AUTOMATIC STATIC POSITION SETTING CONTROL OF THE AMBULANCE COUCHETTE SUPPORT

Ondřej Kohl

Technical University of Liberec
Faculty of Mechanical Engineering
Department of the Design of Machine Elements and Mechanisms
Studentská 2, 461 17, Liberec 1, Czech Republic
ondrej.kohl@tul.cz

Abstract

This project deals with the problem of the static position setting control of the ambulance couchette support. The static position is adjusted by an air spring, which serves as an active vibration insulation element. The vibration insulation mechanism is also described. Various types of control are designed, compared and afterwards the optimal type of control is selected. The project includes the possible connection schemes. Based on measurement, the optimal tube diameter is chosen to inflate an air spring with compressed air.

Introduction

The demand for quality and safe patient handling and patient's transportation arose from fast rescue service's experience [1]. Most of the couchette supports are based on hydraulic or pneumatic systems, which allow the crew of ambulance fairly easy manipulation with the patient's couchette and very good positioning. To increase the patient's transport comfort an ambulance couchette support with integrated vibration insulation was designed at the Technical University in Liberec. This added value is provided by the air spring, damper and lead mechanism.

1 Description of the springing mechanism

The springing support consists of the base, two shoulders, the platform and other complementary components such as gear segments, linear motors, lead mechanism, etc. Vibration insulation is stored in the fixed shoulder (Fig. 1). The movement is transmitted from the rods to the lever, which is rigidly fixed to the air spring lid. The second lid is fixed to the frame of the shoulder. The shock absorber is placed between the rods and the frame. Air spring's stroke tracking is next the air spring [2, 3, 4, 5, 6].

The air spring fulfils its function correctly on condition that the air spring is at the static position during loading. Control of the static position can be realized in several ways with regard to automation, speed, accuracy, complexity and financial cost of the system.

The spring position can be adjusted manually, using pneumatic valves that control the pulley system; or proportionally. The comparison of control methods set up a static position of spring is shown in Tab. 1.

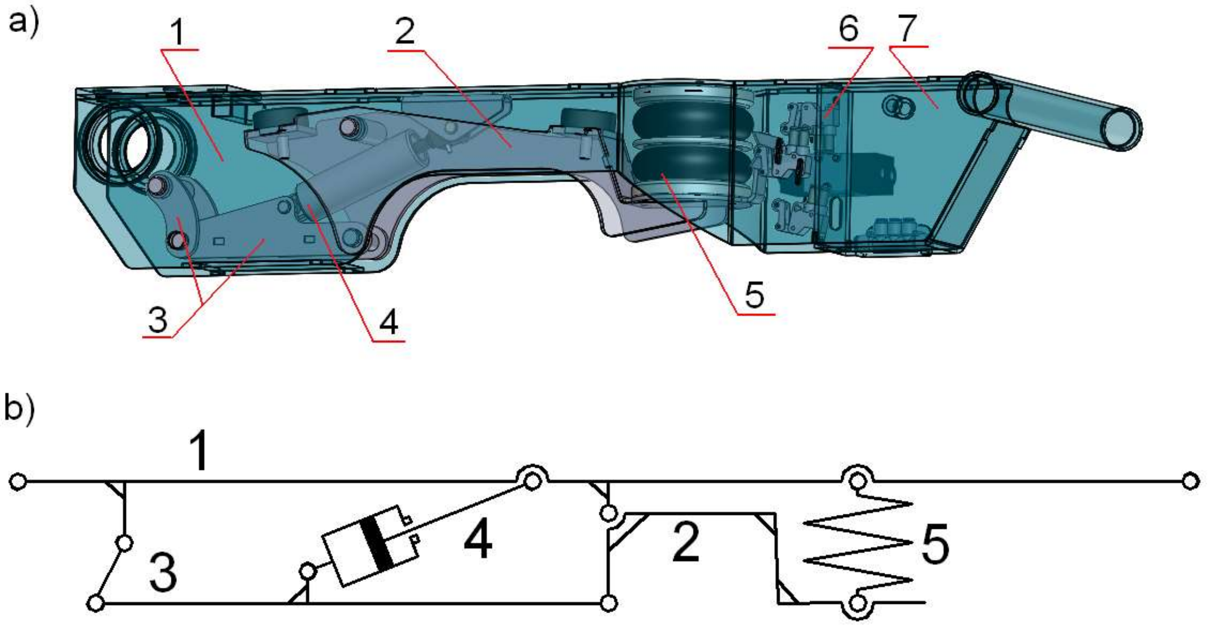

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Fig. 1: *Vibration-Insulation shoulder; a) prototype design, b) mechanical model (1 – Shoulder's Frame, 2 – Lever, 3 – Rods, 4 – Damper, 5 – Air Spring, 6 – Pneumatics Elements, 7 – Additional Volume)*

