NEW HORIZON COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL
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A PROJECT REPORT ON

"ELECTRIC VEHICLES – TESLA INC. "

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Submitted to

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CERTIFICATE

It is certified that the report entitled **"ELECTRIC VEHICLES – TESLA INC."** carried out by **ANUBHAV GUPTA (1NH18ME018),** a bonafide student of **New Horizon College of Engineering, Bengaluru,** during the year **2020-21**. It is further certified that all corrections/suggestions indicated for internal assessment has been incorporated in the report deposited in the department library. The report has been approved as it satisfies the academic requirements in respect to Product Lifecycle Management Assignment prescribed for the **Bachelor of Engineering** degree.

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Abstract

The transportation sector has been reported as a key contributor to the emissions of greenhouse gases responsible for global warming. Hence, the need for the introduction of electric vehicles (EVs) into the transportation sector. However, the competitiveness of the EVs with the conventional internal combustion engine vehicles has been a bone of contention. Life cycle analysis (LCA) is an important tool that can be employed to determine the competitiveness of a product in its early stage of production. Moreover, the LCA obtained from the different models of EVs were compared. There was a growing interest in research on the LCA of EVs as indicated by the upward increase in the number of published articles. A variation in the LCA of the different EVs studied was observed to depend on several factors. The goal of this methodology is to highlight vehicle development bottlenecks and make recommendations on the best practices. The intent is to layout a vehicle development process that will focus on the major development of new technology in hopes of minimizing costly changes. The methodology developed in this thesis starts with literature review, which provides a historical perspective of the technology and discusses the advantages and disadvantages of electric vehicles. Environmental issues and concerns will be explored as well. The capital cost of developing this new technology, and assembly plant issues to accommodate this technology will be discussed.

Acknowledgement

I thank the Lord Almighty for showering his blessings on us.

It is indeed a great pleasure to recall the people who have helped me in carrying out this product analysis. Naming all the people who have helped me in achieving this goal would be impossible, yet I attempt to thank a selected few who have helped me in diverse ways.

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Contents

Introduction

Unlike conventional cars that are powered by heat energy produced during the combustion of gasoline, electric cars are powered by electricity. The electricity is generated by chemical reactions that take place in batteries. Rechargeable lead-acid batteries (similar to those used for starting the engine in conventional cars) are commonly used. The main advantage of electric cars is that there are no tailpipe emissions; indeed, they are the only zero-emission vehicles. Polluting emissions do result from power plants that produce the electricity needed for recharging the batteries, however, emission control is easier at a single stationary plant than for the comparable number of motor vehicles. Including pollution from recharging its batteries, electric cars generate only one-tenth the pollution of conventional cars.

Electric vehicles are radically different from today's gasoline powered vehicle. Instead of storing gasoline, the electric vehicle stores electric energy in a large, rechargeable battery. A vehicle system controller sends this power to the electric drive motor whenever the driver pushes down on the accelerator pedal. Refuelling is accomplished by plugging the vehicle's charge plug into a 240-volt charge receptacle specifically designed for an electric vehicle. We prefer 240 volts because the vehicle charges faster - recharging at 120 volts can take up to 24 hours.

Electric Vehicles (EV) is the latest technology that the automotive industry is pursuing. Electric cars have been around since the beginning of the automobile. However, the internal combustion engine (ICE) was chosen because it turned out to be the best power system. Modem cars have much lower emissions than their predecessors, but still are not clean enough. As easily recoverable petroleum deposits dwindle, automobile populations soar, and cities become choked with combustion by-products, ICE is increasingly becoming the victim of its own success.

Automobiles must become cleaner and more energy efficient. Nearly after ten decades, the electric vehicle and hybrid electric vehicle may actually prevail. In order to assess the potential benefits of various technologies, it is critical to understand how vehicles are used. Technological research and development have shown that electric vehicles can make a difference in reducing the emission standards. The use of electricity as an energy transporter makes it possible for conservation of environmental quality. Further technology development in the field on energy and drive systems must take place in order to find the proper vehicle process. No one really knows if there is a market for electric vehicles, and how successful they will be? Many automotive manufacturers are developing and implementing EV and HEV. General Motors and Toyota have both release vehicles in 1998, GM EVI and Toyota Prius Hybrid. Ford, Daimler-Chrysler, Honda, and others are also developing this technology as well.

CHAPTER 1

DEVELOPMENT OF TESLA ELECTRIC VEHICLES

Development of Tesla Inc.

Tesla was founded (as Tesla Motors) on July 1, 2003 by Martin Eberhard and Marc Tarpenning in San Carlos, California. The founders were influenced to start the company after General Motors recalled all its EV1 electric cars in 2003 and then destroyed them, and seeing the higher fuel efficiency of battery-electric cars as an opportunity to break the usual correlation between high performance and low fuel economy in automobiles. The AC Propulsion t-zero also inspired the company's first vehicle, the Roadster. Eberhard said he wanted to build "a car manufacturer that is also a technology company", with its core technologies as "the battery, the computer software, and the proprietary motor".

