sheet with respective surface finishing. This specific container architecture has been established all over the world, primarily in the USA and Europe, and has become a distinct phenomenon which attracts attention of media, experts, as well as general public. There are multiple container versions that differ in designs and applications despite the unified container system [Balara 2018, Szabo 2020, Yasothei 2022].
Although the issues related to containers cover a wide spectrum of topics, only a few publications have been released on heavy containers for bulk wastes. The most important publications and patents that deal with containers are as follows:
Patents:

1. US 20140224791 B2, Rein for cedinter modal container, date of publishing 14/08/2014;
2. US 2457841 A, Freight Container, date of publishing 04/01/1949;
3. US 3265235 A, Container construction, date of publishing 09/08/1966;
4. AU 2011901729 A, Container and lid, date of publishing 19/05/2011;
5. US 20150203293 B2, Cover for container, date of publishing 23/07/2015.

Containers were originally designed as open top containers or hard top containers with a hinged lid that is fixed in hinges located on one side of the top rectangular or tubular profile. It is basically a welded structure consisting of a frame made of a rectangular profile with crossbars, covered with a 2-millimetre-thick sheet. The lid opens in approximately 87°. The lid is usually opened by a mechanical hoist as the hinged lid is very heavy. A drawback of this design is that the loading options are limited as the lid occupies a large part of the cargo space.

2.2 *Proposed innovated technical design of an industrial container*

The innovated technical design of a lid opening system is based on the original lid design. The innovations were applied to the hinges and the lid opening mechanism, through which the opening angle of 270° was achieved. The container with a hinged lid, intended for bulk and piece materials, consists of a body equipped with reinforcements. The lid is anchored to the body by means of the arm, which is anchored by means of the arm pin and the front pin. In its apertures, the front pin and the arm pin are pivotally inserted and the lid is attached on the rear side to the hinged frame by means of pins and bearing housings. The other side of the hinged lid is pivotally connected to the body by means of pins and housings attached to the body. The lid opening trajectory begins above the top frame of the container. After the lid is slightly lifted, it begins to slide over the top rear edge of the body [Matiskova 2019]. In the opened position, the entire lid is positioned parallelly with the rear side of the body. Lid opening does not require a large manipulation space. The cargo space as such is fully accessible for loading and unloading. In the proposed design, the hinges are attached to the rear side of the container body, on the lid, and on the side wall of the container body. By designing an appropriate combination of hinges, it is possible to achieve stability when handling with the lid even when transverse forces are in action. Lid stability is ensured along all axes [Balara 2018, Szabo 2020].

3 RESULTS

The innovated design is visualised in more detail in the drawings; Figure 2a presents a side projection of the closed container; Figure 2b presents a side projection of the open container; and Figure 2c displays a schematic design of the hinged frame of the lid mechanism.

3.1 *Description of the container assembled based on the innovated design*

The container for bulk and piece materials with a hinged lid and a right-angled arm consists of the body 1 that is equipped with reinforcements 2 (Fig. 2a). The lid 3 is anchored to the body 1 by means of the right-angled arm 5 using the arm pin 7 and the front pin 6. In the arm apertures, the front pin 6 and the arm pin 7 are pivotally inserted, and the lid 3 is attached on its rear side to the hinged frame 4 by means of rear pins 11 and bearing housings 10. The second part of the hinged frame 4 is pivotally attached to the body 1 using the pins 8 of the hinged frame 4 and the attached housings 9 of bearings of the hinged frame 4. When slightly lifted, the lid 3 begins to slide over the top rear

side of the body 1. When fully opened, the entire lid 3 is positioned parallelly with the rear side of the body 1. Lid 3 opening does not require a large manipulation space, and the cargo space as such is fully accessible for loading and unloading.

