

Potential role of aluminum in indoor furniture

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ABSTRACT (Arial bold 10)

The aluminum industry has, especially after world war two, actively promoted the use of aluminum towards industrial designers with the goal of finding new outlets for raw aluminum. This also includes the furniture industry but has resulted in moderate success. One reason is that present aluminum furniture design does not give sufficient value and meaning to the consumer. Aluminum is a promising material in the indoor furniture market due to its physical qualities such as malleability, durability and high strength to weight ratio. It is also a sustainable material as it can be recycled indefinitely and with a 95 % lower energy consumption than the production of new aluminum. Considering that the consumer market today is largely driven by desire and not only by functional needs, aluminum furniture must embrace both the physical qualities of the material and create value and meaning for the consumers. A product is perceived as a whole through its function, materials and appearance, and this may be altered by varying colors, forms and combining materials. There is a need for exploring how aluminum successfully can be applied in furniture, as well as a need for greater knowledge exchange between the aluminum industry and designers. The aluminum industry, as a driver in promoting aluminum, should therefore provide knowledge about aluminum and inspire designers and manufacturers to explore the use of aluminum in furniture.

KEYWORDS: aluminum, product design, furniture, material selection, product perception

1. INTRODUCTION

Aluminum is one of the key engineering materials we have today. It is present almost everywhere; in our homes, in food packaging, cars, airplanes, phones, computers, and so on. The history of aluminum is fairly young, but it is one of few metals which have managed to become major in industrial use only 60 years after its discovery (Benvenuto, 2015). The production and demand for primary aluminum continues to increase, and in 2017 the production reached 60 million tons. The main applications areas are within construction (49.8 %) and transport engineering

(15.2 %), while consumer goods stand for 3.2 % of the global aluminum demand (Dudin et al., 2017).

The later years we have seen an increase in the use of aluminum in electronic devices and gadgets. Computers, TVs and cellphones are typical examples of equipment that have replaced steel and plastic with aluminum. Several companies, such as Apple and Bang & Olufsen, are opting for aluminum, especially within the electronic industry (Aluminiumleader, 2018). Aluminum serves as a great material for these

purposes, as it is strong, light and thermal conductive.

The same trend has not been seen in the interior furniture market. Interior design in aluminum is still mostly regarded as highly fashionable (Aluminiumleader, 2018). On the other hand, aluminum furniture for outdoor use is market leading, due to its anti-corrosion mechanism and light weight. But why is it not being used to a greater extent also in the indoor furniture market? This question is hard to answer from a scientific point of view, as little research has been done on the area and on the perception of metal aesthetics and furniture. One can speculate if the visual and tactile appeal of metal furniture comes to short compared to more traditional, warm and soft materials such as wood and upholstery, or if the design of today's metal furniture is perceived as too industrial and institutional for most people to want to embrace in a more domestic setting. Nevertheless, aluminum seems to be a good material for furniture, due to its flexibility in production and high strength to weight ratio. How can designers and manufacturers be inspired to make more use of aluminum in indoor furniture? And is it possible to design aluminum furniture with a greater appeal to the consumer than the aluminum furniture of the past?

As there seems to be a market of potential within indoor furniture in aluminum, this article will attempt to establish some fundamental guidelines for how the aluminum industry, designers and manufacturers could proceed in discovering applications for aluminum in indoor furniture. This will be done by examining the key properties of aluminum, previous history of promoting aluminum in both industry and furniture, and how consumers attribute meaning and value in products.

2. METHOD

This article is based on a literature review of articles and books found through searches on the university library of NTNU (Oria) and Google Scholar. Some information has also been found

on web sites. Relevant information and papers included general information about aluminum, history of aluminum, material selection theories, and marketing strategies.

3. WHY ALUMINUM?

In order to encourage the use of aluminum in indoor furniture, it is essential to know why it should be encouraged and if it is a suitable material. Simon Sinek (2009) states in his book *Start with why* that: "it doesn't matter what you do, it matters why you do it" (Sinek, 2009). Communicating your values, your beliefs and your cause is important in inspiring someone to follow your ideas and recommendations.