Ian Wright was the third employee, joining a few months later. The three went looking for venture capital (VC) funding in January 2004 and connected with Elon Musk, who contributed US$6.5 million of the initial (Series A) US$7.5 million round of investment in February 2004 and became chairman of the board of directors. Musk then appointed Eberhard as the CEO. J.B. Straubel joined in May 2004 as the fifth employee. A lawsuit settlement agreed to by Eberhard and Tesla in September 2009 allows all five (Eberhard, Tarpenning, Wright, Musk and Straubel) to call themselves co-founders.

Musk took an active role within the company and oversaw Roadster product design at a detailed level, but was not deeply involved in day-to-day business operations. Eberhard acknowledged that Musk was the person who insisted from the beginning on a carbon-fiber-reinforced polymer body and that Musk led design of components ranging from the power electronics module to the headlamps and other styling. Musk received the Global Green 2006 product design award for his design of the Tesla Roadster, presented by Mikhail Gorbachev, and he also received the 2007 Index Design award for his design of the Tesla Roadster.

CHAPTER 2

COLLABORATIVE PRODUCT DEVELOPMENT

Requirements of the Product

Supercharger network

In 2012, Tesla began building a network of 480-volt fast-charging Supercharger stations. As of November 2020, Tesla operates over 20,000 Superchargers in over 2,100 stations worldwide. The Supercharger is a proprietary direct current (DC) technology that provides up to 250 kW of power. The navigation software in Tesla cars can recommend the fastest route for long-distance travel, incorporating possible charging delays.

Almost all Tesla cars come standard with Supercharging hardware. Model S and X cars ordered before January 15, 2017 received free unlimited supercharging. Model S and X cars ordered between January 15, 2017 and August 3, 2019 got 400 kWh (1,400 MJ) of free Supercharging credits per year, which provides a range of roughly 1,000 miles per year (1,600 km/a). Between August 3, 2019 and May 26, 2020, all Tesla Model S and X cars ordered came with free unlimited supercharging again. Being a less premium model, Model 3 cars do not come with free unlimited supercharging.

Tesla Model S charging at a Supercharger station in Newark, Delaware

Destination charging location network

In 2014, Tesla launched the "Destination Charging Location" Network by providing chargers to hotels, restaurants, shopping centres, resorts and other full service stations to provide on-site vehicle charging at twice the power of a typical home charging station.

Destination chargers are installed free of charge by Tesla-certified contractors; the locations must provide the electricity at no cost to their customers. All installed chargers appear in the in-car navigation system.

Software updates and upgrades

Tesla vehicles' software is regularly updated over-the-air when new software and firmware versions are released. This allows the cars to remain up to date and improve after purchase. Tesla also offers the option to unlock features in the car through over-the-air software upgrades after purchase. Available upgrades include basic Autopilot, Full Self Driving, acceleration boost (for Model 3 owners), and rear-heated seats (for Model 3 owners).

Part numbering and Information gathering

After so many attempts and efforts which were made to create the product global are examined and the most promising plan has been worked upon. All the necessary documentations related to the product data in terms of its characteristics and features can be backed up using the screen which is provided in the vehicle and this information is also stored in Tesla's database. So Tesla vehicles serves their customers in the best way possible.

With Tesla vehicles, it is possible to get right information and processes whenever the user needs it. In September 2020, Tesla signed a sales agreement with Piedmont Lithium to buy high-purity lithium ore for up to ten years, specifically to supply "spodumene concentrate ('SC6') from Piedmont's North Carolina mineral deposit to Tesla". Also at the beginning of 2010, Panasonic invested $30 million for a multi-year collaboration on new battery cells designed specifically for electric vehicles. Also, bringing the information from the virtual storage to the real storage is easy.

Engineering Vaulting

At the time of Tesla's founding, electric vehicles were very expensive. Tesla's strategy was to first produce high-price, low volume vehicles, such as sports cars, for which customers are less sensitive to price. This would allow them to progressively bring down the cost of batteries, which in turn would allow them to offer cheaper and higher volume cars. Tesla's first vehicle, the Roadster, was low-volume (less than 2,500 were produced) and priced at over $100,000. The next models, the Model S and Model X, are more affordable but still luxury vehicles. The most recent models, the Model 3 and the Model Y, are priced still lower, and aimed at a higher volume market, selling over 100,000 vehicles each quarter. Tesla continuously updates the hardware of its cars rather than waiting for a new model year, as opposed to nearly every other car manufacturer.

