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Plastic Containers: Sustainable Solutions through Repair

EXPERTISE | Repairing Plastic Pallet Boxes



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Management Summary

Starting Point

Efficient transportation and storage solutions are critically important in the logistics industry. Plastic pallet boxes are used in a variety of sectors, such as the food, automotive and chemical industries, as well as waste logistics. These containers are durable, but also subject to wear and tear.

Aim

The main aim of this white paper is to investigate and assess repair methods for plastic pallet boxes in order to extend their service life and to evaluate the economic viability of these measures.

Repair Methods

- **Hot Air Hand Welding:** suitable for hard-to-reach areas and minor repairs.
- **Hot Air Speed Welding:** more efficient and uniform than free hand welding, perfect for small containers.
- **Hot Air Extrusion Welding:** for larger repairs and thicker materials, offers high levels of mechanical strength and process safety.

Analysis

An economic assessment of the repair of plastic pallet boxes showed that repairs are often more cost-effective than buying new. Successful repairs can significantly extend the service life of the boxes. Aside from direct costs, factors such as operating costs, risks and environmental impact must also be taken into account.

Recommendations

Companies should assess the type and severity of the damage and compare the cost of repair with the cost of a new purchase. A comprehensive assessment that includes all relevant economic and environmental factors is crucial. It is worth taking a more in-depth look, as repaired plastic pallet boxes remain in circulation for longer and can therefore be used sustainably and cost-effectively.

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1. Introduction

In the logistics industry, efficient transportation and storage solutions play a vital role in the smooth flow of goods. Large logistics containers, pallets and, in particular, plastic pallet boxes are indispensable tools. They not only enable the safe and stable storage of a wide range of goods, but also efficient transportation over long distances. Pallet boxes are used in various ways, for example for the transportation and production of food, waste, bulk industrial goods, chemicals. Many of these boxes are made from food-safe plastic and are ideal for the safe handling of unpackaged food. The versatile containers are therefore used in a number of industries, including:

- Food and beverage industry
- Automobile industry
- Chemical industry
- Retail and wholesale
- Pharmaceutical industry
- Agriculture and agribusiness
- Waste logistics

Like other products, these containers are subject to wear and tear over the course of their service life. The topic of the repairability of large-format logistics containers is therefore of vital importance for companies that rely on smooth logistics. In this report, we examine the various aspects and techniques of repairing plastic pallet boxes and assess their effectiveness and economic viability.



2. The Plastic Container Market

In Europe alone, around 135 million plastic containers and 20 million pallet cages go through a cycle that includes a number of stages: from the supplier to the depot to the producer, then to the customer, to cleaning or maintenance and – assuming everything runs smoothly – back to the beginning.

However, the precise number of logistics containers in circulation worldwide can vary and depends on various factors, such as the volume of international trade, the size and growth of the global logistics industry and the specific logistics requirements of different industries.

Choosing the right material for logistics containers plays a decisive role in the efficiency, intended use and durability of storage and transportation solutions. Compared to wooden and metal pallet boxes, plastic pallet boxes have a number of unique features that make them an attractive option for a variety of industries.

Comparison	Wooden pallet boxes	Plastic pallet boxes	Metal pallet boxes
Distribution	Largest share of the market. Frequently used in transportation logistics.	Widely used in the manufacturing industry.	Niche application in the metal industry.
Acquisition costs	⊕⊕ low	⊕⊖ medium	⊖⊖ high
Lifespan	⊖ life cycle of around 2–3 years	⊕ average life cycle of 10 years	⊕⊕ >10 years, depending on application
Weight	⊖ slightly heavier compared to an equivalent plastic pallet	⊕⊕ light compared to an equivalent wooden pallet	⊖⊖ very high dead weight

Continues on next page

Comparison	Wooden pallet boxes	Plastic pallet boxes	Metal pallet boxes
Maintenance	⊕⊖ can be repaired	⊕ can be repaired very well	⊕⊕ requires little maintenance
Wear and tear	⊖⊖ Chipping ⊖⊖ Exposure to moisture/loss of strength	⊕⊖ Breakage	⊕⊖ Corrosion
Work hazards	⊖⊖ Splinters and nails can cause injuries during handling	⊕⊕ Lightweight and splinter-free – therefore few work hazards during handling	⊖⊖ High physical strain during manual transportation
Sustainability	⊕⊖ Manufactured from renewable raw materials, repairable ⊖⊖ Wood can be a carrier of insect pests	⊕⊖ Fossil raw materials ⊕⊕ Highly sustainable thanks to repair, recycling and recovery options	⊕⊖ Very high energy requirement for production but long life cycle ⊕⊕ Recyclable
Hygiene	⊖⊖ Absorb moisture ⊖⊖ Potential carrier of bacteria and fungi ⊕⊖ Limited cleaning options	⊕⊕ Very good thermal and chemical cleanability ⊕⊕ Can be run through automatic washing processes	⊖⊖ Corrosive, not suitable for hygienic use

The following subsections deal with relevant points in more detail.

Durability and Resistance

Plastic pallet boxes are generally very durable and resistant to the stresses and strains of everyday use. Compared to wooden and metal pallet boxes, they are less susceptible to splintering, rust and rot.

They can be used indoors and outdoors without any issues and are resistant to many chemical substances, moisture and fluctuations in temperature.