3.1 Background

Aluminum is the most abundant metal on earth, as it constitutes over 8 % of the earth's crust. However, the metal does not appear in nature in a pure state but has to be extracted from compounds. It was not until 1886 that scientist discovered an efficient way to extract aluminum, which enabled a range of new applications and markets. Originally, aluminum was not created with a specific application or market in mind, but it was rather an intellectual pursuit. When scientists finally succeeded in extracting aluminum into an accessible state, it was up to the entrepreneurs, manufacturers, designers, marketers and consumers to determine the role that aluminum would play in the society (Nichols et al., 2000). Today the search for new applications is still relevant as the material has many good qualities which make it an excellent choice in many fields.

3.2 Shaping qualities

All manufacturing processes used in steel fabrication can generally be applied to aluminum and are both cheaper and faster due to aluminum's softness and malleability (Müller, 2011). Aluminum can easily be cut, formed, rolled, joined and finished, and processed under pressure both as hot and as cold. It can also

easily be cast, and it is considered to be the material most suited for complex-sectioned extrusions. Aluminum is more exposed to fatigue than steel and weakens more quickly when temperature increase. However, due to its malleability and elasticity, aluminum can create shapes in which steel cannot. (Dwight, 1999)

3.3 Alloys

Pure aluminum is as mentioned fairly malleable and soft, which limits its uses. It has almost no other applications than electronic conductors and domestic products such as pans, cans and packaging. One can easily combine aluminum with small quantities of other metals, such as magnesium, copper, and silicon, in order to expand or change certain qualities without it losing its lightness, which in fact is one third of iron and steel (Nichols et al., 2000). Aluminum is generally weaker than steel, although the strongest aluminum alloys can compare to some steel alloys in strength.

3.3 Anti-corrosion and surface

Aluminum has its own anti-corrosion mechanism due to the hard microscopic oxide layer that forms on its surface when exposed to air. This quality can be enhanced by anodizing, which is an electrolytic process to increase the thickness of the oxide layer. One can also add a dye in this process to color the aluminum. However, this anti-corrosion mechanism makes the metal more difficult to solder and weld (Nichols et al., 2000).

In addition to anodizing, a range of other surface treatments can be applied to achieve desired appearance. One can also use surface treatments to enhance physical properties such as surface texture, hardness, abrasion resistance and reflectivity.

3.4 Sustainability

The electrolytic procedure of producing primary aluminum requires large amounts of water and electric energy. Hydroelectric dams have

disrupted ecosystems, the burning of fossil fuels results in large CO₂-emissions, and bauxite mining puts its marks on nature as it can pollute ground waters, damage forests and rupture ecosystems (Zimring, 2017).

Aluminum is easily and economically recyclable due to its low melting point (660 °C). Only 5 % of the energy required to produce virgin aluminum is needed for recycling. In comparison, the energy savings of recycling lead, steel and copper are 65 %, 74 % and 85 % compared to production of the virgin materials (Das & Yin, 2007). As many other nonferrous metals, aluminum can be recycled indefinitely, and aluminum scrap is recognized as a highly valued source for new aluminum production. One third of current aluminum produced globally originates from recycled scrap (International Aluminium Institute, 2009).

Industry leaders and environmentalist are increasingly recognizing that it is more energy efficient and economical to produce aluminum from recycled scrap aluminum (Nading, 2012). It reduces the environmental damage caused by primary aluminum production, it reduces the amount of scrap sent to landfills and it is far less energy demanding to produce which results in additional environmental and economic gains. Most aluminum products are in a sense not actually consumed during a lifetime, but rather used, which gives the life cycle of aluminum a renewable “cradle to cradle” sequence and not a “cradle to grave.” Sorting and pre-treating the scrap appropriately, according to different alloys, will also reduce down-cycling (recycling that leads to lower quality material) (International Aluminium Institute, 2009). Measures in developing a sustainable aluminum industry are to develop energy efficient and environmental friendly methods for producing primary aluminum, basing the production on renewable energy, and increasing the ambitions of recycling. One of the key objective of the International Aluminum Institute is to “Encourage and assist continuous progress in the healthy, safe and

environmentally sound production of aluminum” (International Aluminium Institute, 2018).

