

THE EFFICIENCY ENGINE: HOW TESLA HARNESSED ROBOTICS TO BUILD THE FUTURE OF CARS (AND SAVE ITSELF)

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Abstract. *The automotive industry has experienced a profound shift since the emergence of Tesla. Not only has the company revolutionized electric vehicles, but it has also redefined manufacturing standards through strategic integration of robotics. This article delves into Tesla's pioneering use of innovative robotics, examining how they have enhanced efficiency, elevated quality, and fostered innovation in car production. By leveraging cutting-edge automation technologies, Tesla has not only streamlined its manufacturing processes but has also set new benchmarks for the entire automotive sector. This strategic embrace of robotics has not only propelled Tesla to the forefront of the market but has also exerted a transformative influence on industry practices. Through its visionary approach, Tesla has not just manufactured cars, it has crafted a blueprint for the future of automotive manufacturing, where precision, speed, and sustainability converge seamlessly. As a result, Tesla's impact extends far beyond its own product lines, shaping the trajectory of the automotive industry as a whole.*

Keywords: *robotics, automation, electric vehicles, manufacturing efficiency, automotive industry*

Introduction

Tesla, founded in 2003 by Martin Eberhard and Marc Tarpenning, has become a prominent player in the American automotive industry, focusing on electric vehicles (EVs) and sustainable energy solutions. Elon Musk's pivotal role, from initial investments to CEO, reshaped Tesla's direction, emphasizing innovation in design, technology, and manufacturing.

Since its inception, Tesla has pioneered EVs and clean energy, gaining global recognition. Despite a 2018 financial crisis, Tesla rebounded through advanced automation, showcasing adaptability and forward-thinking. Their integration of robotics revolutionized manufacturing, positioning Tesla as a leader in both automotive and energy sectors, driving innovation and resilience.

The cornerstone

In its early days, Tesla had a bold plan to make electric vehicles the industry standard. The plan involved building a sports car, using its revenue to create an affordable car, then using that revenue to develop an even more affordable car while also providing zero-emission electric power options.

The success of Tesla's approach was evident in the initial stages, particularly with Step 1 of the secret plan. The company introduced luxury models such as the Roadster (figure 1), Model S (figure 2), and Model X (figure 3). These high-end vehicles, produced at lower volumes, allowed Tesla to utilize manual labour extensively, ensuring meticulous quality control and sidestepping the challenges associated with mass production in the automotive industry.



Figure 1. The Roadster



Figure 2. Model S



Figure 3. Model X

In 2016, Tesla transitioned to Step 2 of its plan, aiming to develop a more affordable, high-volume car that would position the company among the ranks of traditional automotive manufacturers. This marked Tesla's entry into the "real car company" club. The introduction of the Model 3 (figure 4), a sedan-style electric car, was accompanied by a wildly successful presale campaign that garnered a staggering 325,000 orders, equivalent to \$11.4 billion in revenue.



Figure 4. Model 3

To fulfil this unprecedented demand, Tesla committed to producing 5,000 cars per week by 2018, a remarkable undertaking that equated to assembling a new and untested car filled with innovative features at a rate of one car every two minutes. Amid this ambitious production goal, Elon Musk, Tesla's CEO, was determined to revolutionize the manufacturing process. This marked the introduction of extensive automation in Tesla's production lines.

However, this shift to automation wasn't without hurdles. Balancing human labor with automation required careful coordination and learning as Tesla progressed. Yet, the company's commitment to innovation and adaptability defined its journey, driving continuous evolution in its manufacturing processes. Tesla's embrace of change positioned it as a leader in redefining how cars are made.

“Production Hell”

The "Production Hell" phase in 2016 was a pivotal chapter in Tesla's journey, particularly with the ambitious launch of the Model 3 aimed at democratizing electric vehicles. Tesla's clear objectives of ramping up mass production while ensuring affordability encountered formidable hurdles, notably due to a heavy reliance on manual labor despite its technological expertise.

This era highlighted the intricate dance between automation and manual labor in manufacturing, presenting challenges that disrupted Tesla's production flow. The struggle to strike the right balance resulted in bottlenecks, missed deadlines, and quality issues with the Model 3 vehicles, impacting both customer deliveries and internal dynamics within Tesla.

Elon Musk's candid acknowledgment of these challenges, often referred to as "Production Hell," encapsulates the intense pressure and scrutiny Tesla faced during this phase. Despite the tumultuous period, Tesla emerged with valuable insights, emphasizing the importance of refining manufacturing processes and optimizing the delicate balance between automation and manual labor.