Weight and Handling

Plastic pallet boxes are generally lighter than their wooden or metal counterparts. The nature of the plastic means no liquid is absorbed. As wood is hygroscopic, the weight of a wooden pallet can fluctuate depending on how much moisture it absorbs. Plastic pallets therefore facilitate handling and transportation, especially when using forklift trucks or other lifting devices. The low weight also reduces the workload on staff and minimizes the risk of injury.

Hygiene and Cleanliness

Due to their smooth surface, plastic pallet boxes are easy to clean and disinfect. This is why they are particularly suitable for sectors such as the food, pharmaceutical and healthcare industries, where strict hygiene regulations apply.

In contrast, dirt, dust and bacteria can accumulate more easily in wooden and metal pallet boxes, which makes cleaning more difficult and increases the contamination risk. Plastic containers and pallets can be cleaned in washing systems.

Adaptability and Modularity

Plastic pallet boxes often have a modular design, meaning they can be easily adapted to different requirements. The option of exchanging or adding side panels, lids and other components enables optimization for a wide range of loads and storage environments. In comparison, wooden and metal pallet boxes are generally less flexible and do not offer as many customization options.

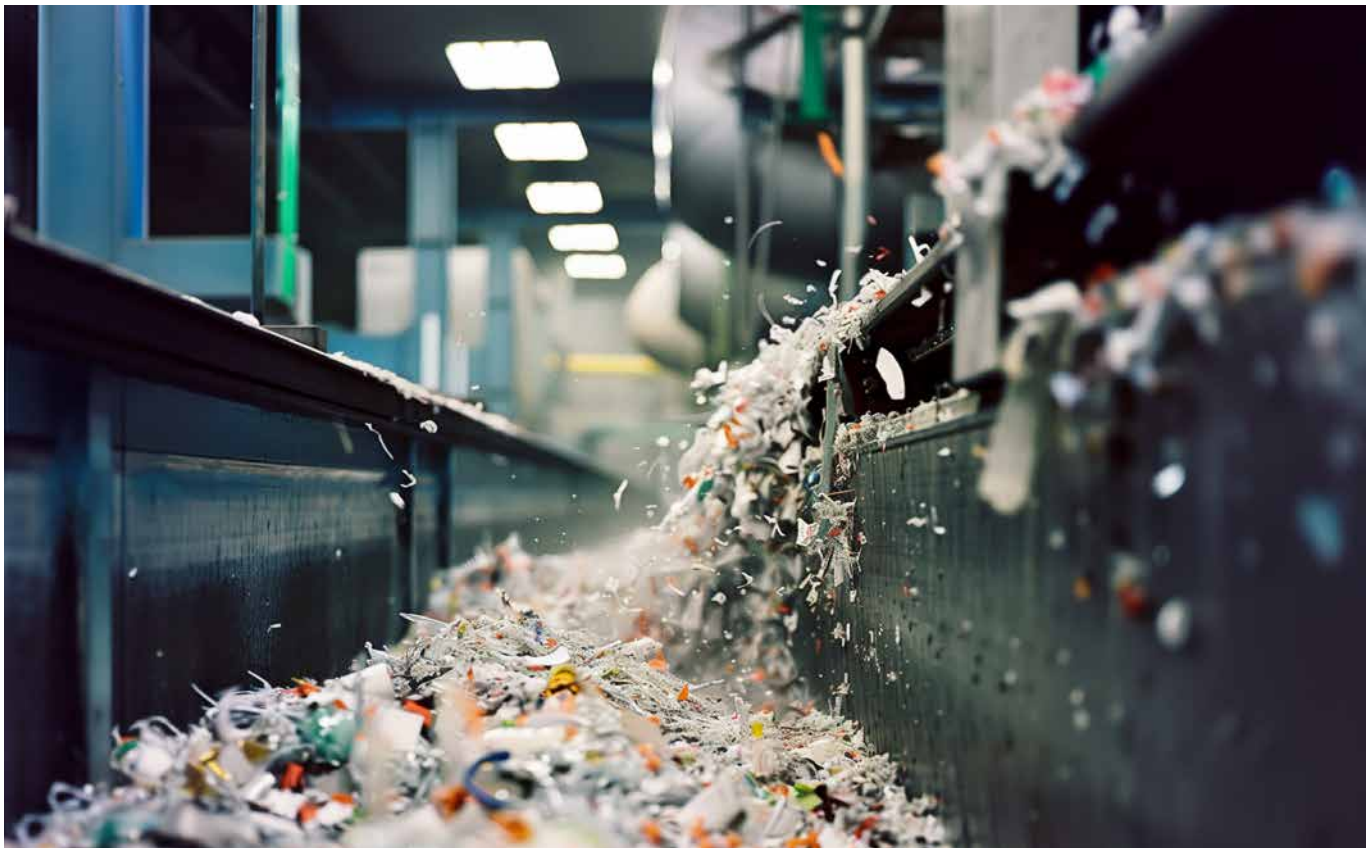


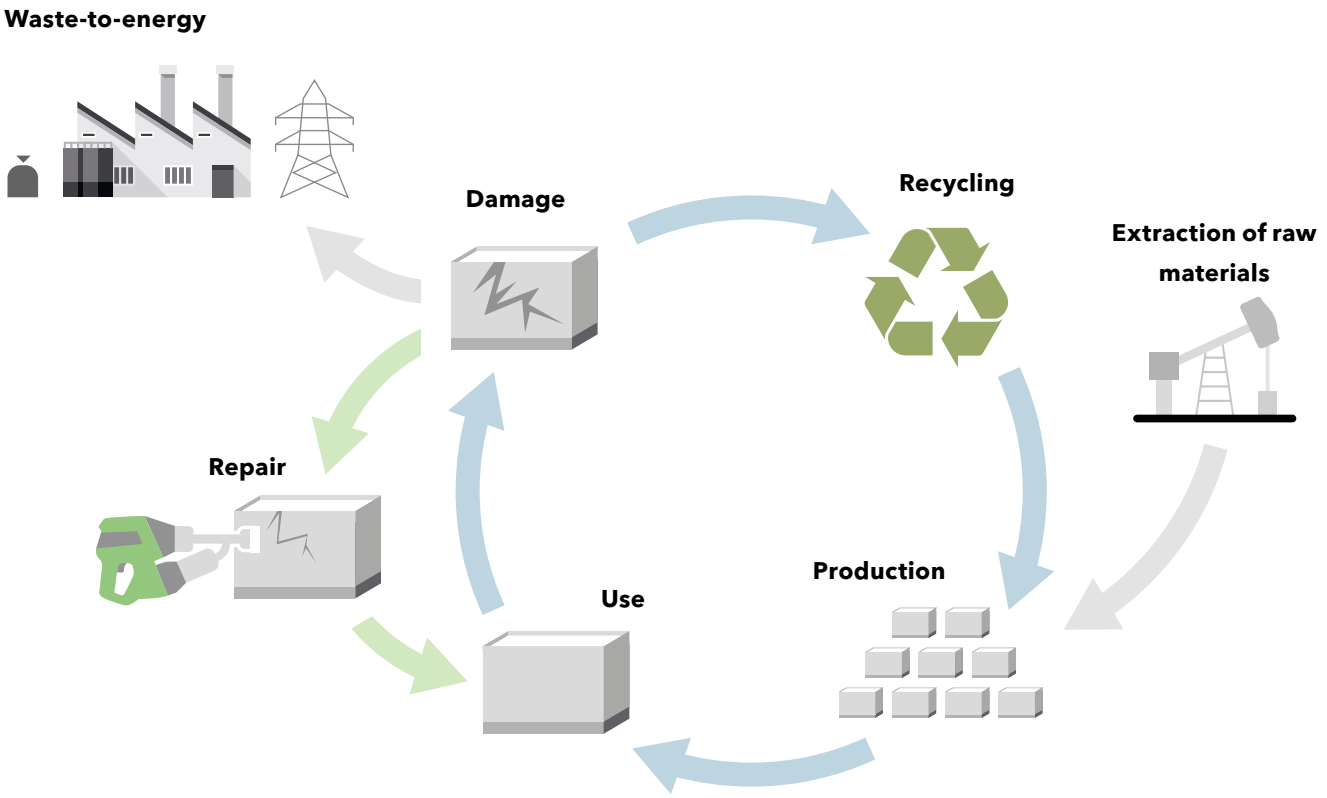
Fig. 1: Plastic shredder example photo
Discord, Midjourney, 2024

Environmental Friendliness

Plastic pallet boxes are often made from polyolefins such as polyethylene and polypropylene. Although fossil resources are consumed in their manufacture, this is practically offset by their durability and good repair and recycling capability over their life cycle. This type of logistics container therefore helps reduce waste and environmental pollution.

