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The Problem of Reducing Consumption of Stretch Film Used to Secure Palletized Loads

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1. Introduction

Damage to cargo during transport occurs as a result of improper securing of the cargo. In some situations, inadequate securing of cargo causes not only material losses, caused by partial or complete damage to the cargo, but may threaten the safety of participants in the distribution of cargo in the distribution chain as bystanders as well. Irrespective of this, these damages can also affect the unplanned extension of deliveries or even prevent further deliveries. As consequence, there are unplanned additional costs charged to the sender preparing the cargo for shipment. Up-mentioned dangers and difficulties as well as additional costs caused by human errors in packing (Bujak & Zajac 2013) and securing cargo can be remedied and certainly significantly reduced.

The way to achieve this goal is to make manufacturers, distributors and carriers aware of the need for proper packaging and securing the cargo ensuring the safety of all participants in the distribution chain. The aim of the article is to present the problem of rational use of stretch film as the most frequently used method of securing loads. The development of methods and procedures for securing palletized loads with stretch film will allow significant reduction of film used while ensuring proper load security. As the result, there will be a major impact on our safety and the surrounding environment.

2. Packaging and security of the cargo

In the literature, we can find various definitions of packaging. A packaging can be understood as a separable coating of the packed goods, protecting and securing the goods against the influence of mechanical energy during the transport process and influence of environment. According to another definition, packaging can be a product intended to protect other products against damage, as

well as to protect the environment against the harmful effects of the packed goods (Salomon 2017).

The package consists of:

- packaging agent – product made of packaging material, intended to cover the packaged goods or maintain them in their entirety,
- auxiliary packaging agents – used for packaging, sealing and preparation for shipment of packaged goods.

Possible features of the product:

- sensibility to weather conditions,
- susceptibility to accumulation,
- susceptibility to explosion, flammability and self-heating,
- harmful to human health,
- possibility of damage or destruction of other products coming into contact with given type of product or located nearby.

The more of up-mentioned features has a product at the same time, the more difficult it is to choose the right packaging.

From the point of view of logistics (Zajac 2015), the most important is to protect the goods from damage or spoilage (during transport and/or storage). The unit packages (1st grade), then collective packages (2nd grade) and transport packaging (3rd grade) created in the process of goods distribution must meet the requirements of standardisation and dimensional coordination (Szpotański 2010, Świeboda & Zając 2016).

Unit packages are mainly required to protect the product against changes in the required properties. On the other hand, the collective and transport packaging should protect against mechanical damage (e.g. vibrations, impacts, static pressure) and climatic (e.g. rain, temperature, humidity, pressure) during transport and handling.

Second line packaging includes packaging materials and components that are responsible for the grouping of packaged units and participate in the creation of a complete shipping unit. This will include collective cartons, bundle films or so-called seams, adhesives, clips and basic carriers of information (labels, pendants, badges). Third line packages include: all types of cargo pallets (Świeboda and Zając 2017), slip sheets (boards replacing cargo pallets), all loading pads and spacers, mats, protective corners, strapping tapes, information labels, stretch films, heat-shrinkable hoods and others being an integral part of pallet cargo.

In the era of increasingly widespread use of multi-level distribution chains and a logistic point of view, packaging should ensure (IRU 2015, Salomon 2017, Szpotański 2010, Woźniak et el. 2016):

- strength of the structure giving/guaranteeing proper protection of packaged products during transport, storage and reloading,
- proper fastening of the contents inside the packaging, taking into account the possibility proper distribution of the weight of the product on the structural elements of the bottom and sufficient protection against shocks,
- protection against weather conditions during transport appropriate for the product and the climate,
- customized packaging based on the expected methods of storage,
- maximum limitation of the size and weight of the package,
- reasonable and economical use of materials,
- technologically convenient structure ensuring ease of packaging and fastening of products,
- possibly low manufacturing costs (material and labour costs),
- the possibility of reuse or recycling of packaging materials,
- the aesthetic appearance of the packaging and the surfaces allowing required marking.

From an economic point of view, packaging should fulfil required functions at optimal (lowest) cost. The requirements for packaging relate to the cost of packaging and the efficiency of packaging. Naturally, the commodity lose analysis is also being taken into account. The costs of packaging of the products are significant and they are valued at an average of 15% of their total value. As per estimation, proper packaging of products can reduce transport and storage costs by around 6%. Moreover, it can reduce the amount of freight losses caused by quantity loss and deterioration of packaged products by around 8%. It is worth to remember, that the results of insufficient packaging of goods are generally much worse than the effects of possible excessive and too expensive packaging (Rucińska & Kędzior-Laskowska 2015).

The value of packaging materials is approx. 50% of all packaging costs. Additionally, we should take into account losses during transport or storage as the result of the use of unsuitable or under-quality material (cost saving procedures by using cheaper, low quality packaging materials).

Logistics market operators as well as manufacturers of various goods are looking for ways to reduce costs, creating the conflicts between both parties. Manufacturers will try to reduce the cost of collective packaging as much as possible (collective packages do not influence customers' purchasing decisions), while for transport operations, properly packed cargo will determine the safety and quality of the transported cargo. As safe cargos we can call all packages delivered without damage to the contents of the package and without final changes affecting the dimensions of an individual package. In practice, it is very difficult

to be achieved. Damage to the cargo can be affected by following factors: package design features (size, weight, shape) and distribution conditions (distance, transport conditions, reloading). Therefore damages and loses can be stopped by proper packaging and cargo securing during transport.

