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MATERIAL AND INFORMATION FLOWS PERTAINING TO ALUMINUM ALLOY PIPE DISTRIBUTION

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This paper discusses the distribution flow of aluminum (Al) alloy pipes, starting with the completion of the manufacturing process and final inspection. The proposed solution considers the use of bar-coded caps produced from recycled polymer materials that are placed on the ends of the tubes in order to achieve protection against potential changes in material properties and preserve the product quality. For the preparation of capped tube bundles for shipment from the manufacturer output storage to the customer input warehouse, a technical solution that enables correct and efficient Al alloy pipe handling is proposed, in terms of safety, security, reliability, financial feasibility and ecological viability, with optimal utilization of transport and storage.

Key words: Al alloys, pipe, production, polymer, material flows

INTRODUCTION

Aluminum (Al) is the most abundant metal on Earth. In relation to the other chemical elements, in terms of its quantity, it is preceded only by oxygen and silicon. It is bright and silvery lightweight metal, about three times heavier than water and lighter than Fe or Cu by the similar amount. When pure, crystalline Al is brittle and fragile. Penoaluminum, the material obtained from Al through a special process, is very sturdy and is five times lighter than water.

Areas of Al alloy utilization include a variety of very important industries, such as construction, engineering – transportation equipment (ranging from engine parts, chassis construction, automobiles and trucks, wagons, and ships, to rockets, satellites and space stations).

According to historical records, the famous Pythagoras was the first appointed logistician, whereby the concept of logistics gained recognition in 500 BC, almost 2 200 years later than its actual etymology. For an explanation of the theory that Pythagoras was the first appointed logistician, it is necessary to go even further back in history, 3 000 years BC, to the beginning of the Bronze Age [1].

The expansion of the market demand for Al alloy pipes has been evident in the recent years. Therefore, this paper focuses on the characteristics and implementation of Al alloys, as they are an integral part of many consumer products (profile pipes, various extruded profiles, and sheets), either as semi-products (raw materials) or finished products (goods). We analyzed the group of the characteristic alloys based on Mg, Al, Si, Cu and Zn, as alloying with these elements gives Al good mechanical properties, such as density, hardness, and strength.

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CHARACTERISTICS OF Al ALLOYS

By JUS (manufacturing standard of Former Yugoslavia), aluminum alloys are designated alphanumeric symbols that form the primary label and are followed by numeric symbols.

Al alloys are characterized by a wide range of different mechanical properties.

Table 1 presents some typical and most commonly used Al alloys, with their mechanical properties (strength and hardness) [2].

Table 1 **Al alloys with corresponding mechanical properties (strength and hardness) [2]**

Designation alloys		Mechanical properties	
JUS	ASTM	Strength / N/mm^2	Hardness / HB
AlMgSi0,5	6 063	200	70 ÷ 80
AlMgSi1	6 082	260	80 ÷ 100
AlMgSiCu	6 061	240	80 ÷ 105
AlMgSiCu	6 066	310	120 ÷ 140
AlCu4Mg1	2 024	270	120 ÷ 140
AlZnMg3Cu1,5	7 049	500	160 ÷ 170

Depending on the alloy, the pipes delivered to the customer have typical dimensions: the outer diameter Ø 10 ÷ 80 mm and a wall thickness of 1 ÷ 20 mm. These pipes are produced through the process known as pressing mandrel (penetrative pressing).

PRODUCTION AND CONTROL

Pressing and pulling are the two key procedures used in the manufacturing of aluminum alloy pipes. The passage of the Al alloy tube through the matrix caliber production and the completion of the production of the same, and its final cutting (dimensioning) to the standard length (6 meters), is followed by the technical control phase.

Technical control includes the following activities:

- the quality of processing external and internal surfaces,
- control of the final cutting – verification of the length,
- control of internal and external diameters,
- control of wall thickness and
- taking control sample to determine the chemical composition and mechanical properties (impact resistance, resilience, strength and hardness).

Once the above processes are completed, capping – closing the pipe ends using the automated system – can commence.

PLUGGING

In this section, we discuss the operations pertaining to manufacture and application of bar-coded plugs/caps on the ends of the completed pipes (Figure 1).

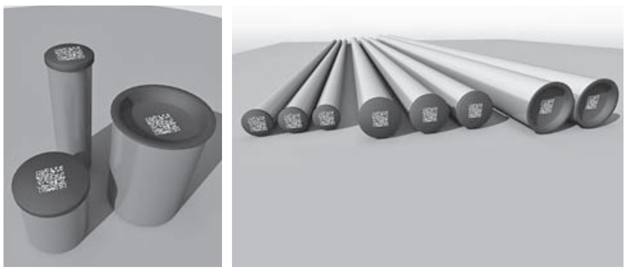

Figure 1 Plugged pipes with bar-cod

The caps are made of polymeric material comprising two components:

- regranulated recyclable materials, i.e. waste plastics (50 ÷ 80 %) and
- pure resin 20 ÷ 50 %.