Although wooden pallet boxes are biodegradable depending on the region, they often require the felling of trees and can therefore pose a challenge to forest resources. Metal pallet boxes, on the other hand, consume a large amount of energy and resources during production.

All things considered, plastic pallet boxes offer a number of benefits over wooden and metal pallet boxes, making them an attractive choice for companies that value durability, hygiene, adaptability and environmental friendliness.



Recycling plastic containers

At the end of their life cycle, when repair is no longer viable, plastic pallet boxes can be shredded and completely recycled. The resulting granulate is used to produce new, high-quality plastic pallet boxes and other plastic logistics containers.

Waste-to-energy

If the plastic containers and pallets can no longer be recycled due to severe degradation, they can still be used as a valuable and efficient fuel for power generation.

3. Economic Assessment of the Repair of Plastic Pallet Boxes

The decision whether to repair plastic pallet boxes depends on a variety of factors, which can also be company-specific. It should be noted that the companies using the containers do not own them themselves. In these cases, the containers are rented. Irrespective of the ownership structure, the following factors must be taken into account:

- Type and severity of the damage
- Intended use
- Requirements of the place of use

Repair costs, which are directly related to a possible replacement/new purchase, the replacement time and the administrative effort are also key. The expected service life after repair also plays a role. A careful economic and environmental assessment is therefore essential in order to find the most suitable solution for the company. Some of these criteria are described in more detail below.

The following considerations are based on the assumption that the component repaired is fully operational again and fully meets the needs of the place of use.