Preparation of the cargo for transportation – properly selected packaging (shape, resistance to pressure, etc.), and most important – the proper way of forming and securing of the single package is a very important issue for the producer/sender (as the first link in the distribution chain). It has a huge impact on minimizing damage to the cargo during the transport (Deja et al. 2017, Tkaczyk 2016).

When analysing the rationality of the use of packaging, we should not only take under consideration costs of materials but also the cost of packaging (labour), transport, storage, shipping and losses as results of damage of products in packages. The optimal option is to consider a product packaging system where the sum of packaging costs and losses is the lowest while maintaining its functionality. Therefore, economically optimal packaging is considered to achieve a minimum total cost (packaging and losses) (Szpotański 2010).

In order to prevent damage in the supply chain, loads are usually secured with stretch film.

3. Stretch film

Synthetic materials (plastics) consist mainly of synthetic organic polymers, i.e. polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET) or polystyrene (PS). Polyethylene (PE) can be divided in to two types, i.e. low (LDPE) and high density (HDPE) (Fig. 1).

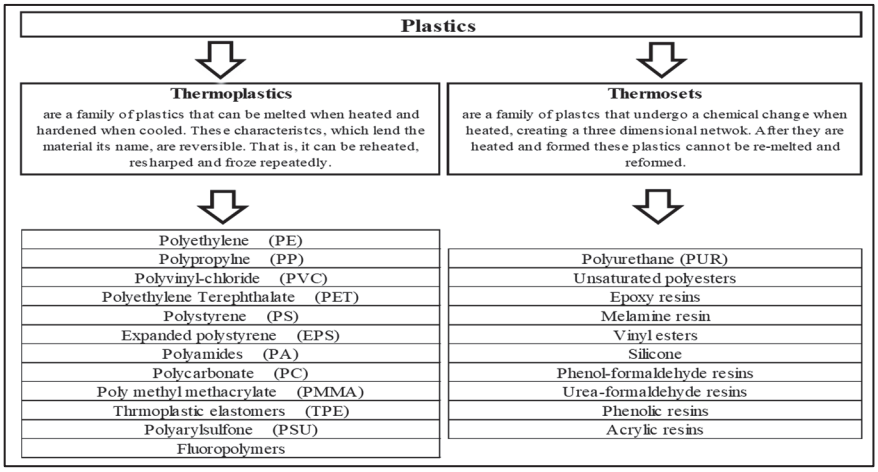

Fig. 1. The division of synthetic materials (PlasticsEurope 2019)

Plastics demand in Europe in 2019 was on the level of 51.2 million tonnes (in 2018 was on the level of 61.8 million tonnes and in 2017 was on the level of 64.4 million tonnes) with a turnover over 360 billion euros (Fig. 2).

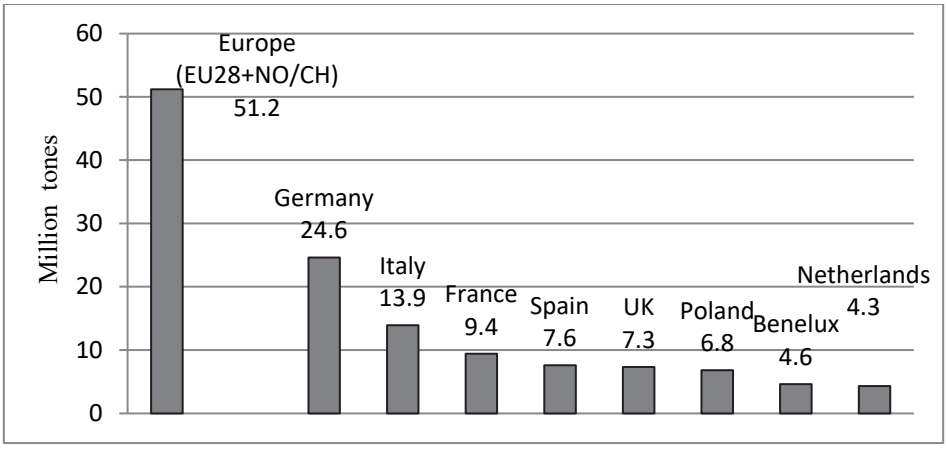

Fig. 2. Synthetic materials demand by country and application segment (PlasticsEurope 2019)

Plastics industry provides employment for more than 1.6 million people in nearly 60000 of companies. The main segments using synthetic materials are: packaging industry 39.9%, construction industry 19.8%, automotive industry 9.9%, electrical and electronic equipment 6.2%, household appliances, sport and leisure 4.1%, agriculture 3.4% and others 16.7% (equipment and mechanical devices, furniture, medical equipment) (Fig. 3). Data collected by Plastics Europe, Association of Plastics Manufacturers in Europe (PlasticsEurope 2019) and EPRO (European Association of Plastics Recycling and Recovery Organisations) (https://ami.international, Lenort et al. 2019).

