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STRUCTURAL DESIGN OF A WORKBENCH FOR THE NEEDS OF A SERVICE TECHNICIAN

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Abstract *The presented paper deals with the structural design of a workbench with adjustable height, which will serve as part of the equipment of a light commercial vehicle for the needs of a service technician. The main objective of this paper is to create a functional design and 3D CAD model of a workbench that will meet the requirements of safety, mobility, and simple utilisation. Moreover, the design needs to consider the requirements of adjustable height and the dimensions of the work vehicle. The lifting mechanism is represented by arms fitted with sleeves that move along a lead trapezoidal screw rotating by a hand crank. In this paper, the force action in the axis of the threaded rod of the lifting mechanism is scrutinised in two extreme positions (highest and lowest position). The highest axial load on the threaded rod was found to be 9927.13 N in the lowest position of the mechanism. Based on this load, a right and left-hand trapezoidal threaded rod TR16×4 is selected, which satisfied the strength condition. The design of the sleeve height and the number of sleeve threads required are essential for safe utilisation. Due to the dimension of the guide rod, the height of the sleeve is selected to be 40 millimetres. The work surface is an important part of the workbench and consists of two parts. The chief larger part is made of medium density fibreboard and the smaller modular part can be in the two modular forms. The first version is the medium density fibreboard, and second alternative is a board designed to fix the components during their maintenance, repair as well as for welding.*

Keywords *light commercial vehicle, workbench, structural design, lifting mechanism, lead screw*

1 INTRODUCTION

Light Commercial Vehicles (LCVs; N1), more commonly referred to as 'vans', are an interesting group of vehicles filling our roads today. The van category is enormously diverse and offers a wide variety of sizes and configurations (Fig. 1) (CE_Delft, 2017). They vary from panel vans to pick-ups with open rear loading areas and a wide range of specialised bodies and conversions to serve industries. These vehicles are employed in construction, road maintenance, refrigerated food delivery, vehicle repair and recovery, waste management and recycling and so forth. No special licence is required to drive a van, a car licence is sufficient. This combination of factors simplifies their acquisition, configuration, and operation (SMMT, 2019). A crucial aspect of vehicle operation is maintenance. The maintenance intensity of a vehicle depends on the number of kilometres the vehicle travels in a repeatable period of time (day, month, year). In the case of a profitability of the transport activity, the maintenance intensity becomes a benefit of the transport system (Caban, 2019). LCVs can be divided into four basic classes: small vans (ordinarily up to 2 tonnes gross vehicle weight (GVW) - this involves car derived vans and small specialised vans), medium vans (commonly up to 2.6 tonnes GVW - they represent a segment that is strongly favoured in the service

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sector), large vans (vehicles of this segment are employed for a wide range of service, construction and parcel deliveries) and Light 4x4 Utilities (Pickup trucks) frequently deployed in construction or agriculture (SMMT, 2019).

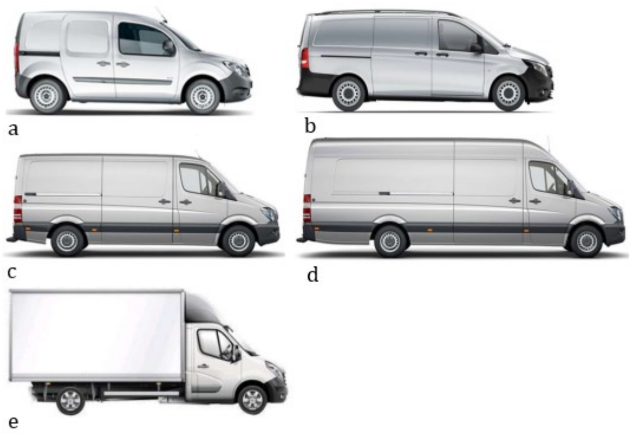

Fig. 1 Various types of vans, a – two-seater, b – regular/standard van, c – large panel van, d – extra-large panel van, e – Luton/box van; source: CE Delft, 2017

From the point of view of size, operating and maintenance costs and regulations regarding the passage through certain parts of cities, LCVs are the most advantageous for operation in cities as well as the last link in the distribution network (Dablanc, 2017). Due to the complexity and growing significance of urban logistics, LCVs are at the forefront of the challenges and solutions that confront global supply chains (IVOTY, 2020). In the era of continually rising demand for transport services, transport companies operate their fleets of vehicles to maximize revenue while maintaining maximum operating intensity of vehicles (Owczarek, 2022). Theory as well as practice are concentrated on increasing economic efficiency, which is based on the level of reliability and durability of vehicles (Brzeziński, 2018; Dziubak, 2021). Road transport is a crucial tool for connecting businesses to all global markets due to its unique, high-quality door-to-door service (Transport & Mobility Leuven and IRU contribution, 2017).

