ANALYSIS OF THE PROPER FUNCTIONING OF FORKLIFT BRAKES

Abstract: The aim of this paper is to analyze the safety of forklift brakes. The research methodology used to analyze forklift brake safety is presented using the checklist descriptive method. The study was conducted on 127 forklifts with an average age of 15 years, where it was found that about 10% of the forklifts did not have a proper parking brake and that about 2% of the forklifts had defective service brakes. Finally, the results obtained from the research on brake safety have been discussed and further research has been proposed.

Key words: forklift, brake, methodology, research, analysis, checklist.

INTRODUCTION

Packaging is a technological process of putting a box around a product, sealing and marking a product which has been packed [1]. Three types of packaging goods are shown in Figure 1 [2].

![Types of goods packaging](adapted from Vladić, 2005)

According to [3], after palletization, the product (pallet + cargo) is wrapped with stretch foil. According to [4], it is additionally secured to prevent cargo from being shattered as well as to increase the stability, thus maintaining complete safety during transport, storage and handling.

The technical base of the palletizing system consists of forklifts and pallets [5]. The pallet is a wooden base, made of boards of standard dimensions, to which various types of goods are loaded. This is how a compact and solid pallet unit is being formed. As stated by [6], a pallet without a forklift would be a static unit, like a wagon without a locomotive. The pallet unit is easily and simply transferred and stacked with a forklift.

Forklifts are powered industrial trucks, which are used in warehouses, factory halls, cargo terminals and other workspaces for handling various types of cargo.

It is a well-known fact that collisions and rollovers are the most common causes of death when working with forklifts. In line with [7], official data released by the OSHA (Occupational Safety and Health Administration) indicate that 96,785 forklift accidents occur in the USA, including 61,800 minor accidents, 34,900 serious accidents and 85 fatal accidents. Comparing the total number of forklifts (855,785) in the US with the total number of occupational injuries, we have found that 11% of forklifts are expected to be involved in minor or major accidents.

The common fatal injuries when operating forklifts are: crushed by tipping vehicle (42%), crushed between a vehicle and a surface (25%), crushed between two vehicles (11%), being struck or run over by a forklift (10%), struck by falling material (8%) and fall from a platform on the forks (4%) [7,8].

Forklift trucks, as self-propelled vehicles used for indoor transport, shall be subjected to periodic inspection and testing not later than three years from the date of the previous inspection and check. A legal entity certified to perform inspection and testing of work equipment, after inspection and check of the forklift truck must provide an expert opinion on forklift safety and prescribed occupational safety measures.

For safe operation of forklifts, it is necessary to examine parking and service brakes, light and sound signaling, the limit switch with a retractable overhead guard, tires, wheels and hydraulic control system. The parking brake must be applied when loading, unloading, lifting and lowering loads to achieve greater stability and to prevent the forklift from tipping over. In case you have to park a lift truck on an incline, it is essential to use the parking brake and secure the forklift against self-propelling forward or backward.

The service (foot) brake is a casual brake designed to slow down and stop the forklift.
RESEARCH METHODOLOGY

DEFINING THE PROBLEM
The problem with the research is the lack of current knowledge about the implementation of protective measures in forklifts, and especially those related to brake malfunction or inefficiency. Based on previous experience, it has been observed that common forklift dysfunction or brake malfunction can significantly increase the potential risk of accidents due to collisions or tipping over. No available research has been found in domestic and foreign literature covering the previously highlighted problem.

RESEARCH OBJECTIVE
The main objective of the research is to determine the percentage of forklifts with defective or inefficient brakes (parking and service brakes) compared to the total number of forklifts analyzed in the company. A specific aim of the study is to determine the causes of parking and service brake malfunctions.

RESEARCH HYPOTHESIS
The assumption is that, within the group of analyzed forklifts, a more pronounced problem would be the failure or inefficiency of the parking brake compared to the service brake.

RESEARCH METHODS
The existing checklists in the Republic of Serbia mostly offer YES / NO answers, with YES being answered for dangerous conditions and NO in other questions, so there is a problem of transparency. It has been suggested that the newly created checklist should contain answers such as "dangerous", "not relevant" and "safe", which even by a quick inspection can easily and quickly identify the number of dangerous conditions in a given checklist. After completing the checklist, appropriate corrective actions must be proposed if the answer is "dangerous" [9,10]. Based on the daily forklift truck checklist [10,11,12,13] and expert findings for periodic forklift truck inspections, there are additional questions on forklift truck safety in the new checklist. A descriptive method was used to prove or disprove the research hypothesis. An example of a completed checklist for the safety analysis of the front forklift truck is given in Table 1. In this paper, there will be additional comments only for questions 8 and 9, referring to the analysis of parking and service brakes.

RESEARCH SAMPLE
The study involved a sample of 127 forklifts, with an average age of about 15 years. The data on brake safety and functionality were collected and analyzed. The survey was conducted in 46 enterprises in the municipalities of Novi Sad (83 forklifts), Bečej (25), Temerin (12) and Beo in (7), with the duration of two months (May–June 2017). Diesel forklift trucks comprised almost 50% (62 trucks), while there were 34 electric and 31 gas-powered forklifts.