In the packaging industry, one of the most popular materials is stretch film, produced by linear processing of low-density polyethylene LLDPE (Fig. 4-5). There are two methods of stretch film production: the "blown" extrusion method and the "cast" slot method. LLDPE is divided into butane (C4); hexane (C6); octane (C8) depending on the length of the carbon chains. Depending on which material we use for further processing, we will obtain a film with different properties.

Fig. 3. Plastics demand by segment 2019 (PlasticsEurope 2019)

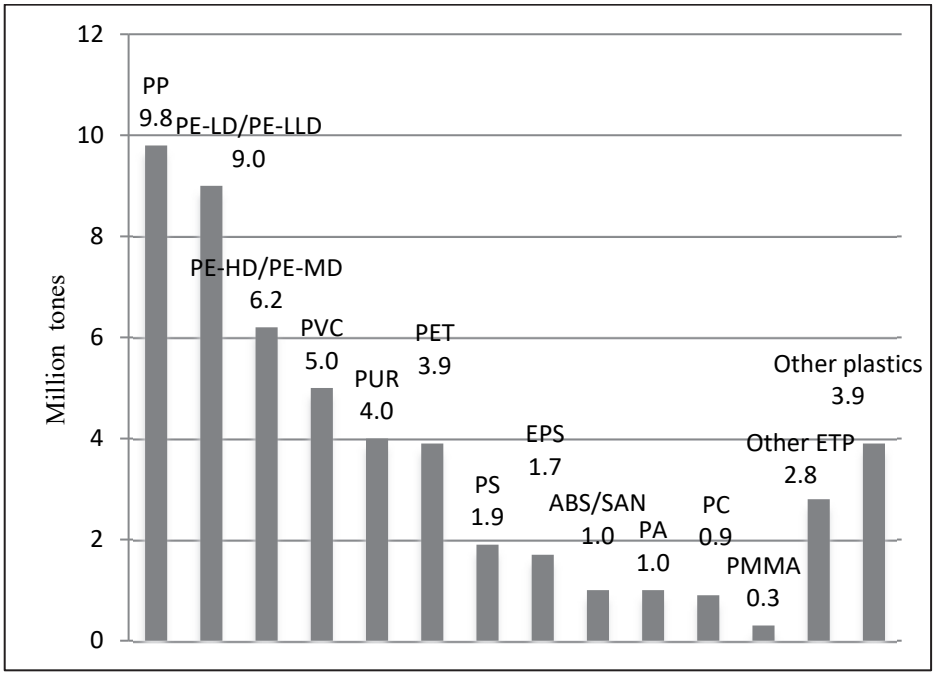

Fig. 4. Plastics demand by resin types 2018 (PlasticsEurope 2019)

Fig. 5. Plastics demand by segments and polymer types in 2018. Total 51.2 M (PlasticsEurope 2019)

Stretch film is the name of a multilayer stretch polyethylene film. The basic raw material for stretch film production is linear low density of polyethylene (LLDPE). It is the most popular and the cheapest form of cargo packaging. It does not require the use of expensive equipment to protect the goods, as in the case of heat-shrink films. In addition to stabilizing function for cargo on pallets, stretch film protects the cargo from the weather conditions. The use of coloured stretch films makes possible to hide the contents of the cargo or to identify a customer or a group of products in logistics centres (http://www.nowafolia.pl, https://opakowania.com.pl, https://tworzywa.org, https://pzpts.pl).

Types of standard stretch films:

- manual – designed for manual wrapping of the load; standard is a 500 mm wide film with a thickness of 17-30 microns. Most popular thickness for manual wrapping stretch film: 23 microns; standard stretch of film: 150-180% (one meter of film can be stretched from 150 cm up to 180 cm during unwinding from the roll until final break), different colours,
- machine – designed for wrapping non-deformable goods using automatic and semi-automatic wrappers (the machine wrapping process saves material and speeds up packing); standard 500 mm wide, 12-30 microns thick, different

colours; it is available in three standards of stretch: standard (150% up to180% stretch), power (200% up to 250% stretch) and superpower (250% up to even 300% stretch).

There are different film classification possibilities:

- standard stretch,
- pre-stretch: pre-stretched film in the production process to a value of about 200%; it is available in both manual and machine versions due to a different production technology (it is created by mechanic stretching the stretch film between 2 rollers - unwinding and winding. Due to the fact, that the secondary roll (winding) is larger and rotates faster than the main roll (unwinding) the stretch film is pulled between them and stretched to the required parameters) the standard width of the pre-stretch is usually 430 mm and it is thinner than the other stretch films (8 up to 12 microns) (http://www.nowafolia.pl, https://opakowania. com.pl, https://tworzywa.org, https://pzpts.pl).

When selecting the stretch film (proper selection of thickness and quality standard of the film for the load to be secured) the specificity of the product, its shape and weight, transport conditions and specification of the wrapping machine should be taken into account.

An important aspect of the widespread and excessive use of plastics is a serious environmental problem. As research shows, we can find them in any environment - in rainwater, in human bodies (6000 plastic particles), which was confirmed by research conducted in Germany – the presence of plastic was found in the organisms of 97% of the examined children (micro-particles with a diameter of 5 μm and nanoparticles with a diameter of <100 nm enter the body through various routes: dermal, digestive and respiratory), in sewage sludge (4196-15385 kg/dry weight), in rivers, e.g. in the Danube (approx. 900 particles/m^3), in ocean waters (from 8 to 9200 particles/m^3) where plastic waste formed a huge island of trash in the Pacific Ocean with the area 5 times larger than area of Poland. Estimated weight of drifting waste can be even 3 million tonnes (Bukowska & Kik 2019, Stachurek 2012).