Regranulate is obtained by collecting plastic recyclables and their fragmentation into small granules, which facilitates their usage in processing and mixing with pure granulate. By adding the appropriate color (masterbach) to the main raw material, caps of different colors can be obtained:

- red, indicates a tube with a thinner wall and greater diameter,
- blue, indicates a tube with a wall of medium thickness and a medium diameter and,
- green, indicates a tube with a thicker wall and a small diameter.

Pipe capping is necessary for several reasons, such as:

- protection of pipe ends from mechanical damage during handling activities,
- protection of pipe cavity from dirt and impurities,
- preventing water from entering the pipe, especially during the winter, when water would freeze and form ice caps that can cause the pipes to crack and
- easier and safer pipe handling.

The caps should be of T or U shape, whereby the functional bar-coded version of the same is schematically shown in Figure 2.

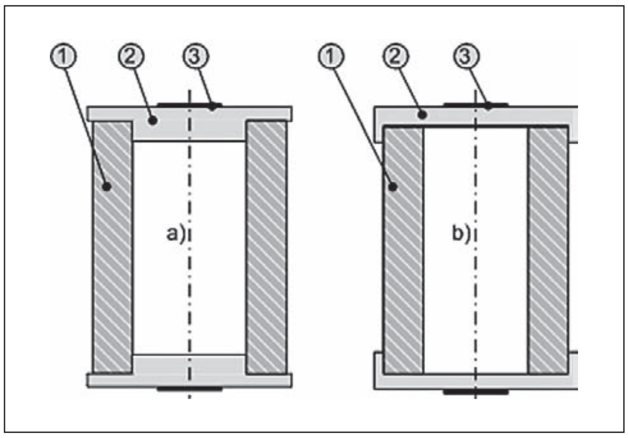

Figure 2 Schematic cap representation: (a) T and (b) U, 1 - pipe , 2 - plug/cap and 3 – barcode

The proposed cap form would contain the following information elements: product name, manufacturer's name, date of manufacture, place of manufacture, controller code, material chemical composition and type, product dimensions (pipe length, wall thickness and the inner diameter), unit weight, surface treatment quality, and number of units produced per year. The carrier of the aforementioned information elements would be a two-dimensional bar code applied to its outer surface.

MATERIAL LOGISTICS WORKFLOW

The product material flow includes the initiation of activities – the origin, activities within the flow – packaging and transportation, and the completion processes – the destination.

The origin includes simultaneous capping of both pipe ends. Transport pertains to the product movement from the origin to the destination. Destination activities include the delivery, receipt and the certificate of the product acceptance.

Within the packaging process, the following activities are of performed:

- plugging the unit product (pipe) and
- grouping the unit products into a transportation unit package (e.g. 50 pieces 6-meter long pipes of ø 50 mm).

Figure 3 shows the pipe distribution flow from production to delivery to the customer.

The bundles of 50 pipe pieces are secured with PVC strips using hand-held tying device. Protection against mechanical damage is achieved by covering the bundles with plastic film, stretch film or other protective material (polymer or textile fabric).

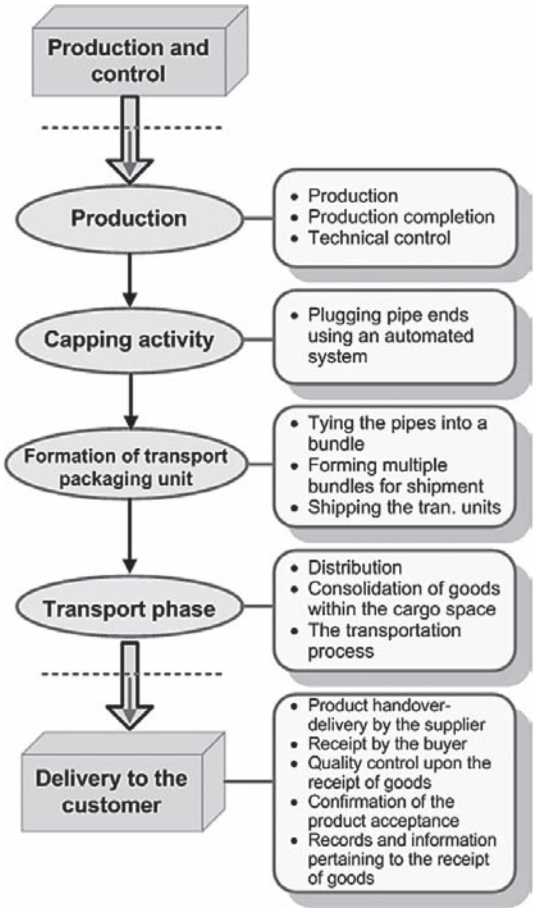

Figure 3 Pipe distribution flow schematic, from production to delivery to the customer

Loading of the goods is accomplished with articulated transportation equipment. During transport, the goods are secured in the transport vehicle cargo space in order to prevent potential shifting (rolling) during sudden change in the vehicle position (movement, increase and decrease in the speed and braking).