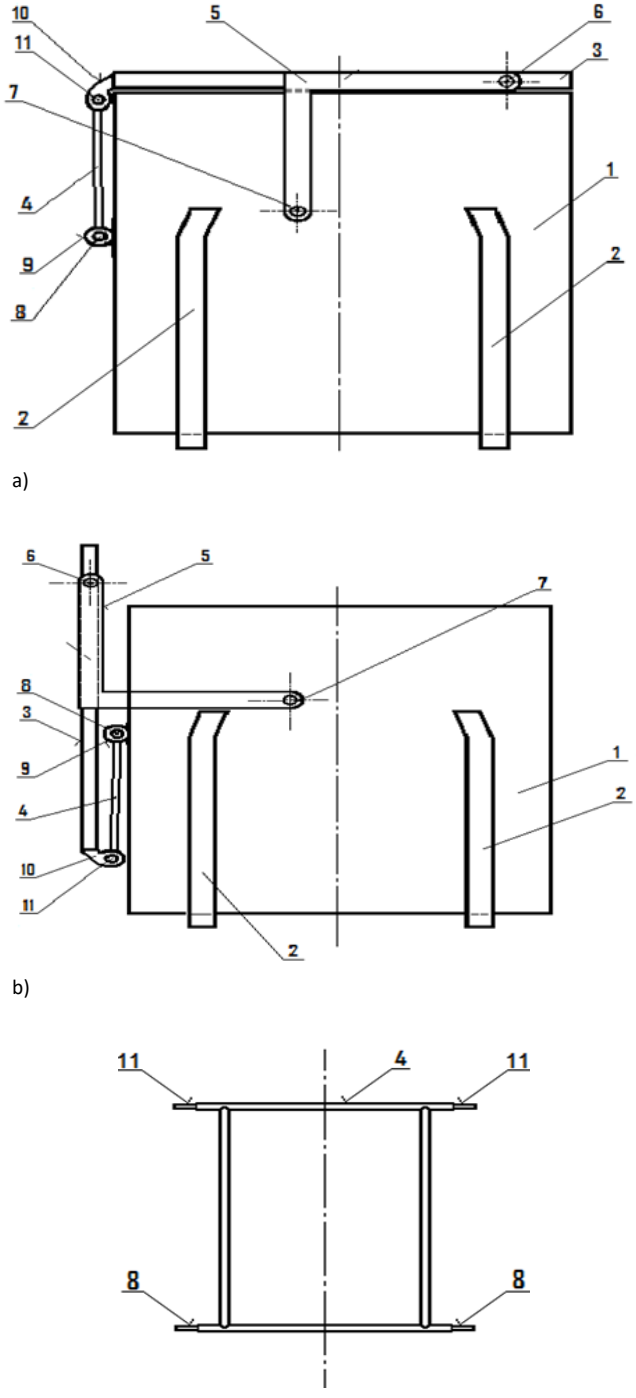

Figure 2. a) A side projection of the closed container; b) A side projection of the opened container; c) The design of the hinged frame of the lid mechanism.

Legend:
1 - Body
2 - Reinforcement
3 - Lid
4 - Hinged frame
5 - Right-angled arm
6 - Front pin
7 - Arm pin
8 - Pin of the hinged frame
9 - Housing of the hinged frame bearing
10 - Housing of the lid bearing
11 - Rear pin

The container constructed on the basis of this design may be used in applications that require industrial containers for metal wastes, building wastes and any other bulk or piece materials. The proposed design is also suitable for undertakings operating in the field metalworking where bulk and piece materials or dry metal wastes need to be stored for potential further processing [Panda 2018, Szabo 2020].

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4 CONCLUSIONS

Large-capacity containers offer a wide range of applications and can be used for basically any kind of solid or semisolid waste, including oversized and sharp wastes. They may be deployed, for example, in the local and community segments for the transport of seasonal waste collected from residential areas, as well as for the transport of building waste and debris produced in new constructions or reconstructions of private or commercial buildings.

Furthermore, they are also very well usable as industrial containers for the storage of various metal wastes produced by industrial plants and production halls. In addition, with regard to their shapes and volumes, they can also be used in agriculture. These containers are tank-shaped and may be loaded from the top, while the loaded waste may not only be solid but also semisolid as the containers are leak-proof and resistant to chemicals [Szabo 2020].

In civic amenity sites and waste collection facilities, these containers are also used for separated waste collection, and they may also be used at public areas. As their volumes are sufficiently high, the periodicity of emptying them is low. Moreover, they are available in various colours. These large-capacity containers are produced by several companies in versions of special closed containers and containers adjusted to dropping in glass item, bottles or paper.

Containers manufactured based on the design described herein may be used for a variety of applications where there is a need for industrial containers for metal wastes, building wastes and any other bulk or piece materials. They are also suitable for metalworking undertakings for the storage of bulk and piece materials or dry metal wastes for potential further processing.

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The presented article will serve as part of the project mentioned at the end of the article

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