Table 1. The analysis of counterbalanced forklift safety (D – dangerous, N/R – not relevant, S – safe)

| Employer’s name and headquarters | Metal processing industry |
|----------------------------------|--------------------------|
| Activity (the area of work)      | Counterbalanced forklift |
| Type of equipment               | Drive Electric           |
| Manufacturer                    | Nissan                   |
| Production year                 | 2005.                    |
| Type / model                    | NO 1L 15 HQ              |
| Load capacity in tons           | 1.5                      |

| No: | The question                   | Comment                                                                 | D | N/R | S | Recommended corrective measures |
|-----|--------------------------------|-------------------------------------------------------------------------|---|-----|---|---------------------------------|
| 1.  | Overhead Guard / Roll          | Overhead Guard in a good state. No visible damage and cracks.           |   |     |   |                                 |
|     | Over Protection Frame          |                                                                         |   |     |   |                                 |
| 2.  | Access to the driver's seat    | There is a handrail on a part of the frame structure. The floor is low - |   |     |   |                                 |
|     | (3-point contact - steps and grab handles) | there is no step, but it can be accessed safely. Steps and grab handles are in good condition and clean. |   |     |   |                                 |
| 3.  | Load handler (forks or other, fork lock - spring/pin) and telescope | The forks and telescope were not distorted or cracked. The forks are properly positioned, there are fuses with studs for the L/R forks. |   |     |   |                                 |
| 4.  | Control mechanisms             | Prevention of unauthorized - a key removed from the ignition switch.      |   |     |   |                                 |
|     |                                | All control commands are appropriate.                                   |   |     |   |                                 |
|     |                                | The emergency shutdown device is not installed.                          |   |     |   |                                 |
|     |                                | There is an undamaged sticker with legible command marks.               |   |     |   |                                 |
5. Lift assembly
   (chains, limit switches)
   The limit switch is in operation, it automatically
   stops lifting the forks upon reaching extreme upper
   position.

6. Sound
   signaling
   The forklift is equipped correct sounding siren.

7. Light
   signaling
   There is a correct rotary light.
   There is a functional headlight and tail light.
   There is a proper STOP light.

8. PARKING BRAKE
   The parking brake does not work.
   Repair the parking brake

9. SERVICE BRAKE
   The service brake is operational. The forklift stops
   by pressing the service brake (mechanical brake
   principle) and release the gas pedal.

10. Hydraulic system
    (hydraulic cylinders,
    hoses, connections)
    The hydraulics for lifting and moving the forks, as
    well as for changing the slope of the mast, work
    flawlessly.

11. Load capacity chart
    There is a graphical representation of the load
    capacity chart - the metal plate is damaged and the
    date is unreadable.
    Place load capacity chart

12. General and technical
    data plate
    The metal plate is damaged, but the data is legible.

13. Signs - Notification,
    Warning and
    Prohibition (Labels)
    Labels are legible and not damaged.

14. Safety belt
    The belt is embedded and is correct.

15. Tires and wheels
    The solid tires are damaged. It has three wheels,
    which is in good working order, there no
    distortion. All nuts secure and in place.
    Replace tires.

RESULTS AND DISCUSSION

The research results on forklift brakes safety are given in Table 2. Based on these data, it is evident that the hypothesis was proved. In analyzed forklifts, a more pronounced problem was the lack of proper parking brake (11.02%) in comparison to the malfunction of service brake (1.57%).

Table 2. Results of the analysis of forklift brakes reliability

| Number of forklifts | Municipalities | Total number of forklifts/ answers | Number of negative (dangerous) answers | % |
|---------------------|----------------|-------------------------------------|----------------------------------------|---|
| BRAKES              | Novi Sad       | 127                                 | 14                                     | 11.02 |
|                     | Becej          |                                      | 2                                       | 1.57  |
| Parking             | 83             | 25                                  | 25                                     |      |
| Service             | 10             | 2                                   | 14                                     |      |

Of the 127 analyzes forklifts, 13 had a defective or inefficient parking brake, while one forklift did not have a parking brake. Two forklifts were found to have a malfunctioning service brake.

Forklifts that have a malfunctioning or inefficient parking and/or service brake become potentially more dangerous for indoor transport, due to the possibility of collisions with stationary objects or workers.

The most common causes of malfunction or inefficiency of the forklift parking brake are malfunctions of the parking brake system and the hand cable cracks. The most common cause of service brake malfunction are mechanical damage to the cylinder (brake wheel cylinder and master brake cylinder), wear of the brake lining or brake drum, lack of brake oil, and oiled brake lining.