N = New procurement costs

R = Repair costs

R<N	Economic approach. Repairs are undertaken because repair costs are lower than replacement costs.
R=N	Sustainable, economical approach. If the repair costs are the same or even higher than the replacement costs, a repair still makes sense.
R>N	Any seasonal, less labor-intensive periods can be used to make repairs, or the administrative effort for replacement and disposal can be kept low. Sustainability also plays a role.

Damage Assessment

The first step is to assess the extent and type of damage to the plastic pallet boxes. Minor damage such as cracks, chipping or defective fasteners can often be repaired relatively inexpensively, while more extensive structural damage requires more expensive repairs.

Depending on the extent of the damage, it may no longer make sense to repair a plastic pallet box. Depending on the design and construction, individual components or entire parts such as runners or pallet feet can be completely replaced. Aside from the type and extent of the damage, the condition of the material must also be taken into account. This is because plastics can age and become brittle over their long service life.

Repair Costs

Repair costs include labor costs, the cost of tools, machines and consumables, plus the costs for transporting the boxes to the repair workshop, if applicable. If the repairs are planned and coordinated by the company, synergies can be taken advantage of that can have a positive effect on cost accounting. It is also possible to compensate for seasonal fluctuations through repairs.



Comparison with the Cost of a New Purchase

An important step in the economic assessment is to compare the repair costs with the costs of purchasing new plastic pallet boxes. This requires an analysis of current market prices for comparable new boxes as well as a forecast of the expected service life after the repair compared to the new boxes.

Service Life Extension through Repair

A successful repair can significantly lengthen the service life of plastic pallet boxes and thus lead to long-term cost savings. It is important to realistically estimate the expected additional useful life after the repair and to include this in the economic assessment.

Consideration of Operating Costs

Aside from pure repair and replacement costs, the operating costs associated with the use of pallet boxes should also be taken into account. These include, for example, storage costs, transportation costs, labor costs for handling the boxes and any downtime due to repairs or replacement purchases.

Risk Assessment

Finally, a risk assessment should be performed to identify possible risks and uncertainties associated with the repair, such as unexpected additional repair costs, quality problems after the repair or a shortened service life of the repaired boxes.

Sustainability and Environmental Impact

Repairing plastic pallet boxes helps reduce waste and conserve fossil resources by extending the service life of the boxes and reducing the need for new production. The use of recycled materials and the promotion of material cycles also conserves natural resources and minimizes pollution of the environment.

Repaired pallet boxes can be recycled or reused at the end of their life cycle, reducing landfill waste and creating additional environmental benefits.

The decision to repair plastic pallet boxes shows a company's commitment to sustainability and environmental protection, which has a positive impact on the corporate image and helps to meet or exceed legal requirements.

A comprehensive economic assessment that takes all relevant factors into consideration is crucial to making informed decisions about repairing plastic pallet boxes and ensuring that the company chooses the most cost-effective solution in the long term.

4. Work Steps

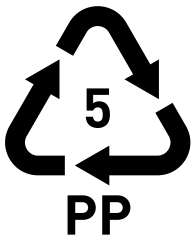
Determination of Plastics

Identifying the material of the container to be repaired is of crucial importance, as only thermoplastics and plastics that become malleable under the influence of temperature can be welded. In addition, it is generally only possible to thermally bond plastics of the same type. Thermoplastic substances can be recognized by special symbols and markings embedded in the injection molds. These symbols provide information about the material and its properties, such as thermal resistance or recyclability. Manufacturers also specify the material type in their technical documentation.

High-Density Polyethylene



Polypropylene



Polyethylene (LDPE/HDPE)

Polyethylene is the most commonly used plastic in the world. It constitutes around a third of all plastics produced and half of all plastic packaging. LDPE (Low-Density Polyethylene) is often used in the production of familiar plastic bottles, bags and other packaging materials. LDPE is characterized by its toughness, flexibility and mechanical strength, making it suitable for a wide range of industrial and consumer applications. HDPE (High-Density Polyethylene) is often used in the chemicals industry for drip pans, in swimming pools, for water and storage tanks, for chopping boards and in the food industry.

Polypropylene (PP)

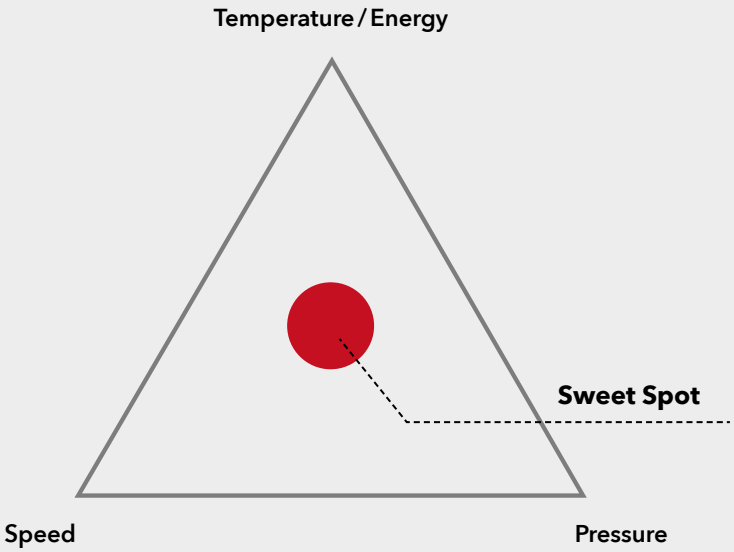
Polypropylene is stiffer, harder and generally more robust than polyethylene and so is often used in the furniture and automotive industries. It can withstand temperatures of up to +140 °C for short periods, but is relatively sensitive at temperatures below freezing. Polypropylene is generally more expensive than polyethylene.