3.5 The why

Aluminum possesses some great properties in terms of formability, manufacturing methods, high strength to weight ratio, alloying for enhanced qualities, anti-corrosion mechanism, and versatility in surface finishes. Other qualities of aluminum are that it's a good electric and thermal conductor and that it is non-magnetic, non-toxic, and highly reflective.

Norsk Hydro considers aluminum to be the metal of the future with almost unlimited areas of applications. One argument for this, in addition to the economic interests of the company, is that there has been a rapid growth in aluminum applications. Aluminum also provides great benefits in comparison to other materials, such as in cars where it reduces the overall weight and consequently saves carbon emissions (Hydro, 2018).

It is worth mentioning that aluminum, despite its abundance, is rarer and more expensive than for instance steel (Dwight, 1999). However, because of easier handling, machining, cutting and so on, the fabrication costs are often lower. For products designed to have a limited life, the relatively high value of scrap aluminum also affects the cost picture.

4. HISTORY OF PROMOTING ALUMINUM

It is interesting to look back at the history of aluminum and the approaches taken in discovering new applications and new markets for the material. As mentioned earlier, aluminum was not originally created with a market in mind. The producers of primary aluminum often took the lead in finding new applications and markets and were the first manufacturers of new products. The book *Aluminum by design* by Nichols et al. (2000) examines the creative uses of aluminum over the years and demonstrates

the materials ability to successfully be utilized in a broad specter of design contexts. It shows how aluminum went from a precious metal, to a cheap raw material for low-end production applications, to a high-performance and mass manufactured material in the postwar growth of consumption and manufacturing.

Dennis Doordan (1993) has in the essay: *Promoting Aluminum: Designers and the American Aluminum Industry* reviewed the history of the American aluminum industry with focus on the postwar campaign to promote the use of aluminum. Here he discusses how “[...] design was a marginal activity within the industry before the war” but “[...] a crucial corporate concern after the war” (Doordan, 1993). The majority of efforts within the aluminum industry before world war two were within production of primary aluminum, as it represented most of the value of any finished aluminum products. However, this dramatically changed after the war. The primary aluminum's share of product value met an accelerated decline due to the increased production of new applications and end products. The war had also resulted in the need for large amounts of strong lightweight metals, which lead to an expansion of the industry's productive capacity. After the war it was important to develop new markets for aluminum to absorb the expanded productive capacity, otherwise jobs in the aluminum industry would be lost.

Designers where now employed by the aluminum industry, in design departments, to actively work with designers outside the industry to educate and encourage the use of aluminum in order to find new outlets. The goal was to stimulate a climate for creativeness and innovation within the aluminum industry. The idea was that if more industries understood the performance and properties of aluminum, the market would expand. Consequently, designers employed by the aluminum industry worked on distributing informative literature and samples, they promoted aluminum use in meetings and lectures, and they visited design offices to

demonstrate the newest developments. They also invited outside designers to the production facilities, and generally worked on making information available (Doordan, 1993). The industrial design departments functioned as a link between the aluminum industry and the design community, and never wanted to compete with the designer, but rather aid them in their projects (Zimring, 2017).

The promotion of aluminum in the American postwar history exemplifies the importance of knowledge and education when working with a material. In order to make designers utilize aluminum they sought to educate and spread knowledge of the materials opportunities and properties.

5. KNOWLEDGE BASE FOR MATERIAL SELECTION

The key role of an industrial designer is in fact to provide the shape and appearance of a product (Lesko, 2008). When working with a material it is therefore important to know which possibilities and restrictions the material holds. This to know if the product is possible to manufacture and that the most suitable material is chosen. Jim Lesko (2008) states in the book *Industrial design: materials and manufacturing guide* that the designer should invest time in acquiring knowledge and understanding in materials and manufacturing, as it could otherwise hinder the creative mindset.

