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How to incorporate sustainable materials and aerodynamic concepts into product design, with an emphasis on lowering emissions and improving energy efficiency?

Aerodynamics – Pollution - Form

Aerodynamics, pollution and form are three major factors that all share a relationship between innovation and environmental responsibility. From Formula one cars to modern aircrafts, aerodynamics not only dictates their performance but also their impact on the environment. The crucial need to reduce pollution, urges designers to seek more sustainable solutions. Moreover, the form of a product is an important consideration, not only for aesthetic appeal, but in vehicles, to improve aerodynamic efficiency and reduce its effect on the environment. This essay outlines each of these three subjects, expanding our knowledge on how design affects each of these areas, along with how they all link together and impact the environment.

The theme of this essay focuses on the crucial factor's that aerodynamics play in improving vehicle performance whilst reducing emissions, the urgent threat pollution poses to ecosystems as well as public health, and the power of form to influence a products functional efficiency as well as its aesthetic appeal, all of which contribute to environmental sustainability. Throughout this essay I will outline the theoretical contributions to aerodynamics, pollution and forms. These consist of works from Leonardo Da Vinci and Luigi Colani, as well as theoretical discoveries by Ludwig Prandtl. Furthermore, this essay will look into artists like Chris Jordan and Banksy and show how they are using their creative expressions to address environmental issues.

Aerodynamics

Aerodynamics refers to how air and gases interact with solid objects in motion. Examples can include vehicles, aircrafts and buildings. For planes and Formula 1 vehicles, aerodynamics is crucial, yet they have different applications. Aerodynamics in aircraft mostly focuses on producing lift to maintain altitude while reducing drag for effectiveness and stability. To accomplish this balance, aircraft designs maximize the forms of their wings and control surfaces, particularly in supersonic flight where shock waves and compression effects become important (J.D. Anderson, 2016). In contrast, the goal of Formula 1 cars is to increase grip and performance by increasing downforce. To maintain an advantage, teams are continuously trying to improve their designs to balance out the downforce and drag whilst adhering to rigorous restrictions.

Aerodynamic components, including wings and diffusers, are examples of such systems (Katz Joseph, 2006).

Ludwig Prandtl is a theorist who has significantly contributed to our understanding of aerodynamics within aircrafts. The German engineer and physicist is widely known for his theory of the boundary layer. His research transformed our knowledge of airflow close to solid surfaces, which is essential for creating effective aircraft wings. To elaborate, Prandtl's research on boundary layer behavior aided engineers in creating airfoil designs that maximize lift and reduce drag, therefore enhancing aircraft performance (J.D. Anderson, 2016).

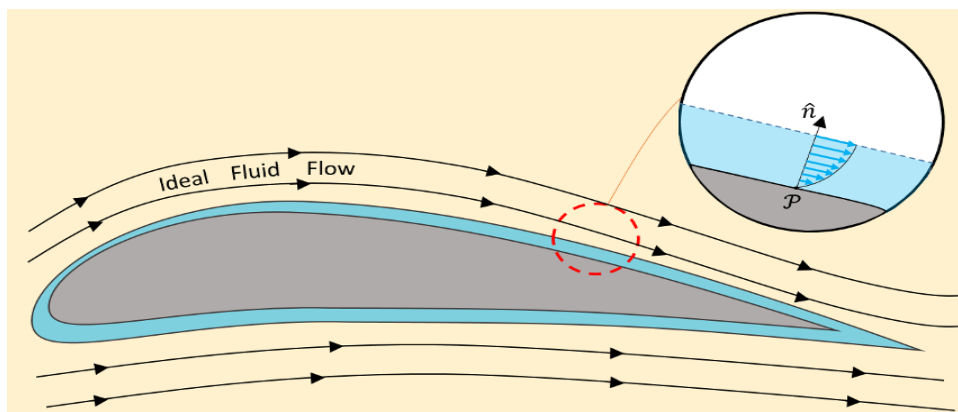


Figure 1 (Prandtl's Boundary layer theory)