In order to extend the service life of the forklift brakes, it is necessary to check the brakes regularly by an authorized service center, as well as to avoid abrupt braking by the operator/driver. It is proposed to install an electronic speedometer to limit the maximum speed of forklifts used within the plant and the warehouse (limited to 5 km/h) and forklifts used in the outside area of the plant (limited to 10 km/h). The installation of an electronic speedometer enables the simultaneous
reduction of the brake pad length and the brake system wear.

CONCLUSION
A descriptive research, relying on a newly developed checklist for the safety assessment of the observed sample is a significant contribution to obtaining data about the functionality and safety of parking and service brakes.

The objective of this research was achieved through the analysis of brake safety on a selected sample of 127 forklifts, where it was found that 11.02% of the observed forklifts had a problem with malfunction or inefficiency of the parking brake, and that 1.57% of the total number of forklifts had a problem of service brake malfunction.

Further research should be directed towards analyzing the functionality of forklift brakes on a much larger sample. Also, research should be extended to the remaining questions from the new checklist for Forklift Safety Analysis.

Injuries at work, resulting from a forklift collision or overturns, can be prevented with the help of efficient preventive measures. Forklift trucks safety is achieved by investing in forklift maintenance and by organizing professional training for employees. Routine inspections should ensure that a forklift truck has proper parking and service brakes, audible alarms, steering mechanism, and a hydraulic system. In order to reduce the number of work injuries, the forklift driver/handler must take care of the forklift load, the way it is stacked and secured to the load, as well as to avoid sharp aggressive turns, excessive speeds and sudden braking/acceleration.

REFERENCES
[1] Cvetković, D., Marković, D: Dizajn pakovanja, Univerzite Singidunum, 2010, Beograd
[2] Vladić, J: Mehanizacija i tehnologija pretnjava - neprekidni transport i specifične mašine i uređaji, FTN Izdavaštvo, 2005, Novi Sad
[3] Gavanski, D., Sokola, M: Bezbedan rad na poluautomatskoj mašini za obmotavanje paletiranih proizvoda streć folijom, 18th International Conference Dependability and Quality management, ICDQM-2015.
[4] Davidović, B. Intralogistika - unutrašnji transport, Intelekt, 2012, Beograd
[5] Regodić, D: Logistika, četvrtto izdanje i dopunjeno izdanje, Univerzitet Singidunum, 2014, Beograd
[6] Jusufrančić, I: Osnove druksnog saobraćaja, tehnologija - organizacija - ekonomika - logistika - upravljanje, Internacionalni univerzitet u Travniku, Saobraćajni fakultet, 2007, Travnik. National Forklift Safety Day is June 10th. Available at: http://forkliftsystems.com/national-forklift-safety-day-is-june-10th/
[7] Forklift Safety: Facts, Stats and Tips of Safe Operation [Infographic]: www.optimium safetymanagment.com /blog/forklift-safety-infographic/
[8] Gavanski, D: Analiza označavanja upravljačkih uređaja viljuškara. Objavljeno u: 14. Međunarodno savetovanje na temu Rizik i bezbednosni inženjerij. pp. 159-165, 2019, Kopaonik, Republika Srbija: Visoka tehnička škola strukovnih studija u Novom Sadu.
[9] Gavanski D, Jelačić, I: 2019. Analiza ispravnosti zvučne signalizacije viličara u Republici Srbiji, Časopis Sigurnost 61 (3), 2019, pp. 251-256, Zagreb, Republika Hrvatska: Zavod za istraživanje inženjering i razvoj sigurnosti d.d.
[10] Forklift Safety Guide. Available at: https://depts. washington.edu/ wineryhs/Content/Forklift%20Safety% 20Guide.pdf.
[11] High-Risk Work - A guide to forklift safety. Available:https://www.safework.sa.gov.au/sites/default/files/forkliftsafety.pdf
[12] Jovanović, M., Tomić, O. 2008. Upotreba viljuškara u podsektoru unutrašnjeg transporta i skladištenja sa aspekta bezbednosti, Objavljeno u: 3. srpski simpozijum sa međunarodnim učešćem Transport i logistika, str. 18.1-18.6, Niš, RS Univerzitet u Nišu. Mašinski fakultet

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ANALIZA ISPRAVNOSTI KOČNICA KOD VILJUŠKARA
Dušan Gavanski, Azra Korjenić

Rezime: Cilj rada je analiza ispravnosti kočnica kod viljuškara. Prikazana je metodologija istraživanja koja se koristila za analizu ispravnosti kočnica kod viljuškara, i to metodom deskripcije pomoću ček-liste. Istraživanje je sprovedeno na uzorku od 127 viljuškara prosečne starosti 15-tak godina, pri čemu je utvrđeno da na oko 10% viljuškara ne postoji ispravna parkirna kočnica, a na oko 2% viljuškara su neispravne radne kočnice. Na kraju su predloženi ukupni rezultati istraživanja ispravnosti kočnica kod viljuškara. Rezultati se nalaze u daljnjem istraživanju.

Ključne reči: viljuškar, kočnica, metodologija, istraživanje, analiza, ček-lista.