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THE APPLICATION OF RECYCLED ALUMINUM AND PLASTICS IN ENVIRONMENTAL PROTECTION

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Environmental protection is a serious problem facing the modern world. Precisely for this reason, in this work, the authors explore its different aspects. From the perspective of conservation of natural resources and energy savings, the replacement of primary materials through recycling is explored as a potential solution in the elementary processes related to the parasol production. Such parasols would be used in designing "urban forest" solutions, which significantly contribute to the protection of the planet from global warming, as well as the preservation of life and survival.

Key words: recycled aluminum, ecology, plastic, anodizing, reverse logistics

INTRODUCTION

Given the increasingly alarming global warming and rising temperature of the Earth's surface, which is gradually reaching a critical point, thus negatively affecting flora and fauna as well as endangering the survival of human life on it, it is necessary to focus all the knowledge, time and resources to protect it. One of the aspects of that preservation effort is the replacement of natural, non-renewable or hard to replace resources and raw materials in the production of goods necessary for conducting everyday life, with environmentally friendly materials that can be recycled.

Due to the global warming, creating an artificial shade is increasingly recognized as a necessity, especially in urban areas, where surfaces are typically covered with asphalt, concrete and other materials that absorb heat, while green spaces, parks, and natural shelters from the sun are scarce [1].

It is also necessary to solve the problem of ever-increasing areas designated as wastelands for raw materials (mostly for paper, plastic, metal, glass, etc.) that can be reused the manufacturing and production processes. In order to achieve better results in solving such complex tasks, it is essential to acquire experience in this field, which implies sound knowledge and application of logistics – reverse logistics, as the only way to connect all the segments in this global process.

Logistics dates back to 500 BC and is still of great importance in solving issues arising in various processes, especially those of more complex nature. The importance of logistics and, within it, reverse logistics, only gained recognition in the 1960s, when it was first implemented in the processes related to economic activity [2].

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URBAN FORESTS

One of the potential partial solutions to the aforementioned problems can be achieved through a design concept known as "urban forest" that can be implemented using recycled materials.

"Urban forests" are envisaged as landscaped complexes under parasols (Figure 1), which would consist of the following elements: a supporting columnar structure and a top covering. The supporting pillar and all the structures would be produced from recycled aluminium (Al) due to its superior its mechanical properties (strength and durability), whereas the fabric of the top cover would be made from recycled plastic [3].

The main advantage of Al as a material stems from its mechanical properties. Its strength and lightness, a wide selection of colors that can be achieved through anodic treatment process (anodizing), anti-corrosion properties, good connective ability, pliability and easy shaping through well-known processes, appealing aesthetics, easy and inexpensive maintenance, and durability make it highly utilized material in many industries.

One of the important Al characteristics is its surface protection method, in terms of which, the profiles can be classified as anodized or powder-covered.

Figure 1 Schematic representation of an „urban forest" with parasol elements (the supporting pillar and the top covering)

ALUMINIUM PROTECTION PROCESSES

Anodizing

Anodizing is the anodic oxidation, i.e. electrochemical process by which the surface of the Al profile is covered by a controlled layer of Al oxide. This coating is applied at a thickness of 12 ÷ 30 μm. The most optimal anodization thickness ranges from 15 ÷ 18 μm, as it provides a good balance in terms of wear resistance and durability of the coating as prevention against cracking during bending, as well as due to temperature extremes (winter, summer). Thicker protective coating provides better wear protection, but can easily crack when the profile is bent repeatedly, as thicker layer is more brittle. The color in which anodizing can be performed ranges from natural Al color, through various shades of bronze, to black. Anodizing in blue, red and green is also possible, depending on market demand. Figure 2 gives a schematic representation of a) conventional and b) electrochemical anodization dyeing process.

Materials that can be used in this process are 99,5 % Al as well as alloys of the so-called “eloxal” quality: AlMgSi 0,5, AlMg1, and AlMg3. The chemical composition of these alloys is shown in Table 1 [4].

Table 1 **Chemical composition of Al and the alloys of “eloxal” quality [4]**

Chemical composition	Material types			
	Al 99,5	AlMgSi 0,5	AlMg1	AlMg3
Si	0,25	0,3 ÷ 0,6	0,30	0,40
Fe	0,40	0,1 ÷ 0,3	0,45	0,40
Cu	0,05	0,10	0,05	0,10
Mn	0,05	0,10	0,15	0,50
Mg	-	0,35 ÷ 0,60	0,7 ÷ 1,1	2,6 ÷ 3,6
Cr	-	0,05	0,10	0,30
Zn	0,07	0,15	0,20	0,20
Ti	0,05	0,10	-	0,15
Other components	-	-	-	Mn + Cr 0,1 ÷ 0,6

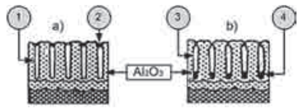

Figure 2 Anodization Al: a) classical and b) electrochemical process, 1 and 3 – oxide pore and 2 and 4 – pigment location [4]

The main characteristics of the semi-products dyed by applying this process are:

– retention of the metallic appearance of the Al surface,
– maximum durability and resistance against corrosion, light and atmospheric elements and
– high resistance to abrasion, as the dye is located deep within the micropores of oxide protective coating cells, which is not the case with conventional staining obtained by chemical dyeing process.