On the other hand, when working with a design and it comes to material selection, it is important to know what materials you can choose from, because you cannot choose what you do not know. It is also important to know about their qualities, how they sourced and how they are processed (Karana et al., 2014). The American aluminum industry aided the designers on their way and made sure they had knowledge available so that aluminum would stand as an alternative in the material selection part of the design process.

Shortly put, material selection is about knowing which materials exist and to choose the best one for your product. This is done by considering technical factors such as manufacturing processes, cost, function, availability, shape, use and so on. Material selection is also about how the materials and products interact with people and not only about technical factors. This interaction involves both the technical requirements and the aesthetical aspects. The product should appeal to senses, emotions and create a meaning for the users (Karana et al., 2010).

5.1 Materials driven design

Turning the material selection process around we have materials driven design. This is when a material is chosen at the starting point of the design process and from there the opportunities are discovered. One key difference from traditional material selection, when materials are considered in a late phase, is that the early phase of a design process is more holistic and abstract. The materials can therefore be used for goal forming rather than product realization (Karana et al., 2014). This allows for new ways of thinking and for reconsideration of shapes and forms. To encourage the exploration of new possibilities within materials and technologies, the industry often invites designers to participate or compete in competitions or hands out special awards.

6. CONSUMER CHALLENGES AND MEANING IN PRODUCTS

The consumer market is today a powerful driver in product design (Ashby & Johnson, 2014). Economic growth and the nature of free market economies makes the consumers buy a product when they desire it or want it, and not only when they need it. Consequently, a lot of product design today is driven by desire and the needs of the market. Thus, the functional aspect of a product is no longer the only factor for today's product consumption. The materials and appearance also plays a part as they will get different meanings in various products (Karana et

al., 2009). The designer needs to look at how the product can be of value and meaning for the customer. Well-designed products are cherished, and with time they can acquire additional value and outlive their intended design life. The materials of the products often lure people's initial attention, and in the longer run they can obtain a lasting positive or negative experience (Karana et al., 2014).

6.1 Aluminum furniture market

One of the hardest markets to crack when promoting aluminum in the postwar history was the furniture market. In *Aluminium Furniture 1886-1986*, Clive Edwards (2001) investigates how the aluminum industry was met with opposing attitudes towards using aluminum in furniture, as the traditional wood and wood-based products dominated, which also can be seen to some extent today. One of the reasons was that the furniture industry would have to invest in new equipment, and to rethink the manufacturing and design process, which in fact was predominated by woodworking practice. Another reason suggested that there was a lack of courageous design plans and will to find an application within furniture that was well suited for the characteristics of aluminum and for the taste of the public.



Figure 1: "Swiueling chair" by Gio Ponti (1938)

Domestic furniture makers and customers in particular were not very receptive for use of new materials. Edwards quotes an article that put these attitudes into words: "for the average

home [as compared with contract use] it is not quite right, being too cold and too ultra-modern [...]" (Edwards, 2001). Institutional clients were more receptive to metal furniture, which eventually led to a distinction between markets. Metal furniture became associated with institutions, hospitals and offices (figure 1), while wooden furniture and upholstery remained for the domestic market, as they were more homely. Rather than focusing on the suitability of the materials it eventually became a "common understanding" that metal furniture was not appropriate for ordinary use in the homes.

6.2 Altering meaning of materials

It may seem like the effort to promote aluminum in furniture met adversity as the metal furniture design more or less failed at giving value and meaning to the consumers. However, Karana et al. (2009) argues that sensorial properties (sight, touch, taste, smell and hearing), and not necessarily certain technical properties of a material, may influence the holistic impression of the product in which the material is embodied in. Other factors such as color and form may also work together with the material and the sensorial properties in order to create particular meanings for the consumer. For instance, in a study conducted by Wastiels et al. (2011) concerning visual and tactile warmth perception of indoor wall materials, it was found that applying color to a material appeared to be more effective in altering the perception of warmth than for instance altering the surface gloss or roughness.