Figure 1 shows the dynamics of airflow close to solid surfaces. It shows a thin layer of air next to the surface, called the boundary layer, the thickness of this boundary layer varies with airflow speed along the surface, determining the air's interaction with the surface. The figure also illustrates the velocity profile inside this boundary layer, showing how airflow affects drag and lift forces as it moves from its highest velocity at the boundary to zero velocity at the surface. Furthermore, it also makes a distinction between turbulent and laminar airflow regimes, with turbulence frequently happening downstream of the leading edge.

The art of design saw a revolutionary shift when designer Luigi Colani highlighted the effectiveness of aerodynamics and futuristic forms. Colani's design philosophy, which is defined by flowing, organic shapes influenced by nature, has had a significant influence on vehicle design trends, especially those related to high-performance racing cars, as seen in figure 2 below. Colani pushed the boundaries by promoting the incorporation of aerodynamic principles into design,

motivating designers to prioritise both efficiency and aesthetics. Aerodynamic engineers work tirelessly to improve aerodynamic components like wings, diffusers, and body forms in Formula 1 racing cars as these are critical to success. Although Colani may have made indirect contributions to Formula 1, his innovative approach to design has surely impacted aerodynamic dominance within the sport.

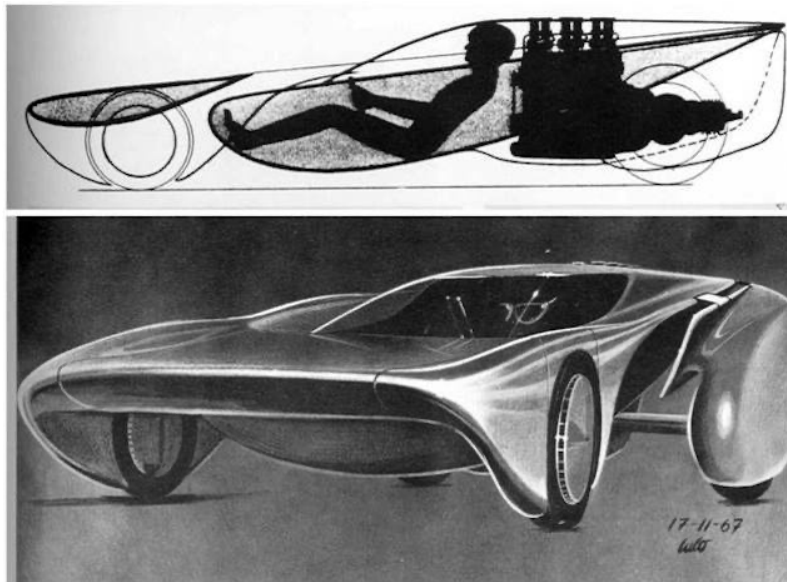


Figure 2 (Luigi Colani, Drawing, 1967 – Concept C-Form Brevet) (Maneval, V 2020)

Another artist that worked on aerodynamics was the well renowned Leonardo Da Vinci. One of his artworks the "Codex on the Flight of Birds" (also called "Codex Leicester B"), is a well-known piece of art that examines aerodynamics. As shown in figure 3, his work encompasses a compilation of sketches and observations on bird flight. Da Vinci carefully examined the wing structures, wing movements, and aerodynamic principles of flight in this codex, documenting his observations on the anatomy and behavior of birds.



Figure 3 – (Leonardo Da Vinci – Codex on the flight of birds) (Zaniker, E 2020).