Tab. 1: *Comparison of control types*

Control Type	**Criteria**				
	Automation	Speed	Accuracy	Complexity	Price
Manually controlled valves	-	-	-	+	+
Mechanically controlled valves	+	+	0	-	0
Proportionally controlled valves	+	+	+	0	-

Source: Own

The way of control of the static position setting by means of the pneumatic valves that are controlled by mechanical pulleys was selected.

There are several possible connection schemes, which enable to adjust the static position of the air spring.

2 Control variants

2.1 Variant I

This is a scheme composed of one 5/3 double-pneumatically-operated valve, two 2/2 double-pneumatically-operated valves, three 3/2 mono-mechanically-operated valves, one 3/2 double-manually-operated valve, one logical OR-element, one check-valve and one noise damper (Fig. 2).

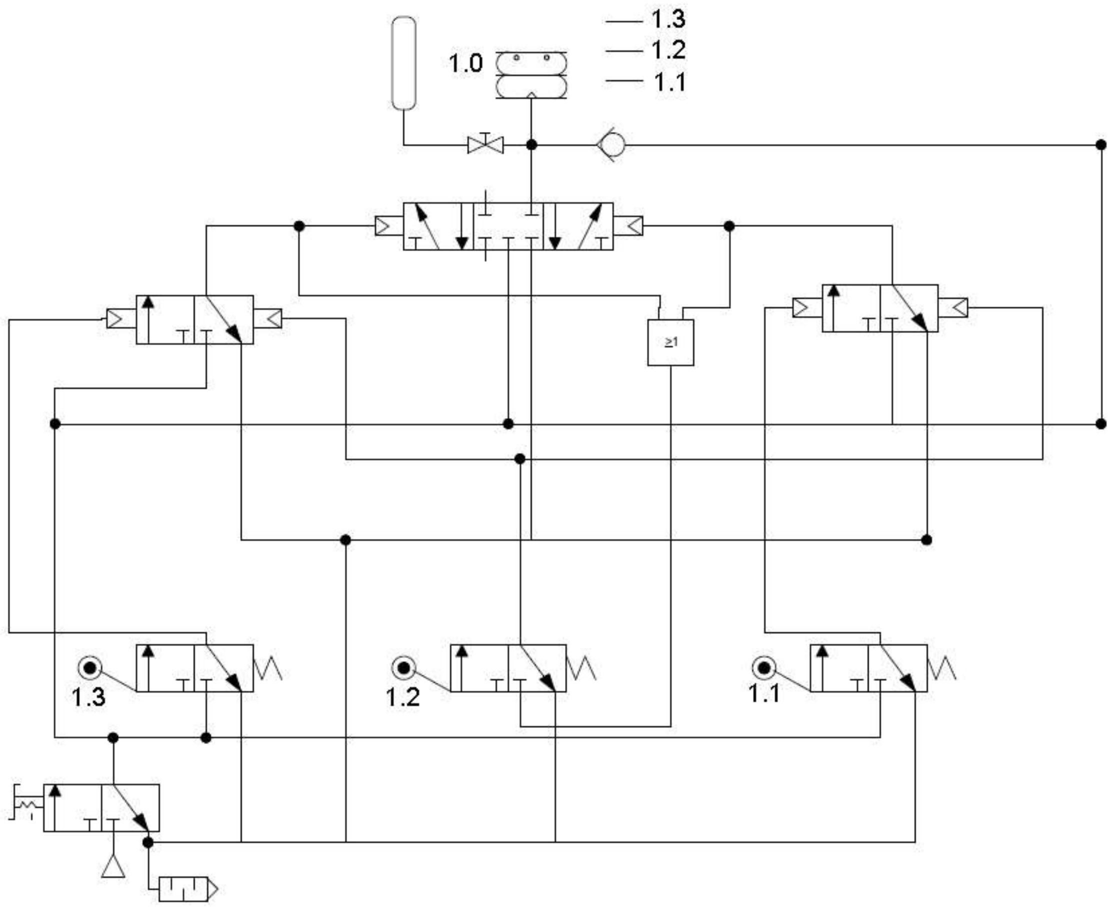

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Fig. 2: *Variant I; pneumatic circuit connection*