2 WORK VAN EQUIPMENT

In today's hectic times, service customers of transport and material handling systems require immediate support when their equipment fails, since every minute the machine is not working is reflected in lost profit. Thus, there is a division of field service technicians who come directly to the failure. When such a field trip is performed, it is necessary to equip the service vehicle comprehensively because of readiness for any failure or situation and to resolve it forthwith. The quality of the service depends on the skills of the technician as well as on the quality of the equipment and tools he works with on a daily basis. If the work vehicle equipment is superior and properly placed in the vehicle, the quality of service performed by the service technician will increase exponentially. Moreover, the ergonomics of the work equipment play a significant role. Whether it is a simple screwdriver or a workbench, it is an essential catalyst for the technician's working potential (Technia, 2021; Yamauchi, 2003).

LCVs are utilised in several applications. As an example, van users in France. Among professional users (i.e., the vehicle is owned by companies, administrations, associations, etc.), who account for 63 % of LCV users in France, LCV users are abundant, diverse and include all sectors of activity, as depicted in Fig. 2. The performed analysis by the nature of the company's activity demonstrates that the construction industry is the dominant consumer of LCVs. The second sector represented by the largest number of LCVs in operation is the wholesale trade, accommodation, and food services sector. In third place, the technical and scientific professions sector, and the manufacturing and industrial goods sector are side by side. It is curious to note, companies where freight transport is the primary activity are ultimately in the minority, accounting for only 7% of all LCVs (Camilleri, 2018).

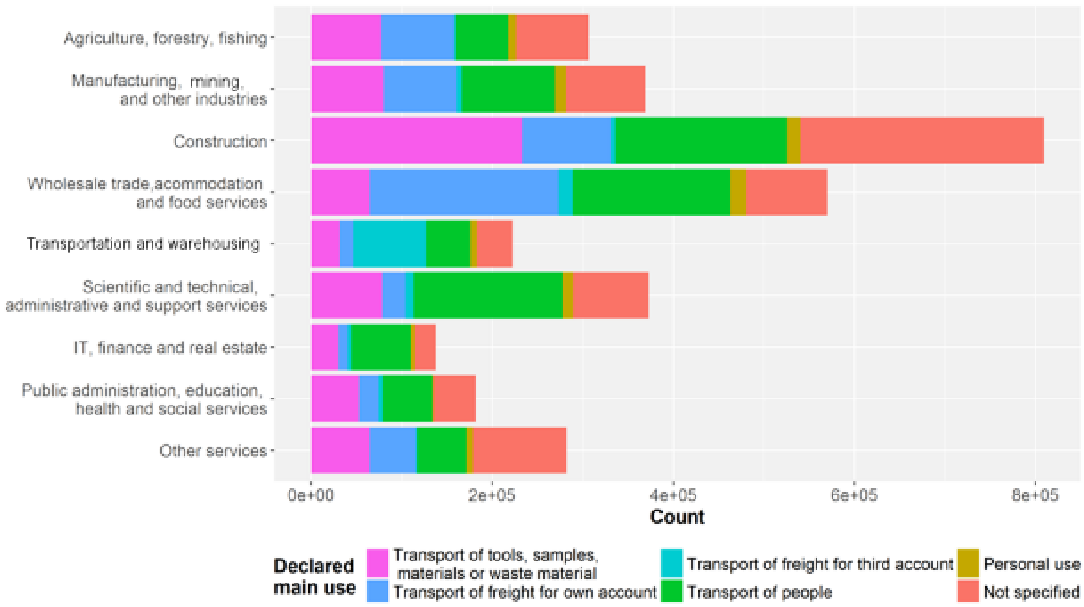

Fig. 2 Use of LCVs in different sectors of activity; source: Camilleri, 2018

The equipment of the individual work vehicles is adapted to these specialisations in terms of the type of equipment or the way in which the individual pieces of equipment are arranged. The chief function of the service vehicle equipment is to make the work easier and more efficient as well as safer when working and driving the service vehicle. With the appropriate selection of equipment and organisation of the service vehicle, the work is made more efficient due to the fact that each piece of equipment has a dedicated place where it can continually be accessible (Fig. 3).

Fig. 3 Equipment of a load compartment of the work van; source: Syncro systems, 2023

An increased level of safety in a traffic accident depends on the proper arrangement of heavy objects such as a drill, compressed gas tank, jack. If such components of the work vehicle equipment are only loosely placed in the service vehicle's load compartment, they can cause severe bodily injury, unnecessary damage to the vehicle and damage to tools in the event of an accident (Technia, 2021).