Combining materials in products may also impact the holistic perception. A material can give both visual impressions such as color, glossiness, and patterns, and tactile impressions such as weight, coldness/warmth, and surface hardness, softness and elasticity. Both of these senses may also perceive surface texture such as roughness (Karana et al., 2014). A product experience is based on all the incoming sensory information about the materials used. How materials are combined and the way they are connected will

impact this experience. It is important to evaluate the combinations as a whole, and not the properties of the individual materials in order to obtain a pleasant combination.

6.3 Developing successful products

Ljungberg and Edwards (2003) in *Design, materials selection and marketing of successful products* presents some insight for understanding how products become successful in the market place. They point out that many given methods for material selection limits the material to a physical entity solely meant to give the shape and function to a product. As discussed, these aspects are not enough for many consumers. In addition, consumers require metaphysical aspects, such as values and feelings, because “from the human side a product is much more than a material” (Ljungberg & Edwards, 2003). The product must in fact feel good to use and have an appealing design.

The history behind a product and thus the product image also has a great influence on a product. Advertisements and marketing are used to generate interest and to give a mental picture of the products profile. Here one can for instance use the materials in creating the history of the product as sustainable, durable or from a geographical place etc. Life cycle assessments and environmental aspects are important to have in mind for creating a successful product. This can help both in finding the cheapest material to use in the long run and minimizing damage to the environment. It can also contribute in creating history and strengthen the product image.

During the marketing one must identify customer groups with unsatisfied needs and choose a material that fulfils these needs. When choosing a new material for a certain product, it is important that there is logic behind it. The material should result in a product that is superior to previous products; otherwise there is a great risk of failure (Ljungberg & Edwards, 2003). In their article they study how Bang & Olufsen have given high metaphysical value to

their products. Their use of materials with high finishes and advanced design, high quality electronics and clean surfaces gives an impression of a prestigious product. They also use natural materials such as aluminum, leather and wood, as in the *Beolab 50* speaker in figure 2, which give a cold and somewhat Nordic feel, (Ljungberg & Edwards, 2003) and thus also give history to the product.



Figure 2: “Beolab 50” speaker by Bang & Olufsen (2017)

Simon Sinek (2009), as mentioned earlier, has also investigated how companies and people have managed to deliver successful products and services. The common denominator is that they all started with “why,” and that this “why” is not to make a profit, but the purpose, cause and belief of what they are doing. He states that “people don’t buy WHAT you do, they buy WHY you do it” (Sinek, 2009). Sinek also talks about how to influence human behavior, either by manipulation or inspiration. Manipulation in this sense is for instance dropping the price, using fear, promising promotions or innovations, which all are effective but often short-term solutions. When inspiring customers by communicating why they do what they do, they can achieve both sales and lifetime loyalty.

7. DISCUSSION

As the early part of this paper discuss, aluminum has potential as a material for indoor furniture, especially due to its physical properties. For an industrial designer it is important to have

knowledge about materials and manufacturing processes in order to make well-reasoned choices in the material selection part of a product development. The industry should provide knowledge about materials and new technologies, and the designer should invest time in acquiring this knowledge.

When designing a product, it is not solely about physical properties of a material, but also about the interaction between product and user. The consumer market today is largely driven by desire and not only by functional needs. Consequently, the materials and appearance of products should create meaning and values for the consumer. This might in fact be where the potential within aluminum furniture lies, as the previous designs of aluminum indoor furniture in the cases discussed have been perceived as cold, too high end or too institutional.

The materials play an important role in how products are experienced, and the designer should strive to use them properly. By altering appearances such as colors and form, the material and sensorial properties may work together in order to create meanings and values for the consumer. Combining different materials can also be a tool for impacting the holistic product perception. It is important that the material used results in a product superior to previous products, and that the combination of materials is well evaluated in terms of the holistic experience in order to create a pleasant combination.

For the aluminum industry, materials driven design could work as a tool for encouraging designers in the exploration of aluminum as a material. Here, the designers can learn about aluminum properties and behavior, use it in goal forming and from there discover appropriate applications, material combinations and product shapes. In order to motivate this exploration, the aluminum industry should seek to inspire both designers and manufacturers by communicating the purpose of why they should do it, and what benefits comes with it.