The pneumatic circuit is fully functional. It was designed and simulated in the program AUTOMSIM PREMIUM. Using the logical OR-element ensures air supply to the 1.2-pulley-circuit only if its function is required. It is lifted to a static position and compressed air is draining when the platform is loaded (only by the previous pulleys 1.1 or 1.3 switching ON). The 1.2-pulley then, when activated, the suspension does not cause a permanent noise by air emission, because the compressed air supply in the pulley is closed. This will also reduce the compressed air consumption. The check-valve ensures that at the closing of the air supply the air spring deflates and the shoulder pushes itself to the stop.

2.2 Variant II

The connection used for economic reasons in the prototype of a vibration-insulation shoulder is demonstrated in picture 3 (Fig. 3). The operational functions are the same as in variant I. The circuit contains neither logical element, tubes for emptying compressed air or a silencer. In addition the ON/OFF-valve is not used. In the process of disconnecting of the air supply the air spring remains filled with air due to the absence of logical elements. The circuit must be disconnected to release the compressed air.

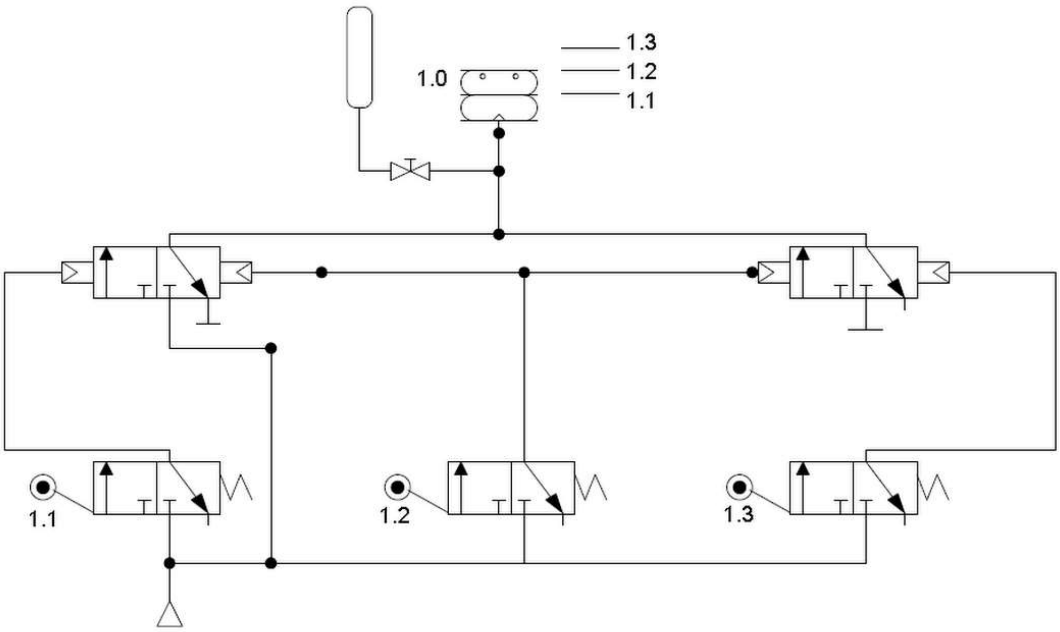

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Fig. 3: *Variant II; pneumatic circuit connection*

3 Description of the control process

The air spring is fully compressed and the lever-stop is leaned on the shoulder frame when loaded or before the air supply is opened. (Fig. 4 a). The 3/2 mono-mechanically-operated valve (pulley 1.1) is in the active position. If the compressed air is supplied to the circuit, the static position setting begins.