Moreover, the appearance of the service vehicle's load compartment is crucial. It becomes the business card of the company itself. In other words, if the load compartment of the van is poorly organized, it does not look credible and professional. In terms of a design of the work vehicle equipment, a great deal of emphasis is placed on lightweight design. Nevertheless, ergonomics, reliability and ease of maintenance must be considered at the same time. As previously mentioned, the equipment of the work van depends on the specialisation of the technician using the van. The vehicle equipment is made up of various modules, protective elements for the load compartment of the vehicle (floor and wall cladding), racking systems and other accessories. The diverse elements and modules of the vehicle equipment can include, for instance, MultiBox cabinets of pull-out containers made of transparent plastic, shelving modules, vertical side panels, lockers, different variations of shelves (sloping shelves made of stainless steel, open shelves with adapters and cases, open shelves with Euronorm plastic containers), case transport systems, pull-out benches for vices, folding shelves, long drawer units, load securing accessories, roof racks and their systems. (Syncro systems, 2023; Technia, 2021). A significant element of the work van equipment is the workbench, the structural design of which is the primary objective of the paper. The workbench is a table of robust construction on which manual work is carried out. They range in design from simple flat work surfaces to more complex designs. The design of workbenches varies based on the type of work they are used for. Nonetheless, they all share the following characteristics:

• comfortable height for working in the course of standing or sitting,

• the possibility of attaching the component in order that the service technician can use both hands when working,

• means for fixing, storage, and simple access to the tool.

Workbenches are made from a wide variety of materials including steel, aluminium, wood, stone, and other composite materials. The type of material depends on the type of work being carried out on the workbench (Landis, 2020).

2.1 Research issue of the workbenches

In terms of the literature, several papers concentrating on the design and development of workbenches can be mentioned. An important contribution was the work focused on the methodology for determining a starting point for the development of multi-purpose workbenches for the needs of modern logistics. Based on an extensive review of literature, the internet, and catalogues from various vendors, they found that there are several useful solutions. It can be asserted that for a well-designed workbench engineers should consider several features related to solutions in the fields of ergonomics, modularity, and flexibility, while the degree of customisation can be further increased by adapting for each client individually. Emphasis has been placed on the composition and installation of workbenches (Halilović, 2015). Another contribution to the issue has been made by a patent dealing with an automatic height adjustable workbench (Malhotra, 2019). In addition, the research problem was addressed in the development of an adjustable multi-purpose table for welding purposes. A pneumatic system was utilised for height adjustment. Nevertheless, the disadvantage of the work table is the size limitation (Nazratulhuda, 2020). Other methods are also known for adjusting the height of the workbench, for example Slot Adjustment Method, Crank Adjustable Method, Hydraulic, Scissor Lift Method (IQS Directory, 2023). Some studies have focused on considering the application of workbenches, for example in a dental laboratory (Han, 2013), or assessing the effects of an adjustable VDT workstation on workers' musculoskeletal discomfort, alertness, and performance (Ebara et al., 2008). Nonetheless, there is a research gap, as none of the above contributions are concerned with the design and placement of the workbench directly into the service van, with the emphasis being on the need for adjustable height, mobility of the workbench, and sufficient working space around the workbench given by the dimensions and other equipment of the van's load compartment.

3 STRUCTURAL DESIGN OF THE WORKBENCH

The primary objective of presented paper is the design of a workbench with adjustable height as part of the LCV equipment for the needs of a service technician of transport and material handling equipment. The structural design must be performed regarding the dimensions of the LCV, the load capacity of the workbench and the adjustable height. The specific limitations are:

- adjustable height from 0.8 m to 1.5 m,
- workbench width up to 1 m,
- load capacity up to 200 kg,

- dimensions of the load compartment of a van with a wheelbase of 4035 mm and an extra-large load compartment.

Fig. 4 Dimensions of the load compartment of a Fiat Ducato Maxi light commercial vehicle; source: Eurotip, 2014

The load compartment of the van is shown in Fig. 4, with the dimensions indicated by the arrows having the values given in Tab. 1.

Tab. 1 Fiat Ducato Maxi van load compartment dimensions; source: Eurotip, 2014

Parameters of a load compartment	**Notation**	**Value [mm]**
Height	A	2172
Width	B	1870
Length	C	4070
Width between inner wheelhouses	D	1422
Distance of the cargo load floor edge from the ground when the vehicle is unladen	E	550

The workbench in question (Fig. 5) is designed with the idea of simplicity as a main priority, from the purchase of semi-finished products, through fabrication and utilisation, to later maintenance and replacement of worn components. All semi-finished products for the fabrication of the workbench are accessible from wholesale suppliers of steel sections. In addition, the subsequent structure consists of the following parts:

- work surface with a modular part for welding,
- movable workbench frame with adjustable height,
- threaded mechanism for adjusting the height of the work surface,
- workbench support frame,
- castors ensuring the mobility of the trolley with the possibility of locking.