Da Vinci's sketch of the "Ornithopter," a flying device intended to resemble a bird's fluttering wings, is one well-known illustration from the Codex. Da Vinci's mastery of aerodynamics and his attempt to adapt it to human flight are demonstrated by this creation in figure 4. Due to technological constraints, da Vinci was unable to construct the Ornithopter during his lifetime, but his drawings and concepts set the stage for subsequent developments. (Richardson, P,L 2018)



Figure 4 (Leonardo Da Vinci – Ornithopter) (Kren, J 2018)

Pollution

Pollution falls under many categories, such as air pollution, water pollution, soil pollution and noise pollution. Pollution is the introduction of harmful gases, liquids and solids into the environment which negatively affect ecosystems, human health, and wildlife. Most pollution is caused by human made technologies, however there are some natural pollutants such as volcanic ash.

Pollution is a widespread environmental challenge, manifesting in various forms, each having distinct impacts on human well-being, ecosystems and the environment. For example, car exhaust, industrial emissions, and farming methods constitute as significant contributors to air pollution, which contributes to climate change, smog development, and respiratory issues. Motor vehicles significantly contribute to climate change through harmful emissions such as CO₂ and nitrogen oxides. These pollutants are predominantly released from car exhausts and are a major source of air pollution. According to the international Energy Agency (IEA), the transportation sector accounts for roughly 25% of global energy-related CO₂ emissions, with road vehicles being the largest contributor.

Another key polluter is oil. In regard to vehicles, leaks in the engines or other components can release oil onto the roads and eventually into our environment. This is because when it rains runoff can occur which washes oil into drains, rivers or oceans. This then has the potential to contaminate waterways, soil and ecosystems. The 2010 Deepwater horizon oil rig explosion was a tragic event that showcases just how detrimental oil pollution can be to marine life. This event severely damaged marine habitats, as well as killing around 82,000 birds, 25,900 marine mammals and a large number of fish, although the number unknown (Centre for Biological Diversity, n.d). This incident brings to light the devastating consequences of water pollution, emphasising the need for proactive measure to prevent similar disasters in the future.

One artist that showcases the issue of pollution is Daniel Beltra's. Most known for his landscape photography, Beltra captures the devastating effects pollution has on the environment and wildlife through his captivating aerial images. His image titled Oil spill 12 as shown in figure 5, captures the vast stretch of oil polluted waters, where the ocean's surface is covered in multi-coloured oil, creating an almost surreal pattern from above. The image portrays a beautiful yet tragic scene, reminding the audience of the catastrophic events of oil spills impacting marine life and ecosystems.



Figure 5 – Daniel Beltra – Oil Spill 12, (Beltra, 2010)

Another artist that depicts pollution in their work is the world-renowned Banksy. It's inspiring to see one of my favourite artists shed light on this pressing issue. The installation called 'Silence of the lambs' is extremely thought provoking. In this artwork, Banksy converts a delivery truck into a mobile gallery that's shows a variety of plush animals being transported around the streets. When the trucks sides open, they reveal pretend animals that seem as if they are in distress. The piece takes a sinister turn as the sound of their screams can be heard leaving the viewers feeling uneasy and uncomfortable.

This exhibition exposes the issues relation to industrial farming and in the way, animals are treated in the farming business. It creates a thought-provoking matter to its audience to come face to face with the brutal reality of animal exploitation and encourages contemplation on whether the environmental repercussion from the industry is worth it.

Research has shown that the livestock business is responsible for 37% of global methane production, 65% of global nitrous oxide emissions and 14.5% of all global greenhouse emissions. Banksy's work reflects the critical issue, amplifying awareness of the environmental impact of industrial practices. (Gerber, P,j et al 2014)



Figure 6 'Silence of the lambs' (Cronin, K. (2013).

One theorist that also showcases how the current pollution issue is greatly increasing, is the renowned former vice president of the United States, Al Gore. Gore is an environmental activist who in his book, "An inconvenient truth" showcases the escalation of harmful element levels in the air and how its effects on the environment and public health. In Gores work, he shows how the burning of fossil fuels are causing the concentration of greenhouse gases, such as CO₂ and methane to rise in the earth's atmosphere. Along with being important contributors to air pollution, he shows how this variety of pollutants have such negative effects on the environment such as rising temperatures, harsh weather and ecological disruptions. Gore's efforts serve as a reminder of the serious issue at hand to combat air pollution and to reduce its effects. He aims to help in the fight against air pollution and raises awareness for the environment by bringing attention to the seriousness of the issue whilst also supporting policies that will reduce emissions and switch to cleaner energy sources.