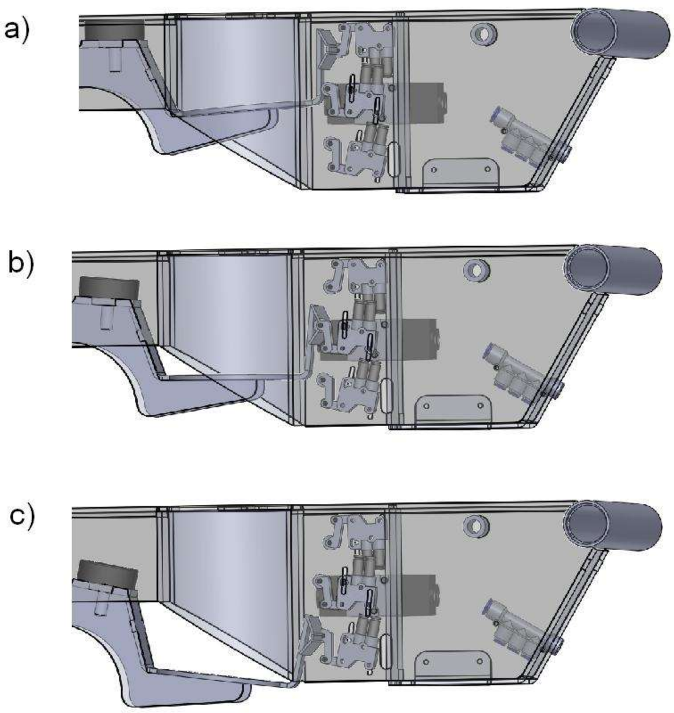

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Fig. 4: *Control process*

The sheet metal rider, which is firmly attached to the handle, moves from the pulley 1.1 to the pulley 1.2, which determines the reference position and the static position of the spring

(Fig. 4 b). By unloading the springing support moves the rider from the pulley 1.2 to the pulley 1.3 (Fig. 4 c). In this position the air deflates from the air spring until the reference position on the pulley 1.2 is set again (Fig 4 b).

The speed and accuracy setting of the required static position is dependent on the compressed air flow through the pneumatic controls to the air spring.

If the flow is too high, the setting is very fast, but it is not accurate. The rider runs over the reference position. The static position setting is related to the acceleration at the start and to deceleration at the end of filling of compressed air.

4 Experiment

The measurements for setting an optimal compressed air flow rate in the terms of accuracy, acceleration / deceleration and setting time were performed with three tubes (4mm, 6mm and 8mm). A silicium accelerometer placed on the platform of the ambulance couchette support, an optical distance-sensor, a computer equipped with a measure-card and a compressed air source were used for measuring [7]. The measurement results (Fig. 5 and Fig. 6) are recorded in Tab. 2.