Fig. 5 3D CAD model of the designed workbench with adjustable height; source: authors

The proposed structural design of the workbench is advantageous due to its durability and favourable resistance to damage. The service technician needs a space with which he is intimately familiar, with the layout, features and functions when working at the client's site, while having confidence in reliable operation of workbench during daily use. The workbench will be also utilised outside the service vehicle since some of repaired components of the transport and handling equipment are of a larger size and weight.

3.1 Lifting mechanism

The mechanism that lifts the workbench work surface (Fig. 6) consists of a lead screw (screw shaft) to which a hand crank is attached. The work surface is lifted by means of the arms equipped with two sleeves that move along the lead screw. In other words, when the hand crank is turned, the sleeves move apart or towards each other on the lead screw and lift or lower the work surface by means of the arms.

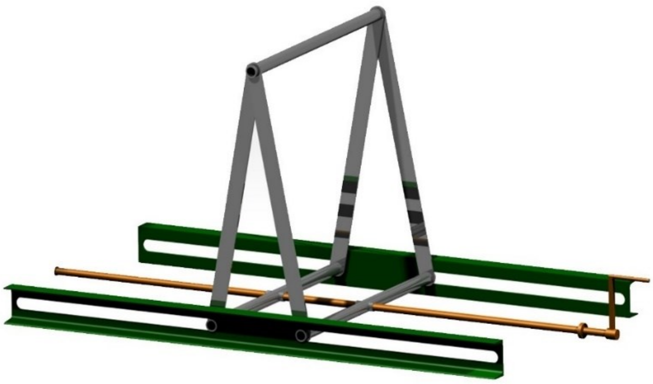

Fig. 6 Lifting mechanism of the mobile workbench; source: authors

3.1.1 Calculation of the forces acting on the screw mechanism

The calculation of the forces acting on the lead screw mechanism is carried out analytically. In this case, the lead screw must transmit the force in the x-axis induced on the arms by the load of Q = 200 kg and the mass of the movable workbench frame with work surface m_r = 90 kg. This mass is obtained from the 3D CAD model in Catia v5 software after assigning materials. The force F_q can be determined using formula (1):

$$F_q = (Q + m_r) \cdot g,$$
$$F_q = (200\ kg + 90\ kg) \cdot 9.81\ m \cdot s^{-2} = 2844.9\ N, \tag{1}$$

where F_q is the loading force acting on the arms of the mechanism, Q is mass of the load, m_r mass of the movable workbench frame with work surface.

After calculating the force acting on the arms, the force acting on the lead screw can be determined. The arms form the shape of an isosceles triangle at each height of the work surface. For this reason, the force can be calculated by means of similarity theory based on formula (2):

$$\frac{h}{\frac{b}{2}} = \frac{\frac{F_q}{2}}{F_x}, \tag{2}$$

where h is height of the triangle, b is width of the triangle, F_q is the loading force acting on the arms of the mechanism and F_x is axial force acting in the direction of the screw. The force F_q is divided in half due to its distribution on two sleeves located on the screw. The force F_x must be determined for the two extreme positions of the mechanism, where F_{x_d} is the axial force acting in the direction of the screw at the lowest position of the mechanism (first extreme position) (Fig. 7) and F_{x_h} is the axial force acting in the direction of the screw at the highest position of the mechanism (second extreme position) (Fig. 8).

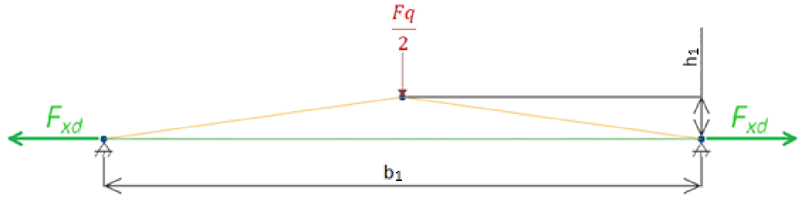

Fig. 7 Application of forces to the mechanism in the lowest position; source: authors

When the mechanism is in its lowest position, the working surface is 860 millimetres from the ground. The calculation of the forces F_{x_d}, F_{x_h} is based on equation (2), where, after adjustment, formula (3) is obtained:

$$F_x = \frac{\frac{F_q}{2} \cdot \frac{b}{2}}{h} = \frac{F_q \cdot b}{4 \cdot h} \tag{3}$$