The "Production Hell" narrative underscores Tesla's resilience and unwavering commitment to innovation, despite encountering formidable obstacles in scaling production and introducing groundbreaking products. It serves as a poignant reminder of the dynamic

nature of the automotive industry and Tesla's unwavering determination to reshape the future of electric vehicles.

The Robotic Revolution: A Necessary Pivot

In response to the challenges faced during "Production Hell," Tesla made a bold shift by heavily investing in robotics and automation. This marked a significant pivot, with key steps taken to integrate advanced robotic technologies into its manufacturing processes:

1. Acquisitions:

Tesla strategically acquired Grohmann Engineering and Perbix, not just as financial investments but to gain expertise and technology in automation. Bringing these companies under Tesla aimed to address specific production challenges.

2. In-house development:

Tesla established an in-house robotics team to design custom robots tailored to its production needs. This internal development aimed to create specialized solutions integrating seamlessly with existing processes, optimizing efficiency.

3. Flexibility focus:

Tesla emphasized robot flexibility, crucial for adapting to industry dynamics. Robots were designed for easy reprogramming and adaptability across tasks, lines, and vehicle models, ensuring agility and responsiveness.

By combining strategic acquisitions, in-house development, and flexibility, Tesla revolutionized its manufacturing capabilities. Advanced robotics played a vital role in overcoming "Production Hell," moving towards a more efficient and adaptable production model. Tesla's commitment to innovation, both in technology and operations, positioned it as a leader in robotics within the automotive industry.



Figure 5. Automation process

Reaping the Rewards of Automation

Tesla's adoption of a robotic revolution had a profound impact across its operations, reshaping the automotive industry in several key ways:

1. Increased Production:

Automation played a crucial role in Tesla's ability to ramp up production rates, surpassing targets set for the Model 3. Integration of robots allowed Tesla to scale its manufacturing capabilities, meeting high demand and achieving production volumes that exceeded expectations.

2. Improved Quality:

Robotic systems were pivotal in enhancing product quality by eliminating human error. The precision and consistency of automated processes reduced defects, establishing higher standards for Tesla's vehicles. The reliability of robotic assembly contributed to overall product quality.

3. Enhanced Efficiency:

Automation not only boosted production but also streamlined manufacturing processes, leading to reduced waste, optimized resource utilization, and lower production costs. These efficiency gains helped Tesla offer competitive pricing while maintaining profitability.

4. Innovation:

Tesla's venture into robotics spurred innovation within the company. Expertise gained from integrating and refining robotic systems drove the development of innovative manufacturing techniques. This ongoing commitment to innovation has solidified Tesla as an industry leader, constantly pushing boundaries and setting new standards.

Beyond the Model 3: A Legacy of Automation

Tesla's expansion beyond the Model 3 saw the application of robotic insights across various vehicle models and manufacturing sites, cementing its position as a leader in automated car production. This expertise extended beyond assembly lines to include the design and implementation of Gigafactories - advanced production facilities meticulously engineered for automation that seamlessly integrated robotic systems aimed at enhancing overall efficiency and productivity (figure 6).

Tesla's commitment to continuous improvement is seen in its iterative approach to robotics and manufacturing. By consistently refining its robotic systems, Tesla leads in automation advancements. This dedication has not only driven Tesla's success but has also influenced the automotive industry, inspiring heavy investments in automation. This ripple effect of Tesla's pioneering use of robotics is evident in the industry-wide shift towards heightened efficiency, quality standards, and innovation in automotive manufacturing.

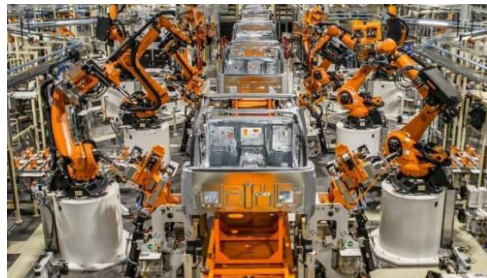


Figure 6. Automotive industry

Conclusions

Tesla's journey exemplifies robotics' transformative impact in the automotive sector. The deliberate integration of automation helped Tesla overcome production challenges, setting new standards for efficiency and innovation. This triumph in robotics has significant implications for car manufacturing's future.

Automation's impact is evident in Tesla's higher production rates, improved quality, and culture of innovation. These achievements show that robotics drives industry norms' redefinition beyond operational improvements.

Tesla's commitment to pushing robotics' boundaries positions it as an industry catalyst. Other automakers are likely to follow suit, recognizing automation's benefits in achieving operational excellence.

In essence, Tesla's embrace of robotics extends beyond its success; it guides the automotive industry towards a future where automation drives advancements, shapes manufacturing, and sets new standards for efficiency, quality, and innovation.

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