8. PROMOTIONAL GUIDELINES

In an attempt to conclude the information presented in this article, two fundamental guidelines are presented as a tool for encouraging aluminum use in furniture design; to inspire and to educate.

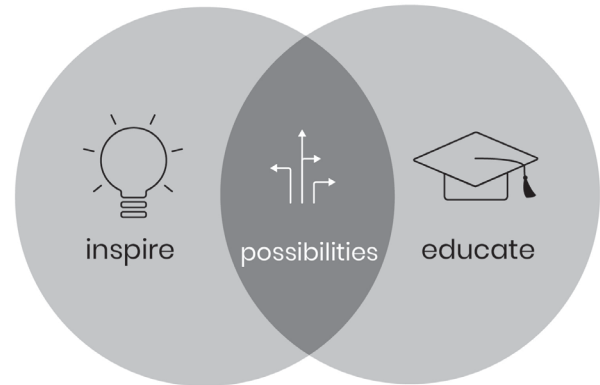


Figure 3: guidelines for encouraging aluminum use in furniture design

Edwards (2001) suggested that there has not yet been a sufficient will or plan to discover an application within aluminum furniture that is both well suited for the physical properties of aluminum and the taste of the public. This indicates that there is a need for inspired and motivated designers that has an urge to explore the material. In order to inspire designers, the aluminum industry should promote the reasons for why aluminum should be used in favor to other materials in furniture. The reasons for “why” could be the overarching visions, beliefs and values of the aluminum industry in for instance making a more sustainable and environmental friendly consumption market. And as a tangible proof that gives life to this vision, the “what” include aluminum and its benefits concerning sustainability, as well as its versatile physical and aesthetical properties which make it appropriate for furniture applications.

The aluminum industry should also inspire and support the designers by providing knowledge about the materials’ properties, possibilities and manufacturing methods. One can learn from the

measures taken in the postwar promotion by the aluminum industry. Bridging the knowledge gap between the industry and designers proved to be an important and fruitful approach in discovering new outlets for raw aluminum. Specific measures from the industry could be seminars or conferences, lectures or meetings and co-operations with designers or universities.

Bridging the gap between the aluminum industry and the designers should also be based on mutual communication, as a product is not only about physical properties of the material but the metaphysical and sensorial perceptions as well. The aluminum industry possesses vast amounts of knowledge about the technical qualities of the material and manufacturing methods, while the designer has more insight and experience in how products interact with people. As there is no direct recipe for how to create aluminum furniture that appeals to consumers on a theoretical basis, it all comes down to physical experimenting with users and testing different material combinations, shapes, colors, textures and so on. Developing successful products has also much to do with how it is marketed. Creating a product image and history is an efficient marketing method, and highly relevant for aluminum furniture. Aluminum, and metals in general, often give a feeling of quality and prestige, (Ljungberg & Edwards, 2003) and considering aluminums' sustainability it has the potential of achieving a highly valued product image.

If the aluminum industry manages to both inspire and educate designers and manufacturers, it will encourage them to explore the material, and thus create possibilities. Together, the aluminum industry, designers and manufacturers have great prerequisites for creating successful aluminum furniture for the indoor market.

9. FINAL REMARKS

This article has discussed how aluminum furniture through history has had moderate success in infiltrating the domestic indoor furniture market. This because the design of the furniture has not given satisfactory value and meaning to the consumers, and because there has not been a sufficient will to explore how aluminum can be successfully applied. There is a need for exploration in finding appropriate use of aluminum in furniture which utilizes both the physical properties of aluminum and that creates values and meaning for the consumer. There is also a need for knowledge exchange between the aluminum industry and the designers and manufacturers, concerning material properties, and manufacturing processes. The guidelines presented in this paper, to inspire and to educate, can work as a fundamental tool for enabling this exploration as well it can be applied to other areas since it is not exclusively relevant for aluminum furniture. Aluminum possesses some great qualities in both physical properties and aesthetic versatility. If there is a will to explore aluminums' possibilities within the indoor furniture market, there is a great potential in finding the appropriate application.

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