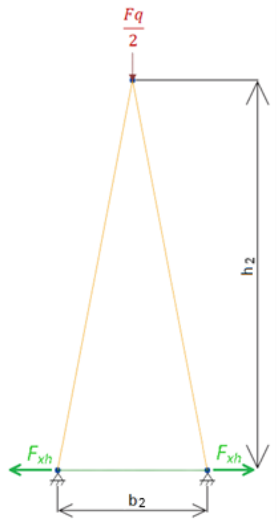

Fig. 8 Forces acting on the mechanism in the highest position; source: authors

After substituting the values into formula (3) for the case of the mechanism in the first extreme position, the magnitude of the axial force acting in the direction of the screw is (4):

$$\begin{gathered} F_{x_d} = \frac{F_q \cdot b_1}{4 \cdot h_1}, \\ F_{x_d} = \frac{2844.9\ N \cdot 1437.65\ mm}{4 \cdot 103\ mm} = 9927.13\ N, \end{gathered} \tag{4}$$

where b_1 is the distance between the arm sleeves of the lifting mechanism at the first extreme position and h_1 is the distance of the arm link from the screw at the first extreme position of the mechanism.

After substituting the values into formula (3) for the case of the mechanism in the second extreme position, the magnitude of the axial force acting in the direction of the screw is (5):

$$\begin{gathered} F_{x_h} = \frac{F_q \cdot b_2}{4 \cdot h_2}, \\ F_{x_h} = \frac{2844.9\ N \cdot 273.35\ mm}{4 \cdot 712\ mm} = 273.05\ N, \end{gathered} \tag{5}$$

where b_2 is the distance between the arm sleeves of the lifting mechanism at the second extreme position and a h_2 is the distance of the arm link from the screw at the second extreme position of the mechanism.

After determining the value of the force acting on the screw in the x-axis direction, it is possible to size its small diameter using formula (6) for the tensile/compressive stress:

$$\sigma = \frac{F}{A_s} \leq 0.7 \cdot \sigma_D \,, \tag{6}$$

where σ is the tensile/compressive stress, F is the applied force on the lead screw, A_s is hazardous cross-section – for a screw it is the smallest cross-section at the thread location, σ_D is the allowable tensile/compressive stress.

For bolts without preload, which are tightened in the loaded state, the cross-section of the bolt (screw) core is subjected to torsion in addition to the tensile stress of the axial force. The screw in question is dimensioned with neglected torsion. Therefore, a correction factor of 0.7 is considered, which is multiplied by the allowable tensile/compressive stress (6) (Bocko, 2006). The screw is made of steel marked r50 (C15-C20) which has a value of allowable tensile stress σ_{Dt} = 350 MPa (SteelGr, 2023).

From the formula (6) the hazardous cross-section of the screw A_s is expressed as follows (7):

$$A_s \geq \frac{F_{xd}}{0.7 \cdot \sigma_D} \,. \tag{7}$$

After substituting the values, the magnitude of d_3 is (8):

$$\begin{gathered} A_s \geq \frac{9927.13\ N}{0.7 \cdot 350\ MPa}, \\ A_s \geq 40.51\ mm^2. \end{gathered} \tag{8}$$

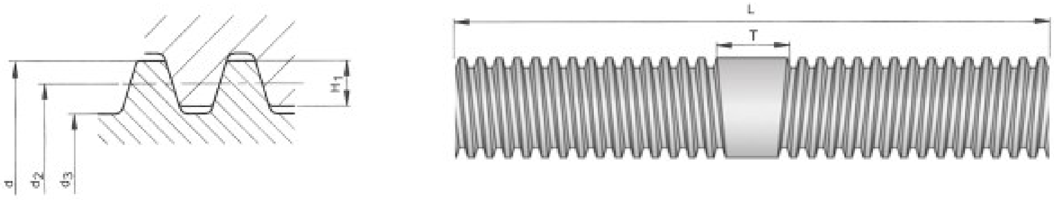

Fig. 9 BFA right-left-hand trapezoidal threaded rod; source: PowerBelt, 2023

Based on the obtained value of minimum cross-section of the screw core A_s, a BFA right-left-handed trapezoidal threaded rod TR16×4 (Fig. 9) is selected (Vávra, 2009), the dimensions of which are stated in Tab. 2.