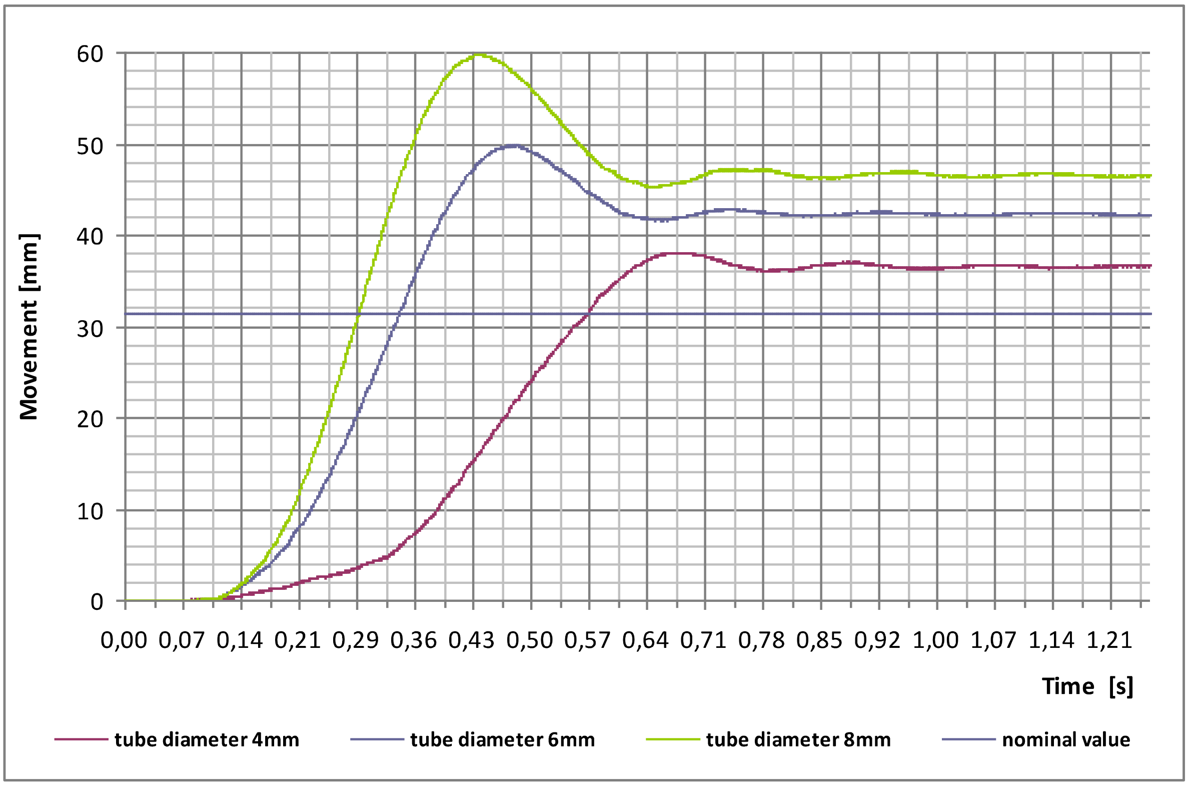

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Fig. 5: *Circuit of static position setting and its accuracy*

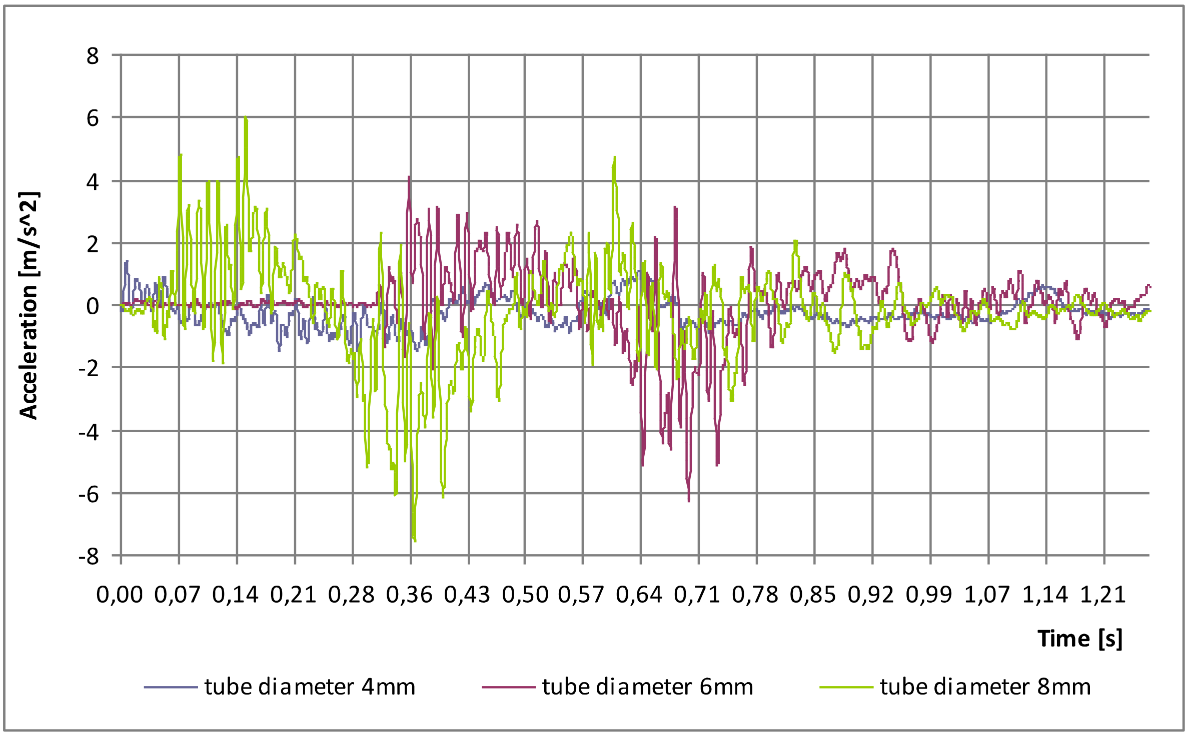

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Fig. 6: *Acceleration circuit*