The pipe bundles are shipped to the customer using a suitable transport mode. At the destination, the delivery to the customer is made, and the confirmation of the receipt of goods is produced.

INFORMATION LOGISTICS WORKFLOW

Bar-code symbologies and systems belong to the category of hardware-software implementation of IT and IS in modern logistic flows. The potential contribution of IT can be conveyed in different ways [3-4]. Correspo-nding to the above-mentioned four roles, the contributions worth noting here are [5]:

- elimination of repetitive manual information processing,
- fast processing of large amount of data,
- fast calculation of complex algorithmic information and
- fast communication of data in contributed information networks.

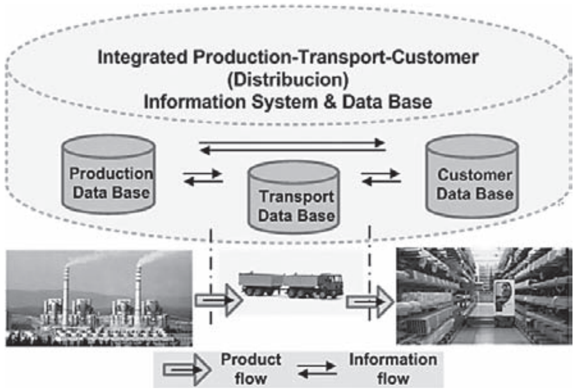

Figure 4 Information and production flows in integrated environment

The major issues that need to be addressed when attempting to enhance the role of information system in distribution integration are discussed in Figure 4 [5].

Information flows pertaining to the distribution of capped pipes can be summarized as follows:

1. Collecting the electronic information and preparing documentation (completion of production, technical control),
2. Applying the bar code information to the placed caps (product, control, and manufacturer information),
3. Collecting the electronic information and preparing documentation pertaining to the identification of: individual pipes within the bundle, contents of the bundles formed for delivery, transport packaging, transport unit, loading, and shipping the transport unit,
4. Transport phase (identification of transport units at the output) and
5. Collecting the electronic information and preparing documentation at the destination (identification of transport units at the delivery point, receipt of goods, quality control upon receipt of goods, confirmation of the product acceptance, information and documentation confirming the receipt of the goods to the manufacturer).

Some of these items are discussed in [7-10].

PROPOSED SYSTEM EFFECTS

The proposed solution for the Al alloy pipe distribution material and information logistic flows realizes several significant benefits:

- The installation of caps separates the unit products within the bundle, thus reducing the risk of product unit damage.
- Shortening the time required for completing logistics activities from the origin to the destination.
- Potential for binding, packaging and loading the products in an open area (e.g., in an open warehouse without roof).

- Continuous monitoring, tracking and tracing of the merchandise (product visibility and process transparency).
- Reducing the risk of mechanical damage during packaging (pipe bundling) and loading onto a transport vehicle, as well as during transport until delivery to the customer.
- The potential for disposal and storage of goods in an open area (such as open warehouse without roof).

All of the above distribution effects of the Al alloy pipe material and information flow confirm that the proposed solution is the optimal, effective and efficient way towards achieving global parameters necessary for the feasibility of the proposed solution in terms of safety, security, reliability, efficiency and ecological viability with optimal utilization of transport and storage.

CONCLUSIONS

Through the Al alloy pipe distribution material and information flow assessment and analysis given above – from the end of the production process and the final inspection and packing, through to shipping, transportation and delivery to the customer – we have demonstrated that significant results can be achieved, as is reflected in the following:

Installation of caps physically separates individual product units,

Shortening the time required for the completion of the logistics activities

The potential for binding, packaging, storage, disposal and loading of the products in an open area,

Continuous monitoring, tracking and tracing of goods,

Reducing the risk of mechanical damage during packing, loading, transport and unloading,

Timely availability of the required information pertaining to the time and the movement of goods in the logistics chain,

Elimination of manual information processing, and

Fast processing and communication of large amounts of data.

The proposed solution, the concept of Al alloy pipe distribution material and information flow, opens up new possibilities of modern technological solutions coupled with modern information technologies. Its implementation can yield substantial benefits in the handling of goods in the logistics chain, characterized as the most important elements of modern business, namely safety, reliability, economy, and ecological viability with optimal utilization of transport and storage.

Future work will focus on improvement of information logistics workflow between transport phase (item 4) and collection of the electronic information and preparation of the documentation (item 5). In future research we will use all database, information system and information technology features together with space-based satellite navigation, global positioning system (GPS), to provide real-time monitoring, tracking and tracing of goods.

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Note: The responsible translator for English language is N. Kozul, Novi Sad, Serbia