Form

“Form” in the context of design refers to an items/objects shape and structure. It includes elements that you can see and feel, such as size, shape and material details. Form is crucial in shaping a design’s appearance and feel, which affects its usability and aesthetic appeal.

Form is more than just a look. It also refers to the arrangement of various design elements in space. Some varying factors consist of how user friendly it is and how well it blends in with an object’s environment. A designs form is also influenced by the materials and building techniques used, which can give an object its own distinct personality. The word ‘form’ in itself can convey concepts or feelings which deepens the meaning of design. The shape is essential to producing designs that are both visually pleasing and functional.

The first designer I have researched is Jonathon Ive. He is the former chief designer at Apple and is a pioneer at developing form to influence his designs. His design philosophy prioritizes simplicity, elegance and user experience.

Ive priorities clean lines, smooth surfaces and minimalist detailing in many of apple’s products including the MacBook and the iPhone. These products are elegant and minimalistic in design. These devices ‘form’ have been meticulously designed to both be aesthetically pleasing and ergonomically comfortable, with a focus on simple operation and intuitive interaction. (Arn, 2019)



Figure 7 - Ravenscroft, T. (2019).

This leads me in to how the form of shape is used in items we see every day such as cars and aircraft. Form is utilized in cars and aircraft to reduce emissions through aerodynamic design, which is the process of sculpting the outside of the car to reduce drag and increase fuel economy. In vehicle optimization, automakers may lower the energy needed to move their cars forward in the air or on the road. This leads to the vehicles having lower fuel consumption and less pollutants being produced.

Form is also important in aircraft design because it improves aerodynamic performance, which lowers emissions. Planes are often created with wingtip devices (figure 8), streamlined fuselages and optimized lift-to-drag ratios to reduce air resistance. These aerodynamic designs allow aircraft to fly faster, longer and they will produce fewer carbon emissions.



Figure 8 – EasyJet wingtip (Infinite Flight Community. 2020)

The Toyota Prius' design serves as one example of how form is utilized to lower emissions on vehicles. The aerodynamic form of the Prius is streamlined, and its elegant body reduces air resistance. The Prius's design includes a sloping roofline, rounded edges and key features such as rear spoilers and underbody panels that are thoughtfully positioned to maximize airflow around the car (figure 9). These design decisions lower drag and increase fuel economy (Andrew Biddle, 2015).



Figure 9 - (Andrew Biddle, 2015).

Conclusion

The 3 research areas, aerodynamics, pollution and form each offer a distinct perspective on how design and environmental concerns interact. Pollution studies how human activity effects ecosystems and public health, while aerodynamics focuses on the fundamental principles guiding airflow around solid objects especially in cars and aircraft. Form concentrates on the structural and artistic elements of design, highlighting the significance of shape, size and material in the creation of useful and aesthetically pleasing products.

All these key words are related due to their common importance to environmental sustainability and design. For example, aerodynamic concepts optimize airflow and minimize drag, which are key factors in lowering emissions in cars and airplanes. Pollution, on the other hand draws attention to the ongoing issue of climate change and forces designers to think about how their designs will affect the environment over time. Form however acts as a link between these two areas, impacting both the functional and visual aspects of design whilst providing chances to improve sustainability through creative practice of materials and production methods.

When we look at these research topics together, we get a better understanding of how design interacts with the environment. To combat pollution, we must adapt our ways and make use of new technologies. In the future I would like to examine how to incorporate sustainable materials and aerodynamic concepts into product design, with an emphasis on lowering emissions and improving energy efficiency.

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