Extremely important in the protection of the environment and living organisms is the handling of used plastic. It can be collected in landfills, where it can last from 100 up to 1000 years or it can be recycled (Directive of the European Parliament and UE Council from2 7 March 2019 about the reduction of the environmental impact of certain plastic products, 2019. Until 2015, there was only one waste incineration plant in Poland, located in Warsaw. Currently, we also have incineration plants in Białystok, Bydgoszcz, Konin, Kraków, Poznań and Rzeszów (Mroziński 2009).

4. Solutions for limiting the use of the film

With the ever-increasing demand for stretch film, both manufacturers and operators involved in supply chain (Chamier-Gliszczyński & Staniuk 2018) freight transport are paying increasing attention to optimising of freight packaging costs. To reduce stretch film consumption companies implement more or less advanced solutions (Fig. 6-9).

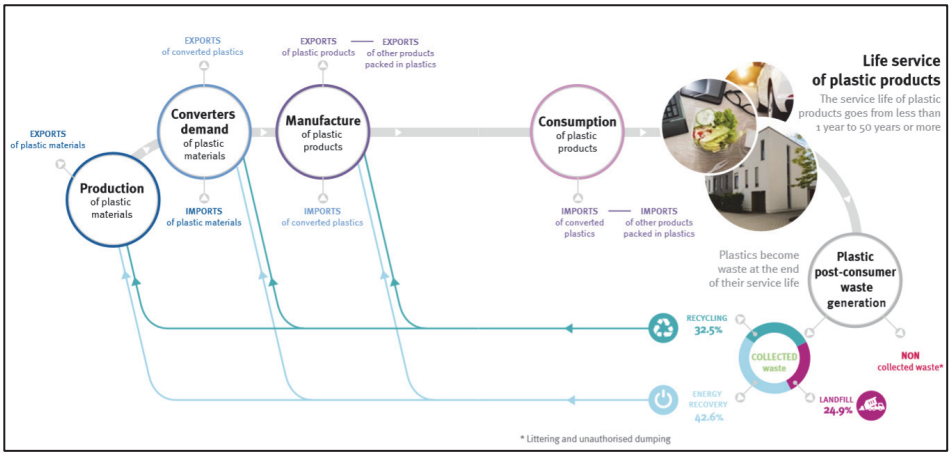

Fig. 6. The life cycle of plastic products (PlasticsEurope 2019)

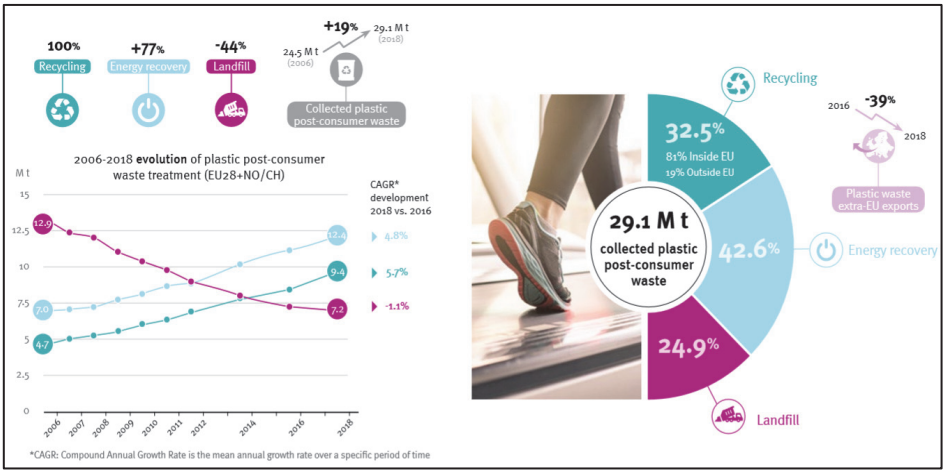

Fig. 7. Plastic postconsumer waste treatment in 2018 (PlasticsEurope 2019)

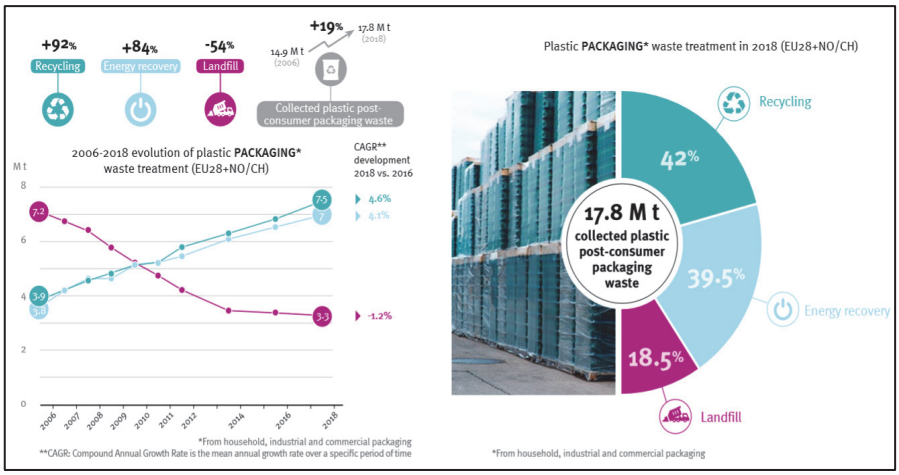

Fig. 8. Recycling is the first option for plastic packaging waste (PlasticsEurope 2019)