Through the special graphic processing of anodically oxidized and dyed Al, a semi-product is obtained, which is characterized by high decorativeness and anticorrosive resistance. Given the high aesthetic appeal and good durability, the surface treated in this manner is designed as a decorative element for interior and exterior applications. Figure 3 presents the decoratively embossed surfaces: a), b), c) – rough and d), e), f) – fine [4].

Powder coating

Powder coating is the electrostatic pulverization is still the most widely used form of protective surface treatment of architectural aluminum. First, the Al surface is cleaned by immersion in sodium hydroxide, after which chrome oxide, i.e. primer, is applied.

Next, special diffusers are used to apply strong positively charged dye powder. As the coated profiles are oppositely charged, firm adhesion of the powder to the Al surface occurs.

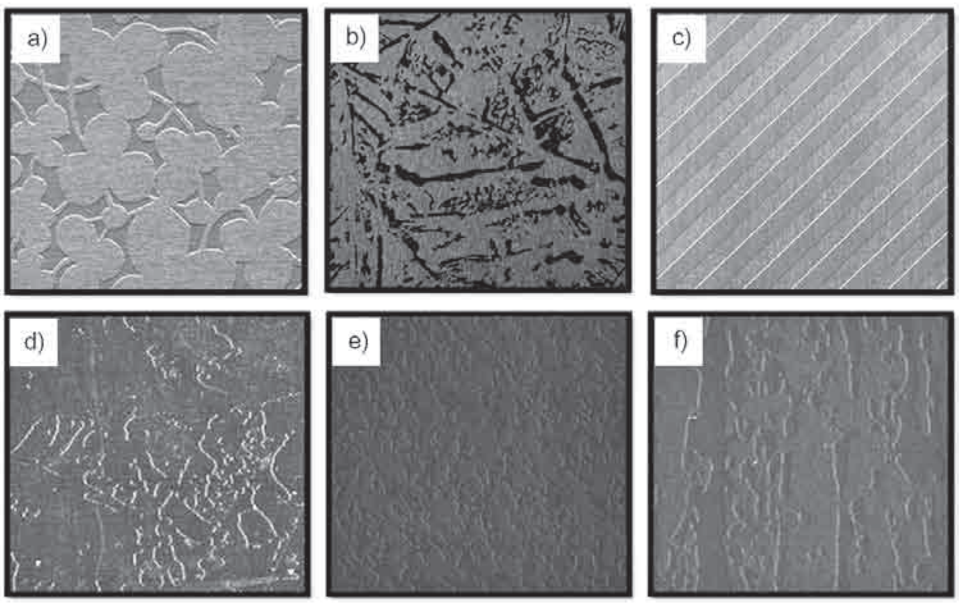

Figure 3 Decoratively embossed surfaces: a), b), c) – rough and d), e), f) – fine [4]

Thus prepared pieces are then placed into the oven heated to 180 ÷ 200 °C. As a result, powder (dye) molecules melt, forming plastic coating of 50 ÷ 70 µm thickness.

If the profile is intended for use in external construction elements, polyester-based dyes are used, as these are more resistant to ultraviolet rays. For profiles intended for internal use, epoxy-based dyes are more appropriate. When dyeing Al profiles by powder coating, any color from the RAL palette can be used.

RECYCLED ALUMINUM AND PLASTIC

Aluminium is one of the most widely used metals globally (Figure 4) and, currently, one-third of this material comes from recycling [5].

Areas of Al application with utilization forecasts until 2020 year are shown in Figure 5 [6].

Manufacturing new products from recycled Al requires less energy and emits only 5 % of CO_2 emissions, compared to the production of primary Al. Aluminium production from its ore bauxite is highly energy inefficient, in contrast, recycling Al does not require bauxite [7].

Recycled Al allows substantial savings in terms of the energy required to produce it, as up to 95 % savings are attainable. Unlike paper, plastic and many other materials, Al can be recycled without loss of its characteristics, whereby the recycled and primary Al are indistinguishable [8].