Tab. 2 Parameters of BFA right-left-hand trapezoidal threaded rod TR16×4; source: PowerBelt, 2023; Vávra, 2009

Thread notation (diameter x lead)	Dimensions [mm]									Lead angle	Moment of inertia [mm⁴]	Mass [kg·m⁻¹]	cross-section of the screw core [mm²]
TR 16x4	d_{min}	d_{max}	d_{2min}	d_{2max}	d_{3min}	d_{3max}	L	T	H_1	γ	I	q	A_s
	15.7	16	13.640	13.905	11.074	11.5	3020	20	2	5°12′	738	1.17	103.9

3.1.2 Force analysis of the crank mechanism

Depending on the position of the work surface, a force ranging from 273.05 N to 9927.13 N is applied to one sleeve at a maximum load of 200 kg on the work surface. The forces in the crank mechanism are scrutinised at the lowest position of the mechanism, in other words, where the force on the sleeve is greatest. Thus, the calculated F_{xd} is considered in the analysis of the screw. Accordingly, a force of 9927.13 N is required to be overcome for the mechanism to start lifting in the bottom position, with a 200 kg load on the work surface. To overcome this force, the hand crank firmly attached to the threaded rod will be employed.

To calculate the force on the circumference of pitch circle of the thread F_{ob}, it is necessary to determine the friction angle φ, which depends on the thread profile α. The thread angle α can be determined by the standard according to which the screw rod was manufactured. The selected threaded rod TR16×4 is manufactured according to the German standard DIN103, and therefore, the thread angle is 30°. The value of the coefficient of friction at steel-to-steel contact is $f = 0.1$ (-). The friction angle φ is calculated by means of the formula (9):

$$\varphi = arctg\frac{f}{cos\frac{\alpha}{2}}. \tag{9}$$

After substituting the values, the magnitude of the friction angle is (10):

$$\varphi = arctg\frac{0{,}1}{cos\frac{30°}{2}} = 5.91°. \tag{10}$$

After discovering the value of the friction angle φ the calculation of the above-mentioned force on the circumference of the pitch circle of the thread F_{ob} is performed. The formula for calculating this force (12) is obtained by modifying the formula (11). The calculation includes a lead angle of the thread γ. The value of this angle is 5°12´ (Tab. 2), which represents a value of 5.2°.

$$F = \frac{F_{ob}}{tg(\gamma + \varphi)}. \tag{11}$$

In the solved case, the force F amounts the axial force acting in the direction of the lead screw at the lowest position of the mechanism F_{x_d}.

$$F_{ob} = F_{x_d} \cdot tg(\gamma + \varphi). \tag{12}$$

After substituting the values into equation (12), the magnitude of the force on the circumference of the pitch circle of the thread is obtained F_{ob} (13):

$$\begin{gathered} F_{ob} = 9927.13\ N \cdot tg(5.2° + 5.91°), \\ F_{ob} = 1949.42\ N. \end{gathered} \tag{13}$$

The force on the hand crank of length l amounts to the force on the circumference of the pitch circle of the thread acting on the pitch (effective) diameter of the thread d_2 (obr. 10).

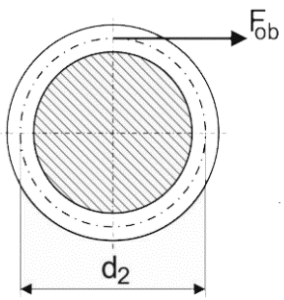

Fig. 10 Application of force on the pitch circle of the thread; source: authors

The value of the force acting on the hand crank F_p can be discovered by dint of equation (14). The selected value of a length of the hand crank arm l is 100 mm, considering the ergonomic requirements of the workbench.

$$F_{ob} \cdot \frac{d_2}{2} = F_p \cdot l \,. \tag{14}$$

After adjustment, the equation (15) for calculating the magnitude of the force F_p is obtained (15):

$$F_p = \frac{F_{ob} \cdot d_2}{2 \cdot l},$$
$$F_p = \frac{1949.42\ N \cdot 13.905\ \text{mm}}{2 \cdot 100\ mm} = 135.53\ N. \tag{15}$$

The resultant moment required to lift the work surface of workbench M_k from the lowest, i.e., most unfavourable, position can be calculated by multiplying the force acting on the hand crank F_p by the length of the hand crank l (16):

$$M_k = F_p \cdot l \,. \tag{16}$$

After substituting the values into equation (16), the value of the resultant moment is:

$$M_k = 135.53\ N \cdot 0.1\ m = 13.553\ N \cdot m. \tag{17}$$

The force F_p for the manual drive is chosen from the range F = (120 ÷ 160) N (Blatnický, 2015). The selected hand crank length is appropriate, inasmuch as the calculated force acting on the hand crank (15) falls within the above interval for the force limitations.