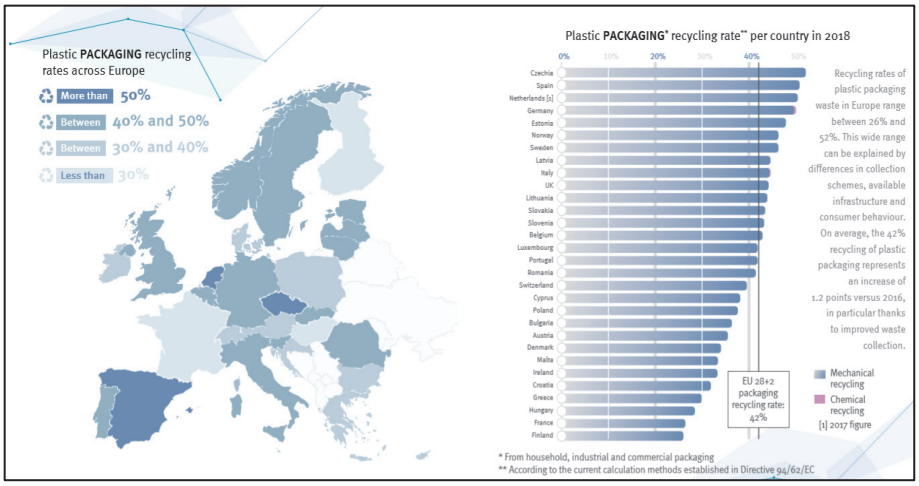

Fig. 9. Plastic packaging recycling (PlasticsEurope 2019)

One of the simplest solutions to reduce the consumption of stretch film is to use stretch film with higher parameters. It is commonly believed that the thicker the film, the more durable it is. However, film manufacturers are increasingly paying attention to the efficient and ecological aspect of film production. Stretch with a higher quality standard (Power or Superpower) can enable more efficient use of one meter of stretch to secure the goods. On the other hand, thin films allow a better use of a kilogram of stretch to wrap the load, within less waste. Currently, increasingly grows the use of pre-stretch film. Experts mention

greater comfort of use, higher efficiency (pre-stretch means up to 65% less consumption per kg of film, half as much waste and 3 times more stretch!) and thus lower cargo-securing costs.

Pre-stretch films are used in following cases (http://www.nowafolia.pl, https://opakowania.com.pl, https://tworzywa.org, https://pzpts.pl):

- packaging light and/or delicate products on a pallet e. g. plastic packaging (bottles, containers, dishes, pans), where thick stretch films are not needed,
- pallet wrapping on straight wrappers without a pre-stretch system (with a mechanical brake); as they have low stretch, significant savings can be made on wrappers without a stretch system, replacing the thick stretch films currently in use.

Another way to reduce film wear is to use film with Nano-layers. It is an extremely ecological, but also economic product. By using Nano- layers, the same gripping forces have been achieved as in a traditional film, but with much less material used. The producer of this film claims: "the improvement of film parameters, leading to a reduction in the number of film used to wrap individual pallets will be an important developmental direction for the coming years".

Another way to reduce the consumption of stretch film is to introduce changes in the management and control of stretch film consumption. One of methods, implemented on the Polish market, is the application of ASM (Auto-Stretch Manager) film consumption management, which consists in the use of a device allowing for the control of stretch film consumption. Its operation is simple - after scanning the employee's ID, the feeder retrieves used film rolls and issues new rolls. The device weighs the used rolls and records how many kilograms of film have been used. The device connected to the storage system enables the collected data to be compared with the number of packed pallets, cartons and global film consumption (in cubic meters). On the basis of the obtained unit indicators of film consumption, it is possible to determine the quantity and level of film consumption in the warehouse check for what purpose it was used and control its quality. By using ASM the operator can reduce film consumption by approx. 10% (https://www.eurologistics.pl/eurologistics/newsy/autorskie rozwiazania logistyczne).

Another approach to the problem of reducing film consumption can be observed in one of the Polish film producers. In his opinion, "among the challenges that producers face, especially important can be re-modelling of the business to function in accordance with the requirements (philosophy) of the Closed Circuit Economy. An effective system of selective waste collection (Chamier-Gliszczyński 2010, Chamier-Gliszczyński 2011, Chamier-Gliszczynski & Krzyzynski 2004) will undoubtedly increase the level of recyclates used in plastic products, which will have a significant and positive impact on the environment

and allow full use of the fantastic possibilities of plastics for reprocessing. However, a huge task will be reminding this to consumers. Products as stretch film, that are produced from one component, are fortunately an excellent raw material for reprocessing" (Ergis 2020).