The fact that recycling does not change the Al properties indicates that new Al products can be made from 100 % recycled materials. This enables the creation of a closed chain, in which used products are continually and repeatedly recycled into new ones, where Al is one of the few materials for which that option is available.

Al recycling, in addition to high cost-effectiveness, is important for the environment due to the reduction of greenhouse gas emissions and energy savings that can be achieved during production. Given the above facts, the economic, energy and environmental feasibility of the use Al as the base material for building “urban forests” is highly justified.

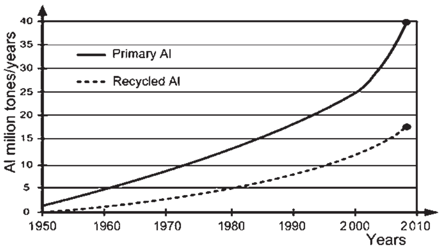

Figure 4 Worldwide Evolution of Recycled and Primary Aluminium [5]

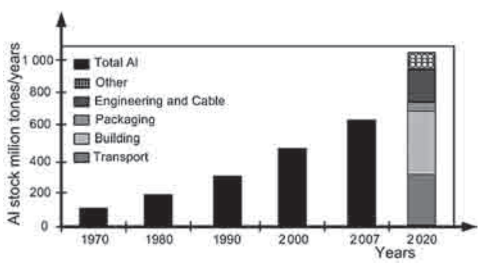

Figure 5 Build-up of Aluminium Use by 2020 [6]

For the production of the parasol top cover, as its other component, recycled plastics should be used. Each type of plastic, irrespective of its characteristics, is produced from petroleum, natural gas, or coal. Plastic bottles (PET) are the most common and most widely used plastic packaging. Although it takes about 500 years for plastics to degrade naturally, they comprise 11 % of all waste deposited on the landfills, and it is estimated that as many as 7 ÷ 8 % of world fossil fuel reserves is spent in the production of plastics.

Plastics manufacturing worldwide has experienced continuous growth over the past 60-odd years. If 1949 is taken as a baseline year, when about 1 million tons of plastics were produced, sustained growth rate of about 9 % is obtained (Figure 6). Globally, in 2008, over 267 million tons of polymers were produced, of which about 245 million tons of plastic and more than 22 million tons of natural and synthetic rubber [9].

By recycling plastic, raw materials for new products are obtained, which helps save electricity, reduces the consumption of fossil fuels and, most importantly, protects the environment.

In addition to the technological developments and the increasing number of new products in the market, it is necessary to adopt a concept that would ensure that only recycled materials are utilized in their production. Industry needs to focus on promoting and raising public awareness of importance of recycling and correct processing of waste materials. Environmental protection is one of the most important and the most common topics of concern for the modern society. The efforts being undertaken for permanent integration of logistics activities in the concept of environmental protection should also be considered in that context [10].

Developing the logistics of sustainable development as a set of logistics activities ensures synergy between the realization of economic and environmental goals, in line with increasingly strict environmental regulations and laws aimed at consumer protection.

Given the increasingly stringent conditions of resource utilization, environmental protection, etc., innovations in the products manufactured from recycled aluminum and plastic have an important social dimension. In

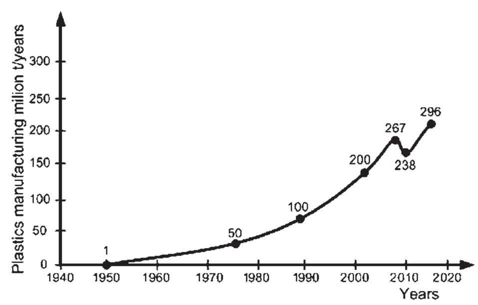

Figure 6 Historical timeline of the polymer production [9]

the present context, the latter is of particular significance, owing to the efforts to ensure healthy competition and purposeful use of limited financial resources.

CONCLUSIONS

Based on the presented analysis and the empirically identified issues pertaining to environmental protection, it is necessary and justified to take concrete actions in order to realize parasol production from recycled plastic materials and Aluminium.

In addition to important economic and energy consumption feasibility, by using recycled materials, in this case, the full effect of protecting the forest reserves is achieved and the problems of landfill expansion permanently solved, which is a major step forward in protecting the environment, as an urgent and current issue facing the modern world.

Therefore, the proposed solution, i.e. the design concept of “urban forests”, is a synergy of several different areas, the use of which has the potential to achieve significant energy and financial savings, based on well-known economic performance criteria.

Thus, through substitution of primary materials with their recycled alternatives (aluminum and plastic), we can create long-term solutions that help reduce the exploitation of scarce natural resources, with the goal of preserving and protecting the global environment.

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