Color

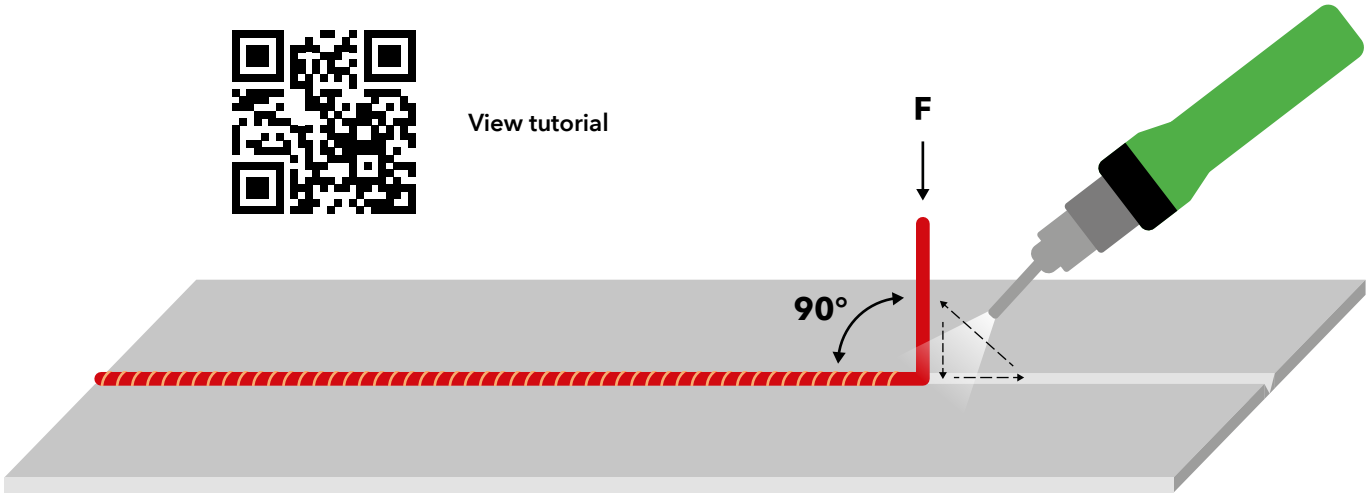
The color of an object says nothing about the type of plastic, as they can be dyed in any color. This facilitates the production of welding consumables or repair materials in any desired color. This ensures aesthetically perfect repairs.

Choice of welding method

All three welding parameters must be correct for plastic welding: Temperature/energy, pressure and speed. In contrast to other joining processes, welding achieves high strength through a strong, homogeneous weld seam. Plastic compounds are very robust and perfectly sealed when processed correctly.



View tutorial



Hot Air Hand Welding

Hot Air Hand Welding is used primarily for areas that are difficult to access and for short seams. This welding process is preferred for processing amorphous plastics, in particular PVC. Particular attention must be paid to uniform pressure and constant speed when welding by hand.

1. During the welding process, press the welding rod vertically onto the seam. The force required depends on the selected base material and the size of the welding rod.
2. The heat escaping from the tubular nozzle should be applied alternate to the welding rod and joint in an oscillating motion in the direction of welding until the seam end is reached.

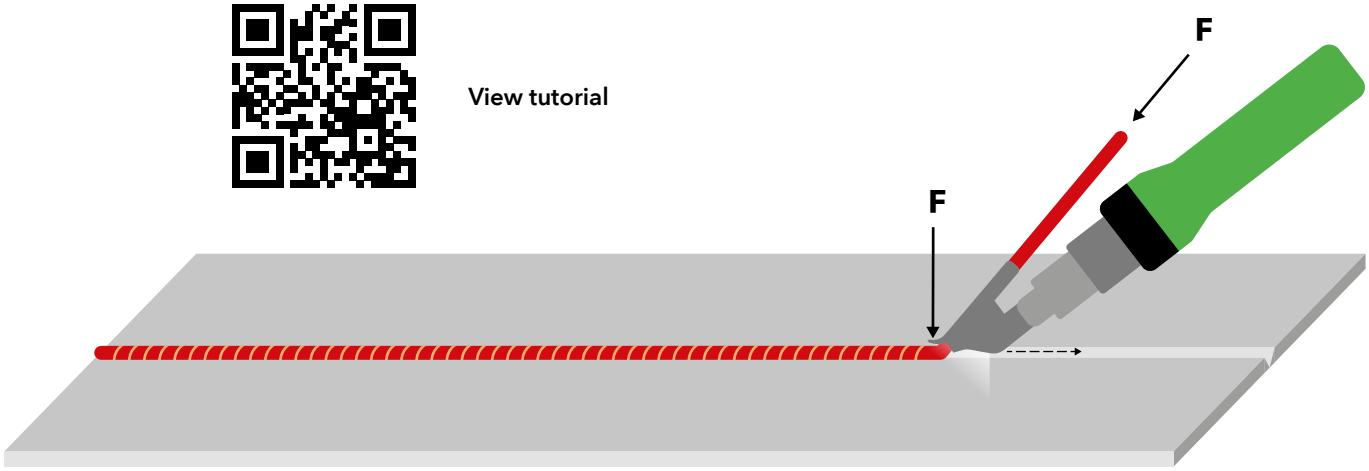
When achieved correctly with the right temperature and appropriate pressure, a welding seam is formed on both sides of the weld bead in the form of a uniform double bead.