3.1.3 Calculation of sleeve height

The work surface is connected by arms with two hollow rods equipped with threaded sleeves that move along the threaded rod (Fig. 11). For the sake of safety operation, it is necessary to design the minimum required height of the sleeves h_{min} (18):

$$h_{min} = z \cdot t \,, \tag{18}$$

where z expresses the number of threads and t represents the thread pitch in millimetres.

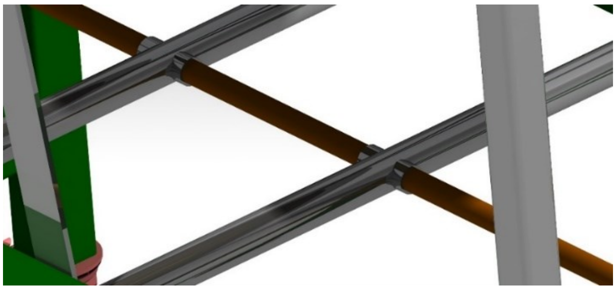

Fig. 11 Location of the lifting mechanism sleeves; source: authors

The first step is to find out the required total thread area S_z, which emerges from the strength condition for the surface pressure represented by formula (19). The selected material for the sleeve is E360 steel involved in 5.8 strength class. Based on strength class of used material, an allowable pressure in threads is p_D = 90 MPa (Bocko, 2006).

$$p = \frac{F}{S_z} \leq p_D \, , \tag{19}$$

where p is the actual pressure in the threads, F is the axial force in the lead screw, S_z is the area of the threads that carry the load and p_D is the smaller of the allowable pressures according to the material (in this case, screw, or sleeve).

After modifying formula (19), equation (20) is obtained with respect to the calculated axial force acting in the direction of the screw in the lowest (most unfavourable) position of the mechanism F_{xd}:

$$S_z = \frac{F_{x_d}}{p_D} \, . \tag{20}$$

After inserting the values into the equation (20), the size of the area of the threads that carry the load (21) is obtained:

$$S_z = \frac{9927.13 \, N}{90 \, MPa} = 110.3 \, mm^2. \tag{21}$$

The area of one thread S_{z1} has the shape of an annulus; to simplify the calculation, the annulus is converted into a rectangle whose side lengths correspond to the circumference of the circle of the pitch diameter d_2 and the bearing height of the thread H_1 (22):

$$Sz_1 = \pi \cdot d_2 \cdot H_1 \, . \tag{22}$$

After substituting the values into (22), the area of one thread is (23):

$$Sz_1 = \pi \cdot 13.905 \, mm \cdot 2 \, mm = 87.368 \, mm^2. \tag{23}$$

The required number of threads in one sleeve is calculated by the ratio of these two areas by means of formula (24). The number of threads z must certainly be an integer, thus, the further higher number from the result is chosen.

$$z = \frac{S_z}{S_{z_1}} \, . \tag{24}$$

After substituting the values in the equation (24), the required number of threads (25) is:

$$z = \frac{110.3\ mm^2}{87.368\ mm^2} = 1.263 \rightarrow 2. \tag{25}$$

The resultant minimum sleeve height is calculated according to formula (18). After substituting the values, the minimum height is (26):

$$h_{min} = 2 \cdot 4\ mm = 8\ mm. \tag{26}$$

The ultimate height of the sleeve must be at least 8 millimetres. Generally, the height of the motion screw nut is chosen within the limits $h = (1.5 \div 4) \cdot d_2$ (Blatnický, 2015). In terms of the structural design in question, the sleeve height of 40 millimetres is selected regarding the dimensions of the guide rod.

3.2 Work surface of workbench

The work surface consists of two separate parts. The larger part is made of MDF (medium density fibreboard) board (Fig. 12). This material is chosen because of its relatively light weight, high durability, wide availability, and affordable purchase price. The dimensions of the larger part of the work surface are 1091×794×35 (length × width × thickness) millimetres.

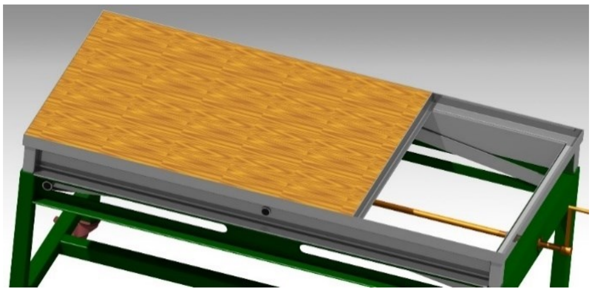

Fig. 12 Worksurface with removed modular platform; source: authors

The smaller (modular) part of the work surface can be provided in two options, namely, an MDF board (Fig. 13a), as well as the main part of the work surface, a steel board with holes for different jigs adapted for welding is the second alternative (Fig. 13b). These parts of the work surface are conveniently interchangeable according to the needs of the service technician. The smaller part of the work surface in the MDF version has dimensions of 500×794×35 millimetres.