All the above mentioned ways of reducing the use of stretch film increase the efficiency of using one meter of film to secure the load. Currently, it is necessary to implement methods and procedures to rationalize (optimize) the consumption of stretch film protecting the transported palletized cargo. Testing methods for the behaviour of cargo and its components in transport processes have been developed on the basis of experience and laboratory tests of packaging, cargo transport and storage procedures conducted by organisations established for this purpose and research units operating in large transport companies, such as ASTM International (American Society for Testing and Materials), ISTA ((International Safe Transit Association) or EUMOS (Europe Move It Safe).

On the basis of gained experience, EU developed the Directive 2014/47/EU to guarantee the safety of cargo transportation on EU roads by ensuring proper securing of cargo on the vehicle. To guarantee quality standards, EUMOS developed the EUMOS 40509 method (included in Directive 2014/47/EU), which aims to guarantee the safety and rigidity of the cargo (EUMOS 40509, 2012). Currently (as of June 2020), EUMOS 40509 standard is in force since 2012. Recently it is being updated and will be published in the third quarter of 2020.

EUMOS 40509 is a dynamic test system that can be used to assess the stiffness and safety of accelerated or decelerated cargo, similar to road transport (EN 12195-1, 2011), (EN 12642, 2006), (Regulation of the Minister of Infrastructure of 25 January 2018 on the method of cargo transportation, 2018), (Regulation of the Minister of Infrastructure of 24 December 2019 amending the Regulation on technical conditions of vehicles and the scope of their necessary equipment, 2019). The method is addressed (inter alia) to manufacturers of goods transported on pallets, where they bear full responsibility for the compliance of the transported product with the above-mentioned legal act. The direct advantages of using this method can be demonstrated within following:

- assessment of the stiffness and safety of cargo subjected to horizontal accelerations and decelerations,
- compliance with the European Directive 2014/47/EU,
- reduction of the cost of packaging ensuring the safety of the transported cargo and safety in warehousing (Kostrzewski 2013),
- increase of road transport safety.

To comply with EUMOS 40509, there must be performed a stability test (Fig. 10). On the horizontal stabilizer can be performed personalized tests. By simulating the conditions of individual loads transport, by way of experiments, is possible to select a film suitable for each customer with exact parameters such as thickness, holding force, stretch, puncture resistance (Tkaczyk 2016, Kostrzewski 2020, Kielec et al. 2018). At the same time, it guarantees the appropriate level of cargo stiffness (determined on the basis of cargo deformation, where the maximum value of deformation is determined by the EUMOS standard).

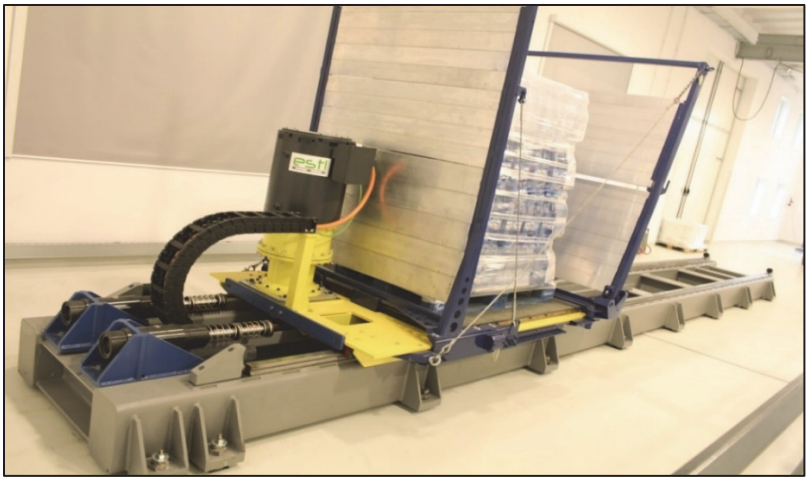

Fig. 10. Stability tester for tests conducting according to EUMOS 40509 (Ergis 2020)

It is important to understand that good stability of the pallet requires an appropriate wrapping specification. The use of higher quality stretch film has the effect of reducing its use while maintaining and improving the rigidity of the palletised load. There is currently only one independent institute, ESTL, which specialises in cargo packaging and securing tests and can offer certification in Western Europe. In Spain, ITENE can also issue certificates.

5. Conclusions

The material losses as results from damage to goods during transport are enormous. It is estimated that on the American market it is U$ 2.6 trillion. It is difficult to obtain data on this subject on the Polish market (CDS 2020, https://its.waw.pl). However, there are even greater losses than just material ones. Many people lose their lives or are injured due to poorly secured goods for car transport. Statistics for 2014 show that 1200 people in Europe have died in accidents as a result of this problem.

Therefore, it will be essential, to take action for significant improvement of methods and procedures of securing the cargo transported. The development of a research method enabling the analysis and assessment of possible behaviours of cargoes transported in the supply chains, used to secure the cargo of stretch film and packaging methods used in the shaping of the juniper, will significantly improve the safety of all the cargo types participating in the execution of the transport. It will reduce the use of the stretch film while reducing the safety risk, damage or destruction of the load and difficulties occurring in logistic processes. Moreover, it will reduce the costs of operations for all.