Tab. 2: *Measurement results*

Intake tube diameter [*mm*]	**Maximal acceleration** [$m \cdot s^{-2}$]	**Maximal deceleration** [$m \cdot s^{-2}$]	**Adjustment time** [*s*]	**Deviation from the reference position** [*mm*]
4	1,39	1,65	0,68	05.33
6	4.12	6.26	0.54	11.07
8	6.02	7.50	0.54	15.29

Source: Own

Conclusion

The patient is during transit without springing support exposed 7.5 m/s^2 acceleration. Using springing support reduce the value to 1.8 m/s^2.

The measurement verified the correct function of the proposed pneumatic circuit. It was further found out that the time needed for setting a static position is not significantly reduced with increasing diameter of the filled tube. Acceleration and deceleration, which is unpleasant for a patient increases with a higher flow rate. The deviation from the required reference position due to the delay of signal transmission is also worse with a higher flow rate.

The measurements show that the optimal dimension of the supply filling tube is 4 mm, which ensures setting the static position of ambulance couchette support with compressed air source under the pressure of 5 bars within 0.68 s. Acceleration or deceleration do not exceed 2 m/s^2. The position deviation from the required value is about 5.5 mm, which is due to the extreme limits of oscillation (+/- 50 mm) an acceptable error.

Literature

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ŘÍZENÍ AUTOMATICKÉHO NASTAVENÍ STATICKÉ VÝŠKY PODSTAVCE SANITNÍHO LEHÁTKA

Tento projekt se zabývá problémem řízení nastavení statické výšky podstavce sanitního lehátka. Statická výška je nastavována pomocí vzduchové pružiny, která slouží jako aktivní vibroizolační prvek. Dále je popsán vibroizolační mechanismus. Jsou navrženy, srovnány a z nich vybrán optimální způsob řízení statické výšky. Projekt je doplněn možnými schématy zapojení. Na základě měření je navržen optimální průměr hadice k plnění pneumatické pružiny stlačeným vzduchem.

STEUERUNG DER AUTOMATISCHEN EINSTELLUNG DER STATISCHEN HÖHE DER KRANKENWAGENLIEGEBASIS

Dieses Projekt beschäftigt sich mit der Steuerung und der Einstellung der statischen Höhe der Krankenwagenliegebasis. Die statische Höhe wird durch die Luftfeder, die als aktives Schwingungsisolierungselement dient, eingestellt. Weiter wird ein Schwingungsisolierungsmechanismus beschrieben. Es werden Steuerungsweisen vorgeschlagen und verglichen und es wird eine optimale Steuerungsweise gewählt. Das Projekt wird mit möglichen Schaltplänen ergänzt. Auf Grundlage von Messungen wird der optimale Durchmesser des Luftfüllungsschlauchs zur Füllung der Feder mit Pressluft vorgeschlagen.

STEROWANIE AUTOMATYCZNYM USTAWIENIEM WYSOKOŚCI STATYCZNEJ PODSTAWY GŁÓWNEGO ŁÓŻKA W KARETCE

Omawiany projekt poświęcony jest tematyce sterowania ustawieniami wysokości statycznej podstawy łóżka w karetce. Statyczna wysokość ustawiana jest za pomocą sprężyny powietrznej służącej jako aktywny element wibroizolacyjny. W kolejnej części opisano również mechanizm wibroizolacyjny. Zaprojektowano, porównano i wybrano optymalny sposób sterowania wysokością statyczną. Projekt uzupełniono możliwymi schematami podłączenia. Na podstawie przeprowadzonych pomiarów zaprojektowano optymalną średnicę węża do napełniania amortyzatora pneumatycznego sprężonym powietrzem.