Advantages: Low investment costs, suitable for smaller repair areas, especially for very thin-walled materials, occasional use.

Challenges: The welding method requires manual skills and it is difficult to achieve high-quality repairs. The welding process is also slow.

Material	Hot air temperature	Hot air volume flow	Welding speed	Welding force (N) with wire ø	
	°C	l/min	mm/min	3 mm	4 mm
Polyethylene HDPE	300 … 320	40 … 60	70 … 100	8 … 10	20 … 25
Polypropylene PP	305 … 315	40 … 60	60 … 100	8 … 10	20 … 25

View tutorial



Hot Air Speed Welding

Hot air welding requires a speed welding nozzle that matches the shape of the filler material. The process is faster, more uniform, and thus more efficient than free hand welding. In addition, larger cross-sectional areas of the welding rod can be processed in a single operation. This results in less residual stress and less welding work.

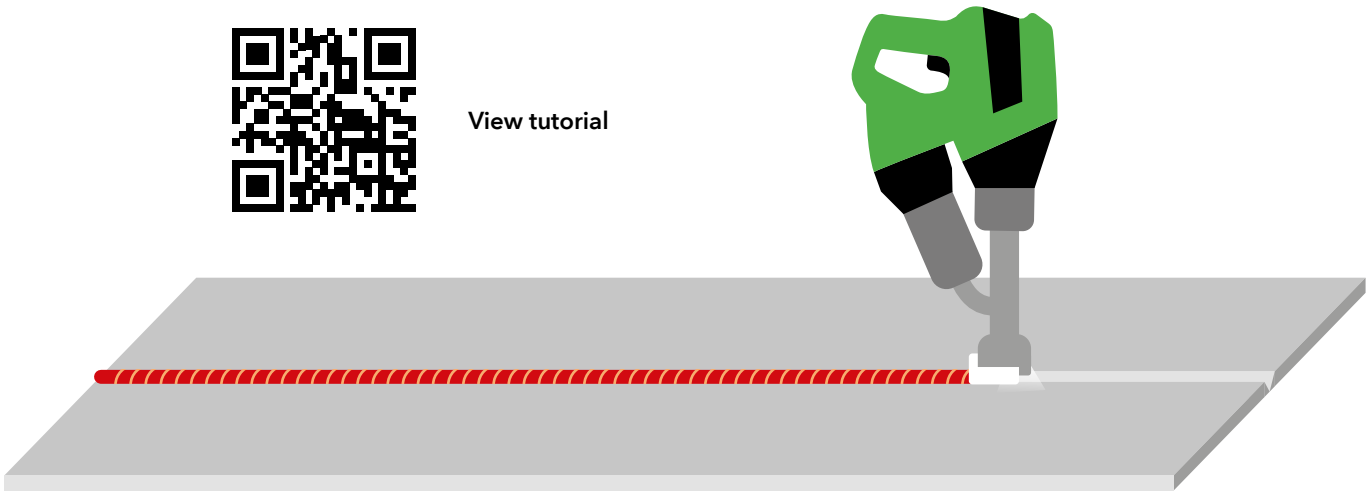
1. Hold the welding tool with one hand and press the welding rod into the nozzle with the other hand. The nozzle shape divides the hot air, which thus melts both the base material and the filler material. The latter is led through a preheating chamber and plasticized shortly before the two materials meet. The tip at the end of the nozzle is responsible for the welding force.
2. If necessary, rework the resulting weld seam after the welding process with an appropriate scraper.

Advantages: Low investment costs and ideal for small repair areas and thin-walled materials. This welding method also offers easy and ergonomic use.

This welding method is only recommended for minor repairs.

Material	Hot air temperature	Hot air volume flow	Welding speed	Welding force (N) with wire ø	
	°C	l/min	mm/min	3 mm	4 mm
Polyethylene HDPE	300 … 320	40 … 60	250 … 350	15 … 20	25 … 35
Polypropylene PP	300 … 340	40 … 60	250 … 350	15 … 20	25 … 35

View tutorial



Hot Air Extrusion Welding

Hot Air Extrusion Welding is preferred over hot air hand and draw welding for wall thicknesses from around 6 mm. Compared to manual welding, extrusion welding is expected to result in shorter working times, higher mechanical strength and lower residual stress. This leads to greater process safety and efficiency. This requires a welding shoe that matches the welding geometry and a filler material made of the same plastic as the base material, plasticized in the extruder.

1. First, the joining surfaces are heated with hot air to a thermoplastic state.
2. The extrudate is then immediately applied to the surface or into the joint using the welding shoe. Different pressure is required depending on the working position.

The welding speed is determined by the amount of extradent as well as the dimensions of the weld seam.

Advantages: Particularly suited to larger repair areas and professional applications. The welding method is efficient and covers a wide range of material thicknesses.