The development of a research method and the implementation of new procedures rationalizing (optimizing) the use of stretch film will help to protect better the planet's environment and its resources. The problem of proper cargo securing becomes even more important when we become aware of other threats. Cargo load, when properly secured with stretch film, protects environment from pollution. It means, that stretch film is no longer understood as environmental pollution (rubbish) and becomes a tool to ensure safety and reduce the effects of the transported products on the environment. Minimizing level of damage and number of damaged loads is another important subject, which we often do not pay attention to. It causes a secondary reduction in the use of the natural resources of the environment, necessary for the re-production of damaged or destroyed products.

The direct and indirect costs of damaged and destroyed products, the costs of used natural resources for the re-manufacturing of goods many times exceed the costs of production and disposal of stretch film used for securing cargo. Nevertheless, it is necessary to strive to reduce the use of stretch film by using appropriate methods and procedures for securing loads with stretch film. Taking into account economic and ecological criteria, we have to ensure high quality of stretch film and its optimal use, as it plays a key and irreplaceable role in the distribution chains of products transported in bulk in the global economy.

References

Bujak, A., Zajac, P. (2013). *Monitoring of cargo in logistic systems of transport and storage*. In International Conference on Transport Systems Telematics, Springer Berlin, Heidelberg, 361-369.

Bukowska, B., Kik, K. (2019). *Plastic in the environment. What do we know about its harmfulness*. Łódź: Foundation for Enterprise Development in Łódź. PRF Bulletin.

Chamier-Gliszczynski, N., Krzyzynski, T. (2004). *On modelling three-stage system of receipt and automotive recycling*. REWAS'04, Global Symposium on Recycling, Waste Treatment and Clean Technology 2005, Madrid, Spain, 26-29 September 2004, Conference Paper, ISBN: 8495520060, 2813-2814.

Chamier-Gliszczyński, N. (2010). Optimal Design for the Environment of the Means Transportation: a Case Study of Reuse and Recycling Materials. *Sold State Phenomena, 165*, 244-249.

Chamier-Gliszczyński, N. (2011). Environmental aspects of maintenance of transport means, end-of life stage of transport means. *Eksploatacja i Niezawodnosc-Maintenance and Reliability, 2*, 59-71.

Chamier-Gliszczyński, N., Staniuk, M. (2018). *Logistics audit 9A in the assessment of supply chain efficiency of companies operating in the industry 4.0*. CLC 2018: Carpathian Logistics Congress Conference Proceedings, 03-05 December 2018, Prague, Czech Republic, 482-487.

Deja, A., Matuszak, Z., Stempień, M. (2017). *Assessment of the functioning of the selected transport company in terms of preventing damage to the transported cargo.* Radom: Buses.

Directive of the European Parliament and UE Council from 27 March 2019 about the reduction of the environmental impact of certain plastic products (2019): Document 52018PC0340.

Directive 2014/47/EU (2014): Document 32014L0047.

EN 12195-1 (2011). Standard for Load restraining on road vehicles.

EN 12642 (2006). Tests of Vehicle Bodies.

EUMOS 40509 (2012). Safe Load Testing Technologies.

https://ami.international (date 24.09.2020).

CDS (2020). CDS Odszkodowania, https://www.cds-odszkodowania.info (date 25.08.2020).

Ergis (2020). Ergis Load Stability Academy, ELSA: https://ergis.eu (date 24.09.2020).

https://www.eurologistics.pl/eurologistics/newsy/autorskie-rozwiazania logistyczne (date 12.08.2020).

https://www.europarl.europa.eu (date 24.09.2020).

https://its.waw.pl (date 25.08.2020).

https://lab4pack (date 10.09.2020).

http://www.nowafolia.pl/certyfikaty-eumos.html (date 24.09.2020).

https://opakowania.com.pl/news/folie-z-tworzyw-proba-opisania-rynku-26459.html 2007.

https://tworzywa.org (date 24.09.2020).

https://pzpts.pl (date 05.08.2020).

IRU (2015). International guidelines for the safe securing of loads in road. IRU I-0323. IRU_CIT-2014 version 01.

Kielec, R., Sąsiadek, M., Woźniak, W. (2018). *Adoption of the Evolutionary Algorithm to Automate the Scheduling of the Production Processes.* Proceedings of the 31st International Business Information Management Association (IBIMA), Milan, Italy, ISBN: 978-0-9998551-0-2. 5039-5046.

Kostrzewski, M. (2013). *Loads Analysing In Pallet Racks Storage Elevation.* CLC 2013: Carpathian Logistics Congress Proceedings, 260-265.

Kostrzewski, M. (2020). Sensitivity Analysis of Selected Parameters in the Order Picking Process Simulation Model, with Randomly Generated Orders. *Entropy, 22(*423), 1-21. DOI: https://doi.org/10.3390/e22040423

Lenort, R., Baran, J., Wysokiński, M., Gołasa, P., Bieńkowska-Gołasa, W., Golonko, M., Chamier-Gliszczyński, N. (2019). Economic and Environmental Efficiency of the Chemical Industry in Europe in 2010-2016. *Rocznik Ochrona Środowiska, 21*, 1394-1404.

Mroziński, A. (2009). *Recirculation of plastics in Poland and Europe*. Bydgoszcz: TOP-garn Science Circle. Technological and Natural Inverternity in Bydgoszcz.

PlasticsEurope, 2019. *Plastics – the Facts 2019.* An analysis of European plastics production, demand and waste data: https://www.plasticseurope.org/application/files/1115/7236/4388/FINAL_web_version_Plastics_the_facts2019_14102019.pdf.