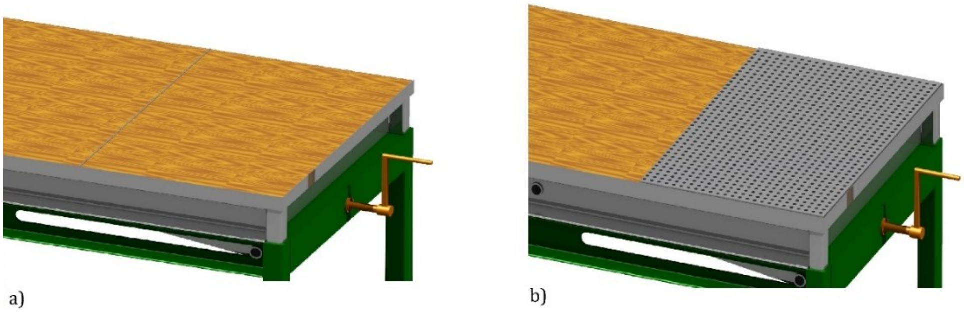

Fig. 13 Bench work surface equipped with modular part, a – MDF board, b – component fixing board; source: authors

The work surface for fixing components during maintenance, repair as well as for welding has dimensions of 500×794×40 millimetres with a cutout on the underside to save weight. The modular part of the bench work surface provides the service technician the choice between a work surface for assembly and a welding board adapted for clamping the weldment in jigs made by the technician, which will be inserted into drilled holes and fixed.

3.3 Workbench frame

The frame of the workbench (Fig. 14) is a predominant part of its construction. It is the supporting component that ensures the stability and strength of the entire workbench. The frame of each vehicle or machine carries diverse loads. Thus, the requirements of the frames are extremely demanding (Harušinec, 2019). The structural design of the frame as well as the analysis of the forces acting on the supporting cross members are the subject of further research. The utilisation of castors with motion locking is envisaged.

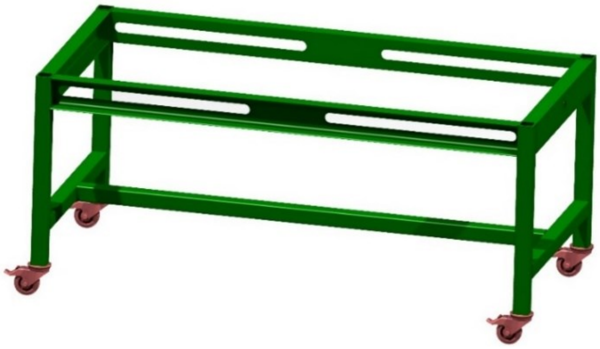

Fig. 14 3D CAD model of the proposed workbench frame; source: authors

4 CONCLUSION

The presented paper aimed to present the design of a workbench with adjustable height as a part of the equipment of a service vehicle for the needs of a transport and handling technician. In the introductory part, the authors focused on a detailed analysis of the current state of the art of LCVs and, in particular, of the different modules of the equipment of the load compartment of the LCV. Further, the authors concentrated on the creation of a 3D CAD model of the workbench with respect to the requirements of its adjustable height and the dimensions of the work van. The condition of adjustable height was met by providing the screw lifting mechanism that can vary the height of the work surface between 860 and 1470 millimetres from the ground. The second condition was dimensional, which was satisfied with a workbench width of 800 millimetres and an overall length of 1842 millimetres. The adjustment of the height of the work surface of the workbench is ensured mechanically by means of the hand crank connected with the lead screw on which the sleeves of the arms move. Thus, the change of the distance of the arms causes the height alteration of the work surface. Based on the investigated axial force on the threaded rod of the lifting mechanism in both extreme positions, the highest axial load on the lead screw was discovered in the lowest position of the mechanism, namely, 9927.13 N. Accordingly, a screw rod with a right and left-hand trapezoidal thread TR16×4 was selected to satisfy the strength condition. Subsequently, the height of the sleeve was sized according to the observed load on the lead screw, which was chosen to be 40 millimetres due to the dimension of the guide bar. Ultimately, the work surface of the workbench was presented, which is made up of two parts. The chief (larger) part of the work surface is the MDF board. The smaller part is modular and can consist of the MDF board or the board designed for fixing components during maintenance, repair as well as for welding. In addition, the frame of the workbench was introduced, the structural design of which as well as the analysis of the forces acting on the supporting cross members will be addressed by the authors in further research.

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