Challenges: This welding method requires greater investment costs and is less suitable for very thin-walled materials.

Material	Material temperature	Hot air temperature	Hot air volume flow[1]	Welding speed
	°C	°C	l/min	mm/min
Polyethylene HDPE	210 … 230	250 … 300	150…400	250...300
Polypropylene PP	210 … 240	250 … 300	150…400	250...300

[1] Repair welding: Choose volume flow in the lower range due to plastic flow behavior

Weld Seam Preparation

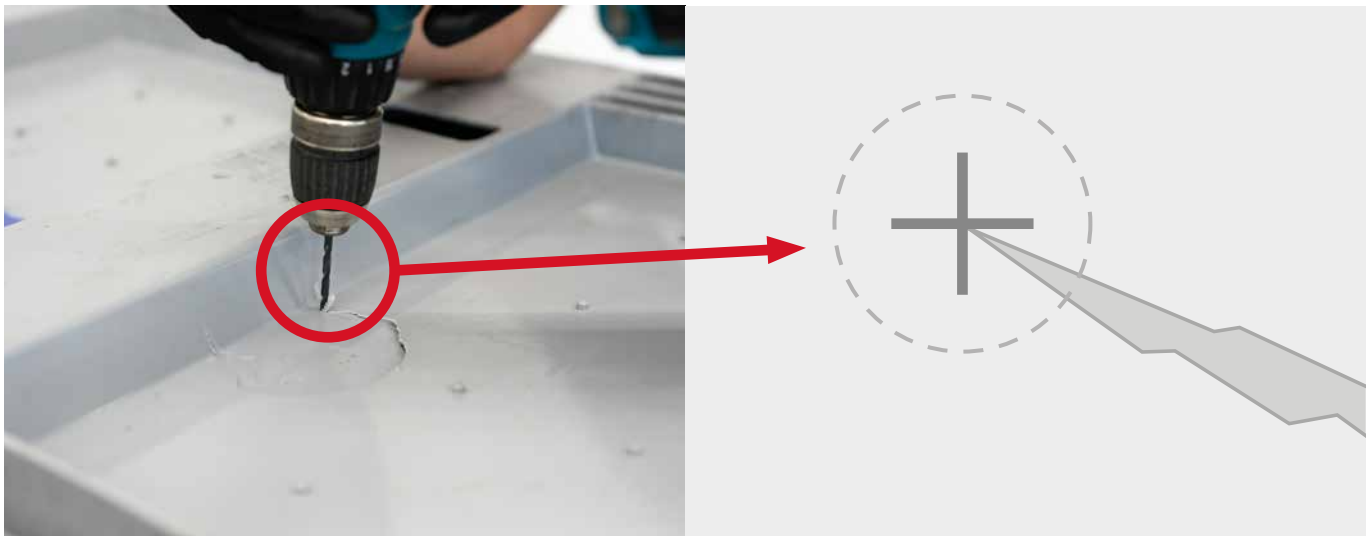
Before starting the actual repair work, the plastic container must be prepared accordingly. Inadequate preparation can make a subsequent repair impossible or negatively impact its effectiveness.

Cleaning

The containers or areas to be repaired must be cleaned with a suitable cleaning agent and water. Chemicals should be avoided as far as possible, as they can attack the plastic.

Drilling

To prevent the cracks from spreading further, holes are drilled at the crack ends. It must be ensured that the center of the hole is aligned exactly centrally to the crack end. It is recommended to use a twist drill with a diameter of 3 to 4 mm.



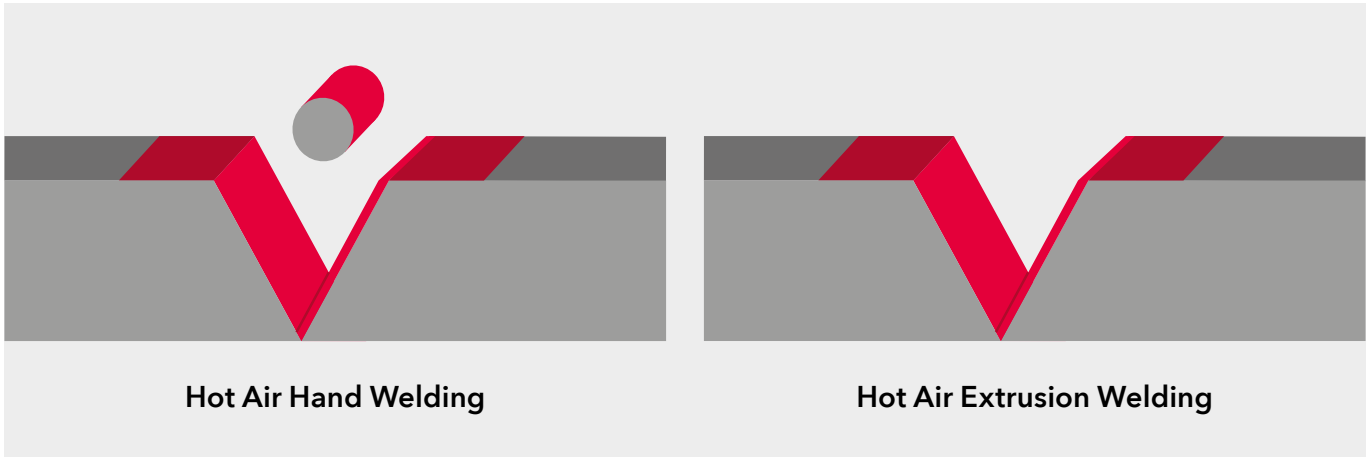
Seam and joint surface preparation

The inner surface of the crack is firstly worked with a standard scraper and the joining angle is opened to around 60 °C. This enlarges the joining surface and removes dirt from the crack.