Regulation of the Minister of Infrastructure of 25 January 2018 on the method of cargo transportation. (2018). Warszawa: Document 20180361.

Regulation of the Minister of Infrastructure of 24 December 2019 amending the Regulation on technical conditions of vehicles and the scope of their necessary equipment. (2019). Warszawa: Document 20192560.

Rucińska, M., Kędzior-Laskowska, M. (2015). *Safety and Timeliness – quality Attributes in Road Transport of Goods*. Scientific Papers of the University of Gdańsk. Transport Economics and Logistics. 57 Contemporary problems of transport development = Present Problems of the Transport Development, 129-144.

Salomon, A. (2017). Cargo stacking as an important element in modeling multimodal transport chains (on the example of the Port of Gdynia). *Materials Management and Logistics, 12*, 988-1007.

Stachurek, I. (2012). *Problems with biodegradation of plastics in the environment*. Katowice: Scientific Journals of the University of Labour Protection Management in Katowice.

Szpotański, M. (2010). Shelf-ready packaging. Technical and Economic Monthly. *Opakowanie, 11-2010*.

Szpotański, M. (2013). Outsourcing as a chance for development. Technical and Economic Monthly. *Opakowanie, 11-2013*.

Szydełko, M., Jagieła, A. (2015). *Selected elements of plastic packaging distribution system – theoretical and practical aspects*. Poznań: Logistics.

Świeboda, J., Zając, M. (2017). *Information System as a Cause of Cargo Handling Process Disruption in Intermodal Terminal.* in: Advances in Dependability Engineering of Complex Systems. Springer, Cham, 418-427.

Świeboda, J., Zając, M. (2016). *Analysis of Reshuffling Cost at a Container Terminal*. In: International Conference on Dependability and Complex Systems. Springer, Cham. 491-503.

Tkaczyk, S. (2016). *Selection of means of transport for the implementation of technological processes*. Warszawa OWPW.

Tkaczyk, S., Ambroziak, T. (2016). *The method of optimal allocation of technical means and means of transport for the implementation of technological processes*. OWPW 2016, Pracy Naukowe Transport, 111, 555-572.

Woźniak, W., Sąsiadek, M., Stryjski, R., Mielniczuk, J., Wojnarowski, T. (2016). *An algorithmic concept for optimising the number of handling operations in an intermodal terminal node*. Proceeding of the 28th International Business-Information-Management-Association (IBIMA), Seville, Spain, ISBN: 978-0-9860419-8-3, 1-7, 1490-1500.

Zajac, P. (2015). *Evaluation of automatic identification systems according to ISO 50001: 2011*. International Conference on Automation. Springer, Cham.

Abstract

Damage to cargo in transport occurs as a result of improper securing of cargo, which causes not only material losses due to partial or complete damage to cargo, but may threaten the safety of participants in the distribution of cargo in the distribution chain. Dangers, difficulties and costs caused by human errors in packing and securing cargo in all modes of transport can be remedied and certainly significantly reduced. The best way to achieve this goal is to build the awareness of the great need for proper packaging and securing the cargo in a way that ensures the safety of all participants in the distribution chain among producers, distributors and carriers. The article discusses the problem of rational use of stretch film as the most frequently used method of securing loads. Author indicated necessity to develop methods and procedures for the proper protection of palletized loads with the use of stretch film to reduce the amount of stretch film used while ensuring proper load security, increase the safety and better protection to the environment of the planet and its natural resources.

Keywords:
stretch film, cargo, cargo damage, cargo securing, cargo securing methods

Problem ograniczenia zużycia foli stretch wykorzystywanej do zabezpieczania ładunków spaletyzowanych

Streszczenie

Uszkodzenia ładunków w transporcie powstają w wyniku niewłaściwego zabezpieczenie ładunku co powoduje nie tylko straty materialne, spowodowane częściowym lub całkowitym uszkodzenia ładunków, ale może zagrażać bezpieczeństwu uczestnikom dystrybucji ładunku w łańcuchu dystrybucyjnym. Takim niebezpieczeństwom i utrudnieniom a w konsekwencji kosztom spowodowanymi błędami ludzkimi przy pakowaniu i zabezpieczaniu ładunku na środkach transportu można zaradzić, a z pewnością znacznie je ograniczyć. Drogą do tego celu jest uświadomienie producentów, dystrybutorów i przewoźników o konieczność prawidłowego opakowania i zabezpieczania ładunku w sposób zapewniający bezpieczeństwo wszystkim uczestnikom łańcucha dystrybucji. W artykule omówiono problem racjonalnego zastosowania folii stretch, jako najczęściej stosowanego sposobu zabezpieczania ładunków. Wskazano na konieczność opracowania metody i procedur prawidłowego zabezpieczania ładunków spaletyzowanych przy zastosowaniu folii stretch co pozwoli na ograniczenie ilości zużywanej folii stretch przy jednoczesnym zapewnieniu prawidłowego zabezpieczania ładunku, a w konsekwencji pozwoli zwiększyć bezpieczeństwo oraz lepiej chronić środowisko naturalne planety i jej zasoby.

Słowa kluczowe:
folia stretch, ładunek, uszkodzenie ładunku, zabezpieczenie ładunku,
metody zabezpieczania ładunku