The seam overlap area is also processed with a scraper or angle grinder and a coarse grinding wheel.

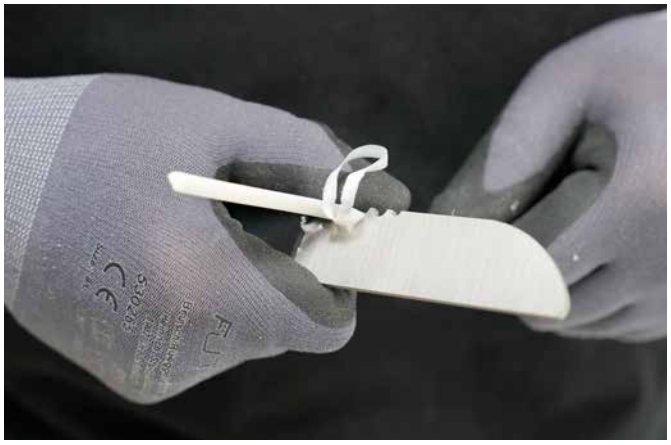
It is strongly recommended that grinding work is carried out in an area separate from the welding area.

Plastic abrasive particles can cause damage to electrical equipment due to melting if they penetrate ventilation slots. If possible, machining is preferable to grinding.



Hot Air Hand Welding

Hot Air Extrusion Welding



If the repair is welded by hand, the corresponding welding rods must also be scraped. The oxide layer could have a negative impact on quality. Specific scrapers must be used for efficient processing.

Fixing the Components

Tools

To ensure that the crack surfaces can be positioned as required and do not move during the welding process, it is recommended to fix them using a tensioning strap or a screw clamp. With the help of a hammer, surfaces that do not meet evenly can be made into a flat shape. As the volume of work increases, it is recommended to use professional clamping and working devices.



Tack welding

Using a tacking nozzle or combination nozzle (swing-away tacking tip), the opposing parts are joined together without additional material. The material is melted and pressed together. This creates an initial connection that holds the torn sections in position for final welding.



Welding

Welding is performed by hand with a high-speed welding nozzle or an extruder.





Transitions

Transitions, ends and inside corners of extrusion seams can be pressed upon with a pressure tool while still warm.



Weld Seam Finishing

The protruding welding rod or welding bead can, but does not have to, be removed. This depends on the environment, the visual requirements or the further processing. This work step can be carried out manually, with a scraper, with a quarter moon knife or using an angle grinder.

It is recommended that sanding work is carried out in a confined area. The plastic sanding dust should not accumulate in the immediate vicinity of welding equipment. The particles can damage heating and welding equipment.

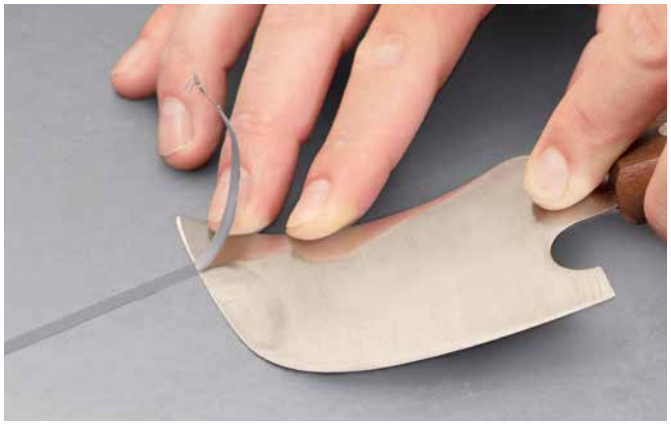




Fig. 2: Angle grinder example photo
iStockphoto.com, 2020

5. Conclusion

Efficient transportation and storage solutions are crucial for the logistics industry, and plastic pallet boxes play an important role here. These containers are indispensable in many industries as they facilitate safe storage and effective transportation. They offer benefits such as durability, hygiene and adaptability compared to wooden and metal pallet boxes. They are also lighter and less susceptible to damage. Repairs, especially by welding, can significantly extend the service life of these containers and reduce costs. The decision on whether a repair or a new purchase makes more sense depends on various factors, including the extent of the damage, costs and service life. In-depth testing shows that plastic pallet boxes can be kept in the cycle for longer by repairing them. Sustainability and environmental advantages make plastic pallet boxes an eco-friendly choice. A careful assessment of all aspects is required to find the best solution for companies.

The knowledge of processes gained in the repair of plastic containers can also be transferred to other industries and their associated logistics products, such as the repair of pallets, waste containers, water sports equipment, car bumpers, filter plates and other large plastic objects.

Sources

Text Sources

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Image Sources

Figure 1	Discord, Midjourney, 2024
Figure 2	iStockphoto.com, 2020

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