Tesla has a high degree of vertical integration, reaching 80% in 2016. The company produces vehicle components as well as building proprietary stations where customers can charge their vehicles. Vertical integration is rare in the automotive industry, where companies typically outsource 80% of components to suppliers and focus on engine manufacturing and final assembly.

With Tesla vehicles, it is possible to get right information and processes whenever the user needs it. Also, bringing the information from the virtual storage to the real storage is easy.

Products Reuse

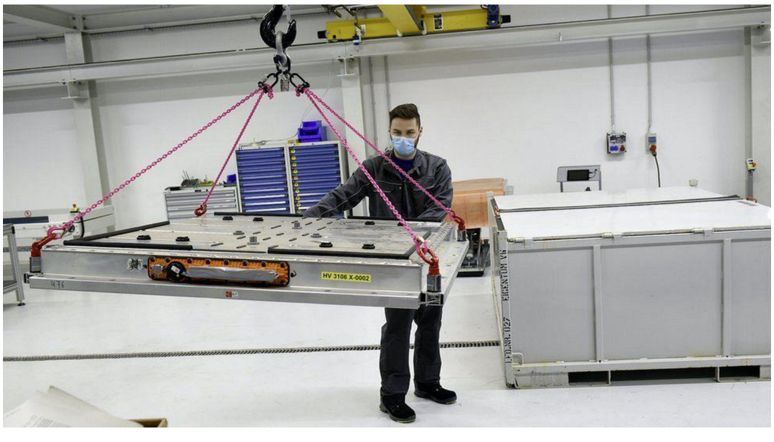
While electric vehicles (EVs) may not emit any carbon dioxide during their working lives, he's concerned about what happens when they run out of road - in particular what happens to the batteries. In 10 to 15 years when there are large numbers coming to the end of their life, it's going to be very important that one must have a recycling industry.

While most EV components are much the same as those of conventional cars, the big difference is the battery. While traditional lead-acid batteries are widely recycled, the same can't be said for the lithium-ion versions used in electric cars. EV batteries are larger and heavier than those in regular cars and are made up of several hundred individual lithium-ion cells, all of which need dismantling. They contain hazardous materials, and have an inconvenient tendency to explode if disassembled incorrectly.

Currently, globally, it's very hard to get detailed figures for what percentage of lithium-ion batteries are recycled, but the value everyone quotes is about 5%. In some parts of the world, it's considerably less.

Recent proposals from the government would see EV suppliers responsible for making sure that their products aren't simply dumped at the end of their life, and manufacturers are already starting to step up to the mark.

Nissan, for example, is now reusing old batteries from its Leaf cars in the automated guided vehicles that deliver parts to workers in its factories.



Tesla is also doing the same, but has also recently opened its first recycling plant name as Redwood materials and plans to recycle up to 3,600 battery systems per year during the pilot phase. **Redwood Materials**, a start-up created by Tesla cofounder J.B. Straubel to profitably recycle lithium-ion batteries, is partnering with ERI, North America's biggest processor of electronic waste, to gain access to thousands of tons of cells it can turn back into valuable raw materials. Tesla is aiming at being able to address 25% of the recycling market. Tesla want to maintain this level of coverage, and of course this would cover by far the needs of Tesla.

Start and Smart Parts

Tesla Motors has used smart parts on far more complicated parts, such as those that make up high performance, smart electric cars. Very sophisticated rules about heat exchange, tensile strength, and minimum and maximum automatic user controls are embedded in their smart parts. If a modification attempt is made, the smart part checks its rules to ensure that the new configuration conforms to the design requirements. Some of the smart parts in Tesla electric cars are listed below:

Autopilot

Autopilot is an advanced driver-assistance system developed by Tesla. The system requires active driver supervision at all times. Starting in September 2014, all Tesla cars are shipped with sensors and software to support Autopilot (initially hardware version 1 or "HW1"). Tesla upgraded its sensors and software in October 2016 ("HW2") to support full self-driving in the future.

Full self-driving

Full self-driving (FSD) is an optional upcoming extension of Autopilot to enable fully autonomous driving. At the end of 2016, Tesla expected to demonstrate full autonomy by the end of 2017.

Engineering Change Management

It is very easy for the system to define changes and modifications in the vehicle.

Tesla vehicles' software is regularly updated over-the-air when new software and firmware versions are released. This allows the cars to remain up to date and improve after purchase. Tesla also offers the option to unlock features in the car through over-the-air software upgrades after purchase. Available upgrades include basic Autopilot, Full Self Driving, acceleration boost (for Model 3 owners), and rear-heated seats (for Model 3 owners).

Tesla service strategy is to service its vehicles through remote diagnosis and repair, mobile technicians, and Tesla-owned service centres. In 2016, Tesla recommended to have any Tesla car inspected every 12,500 miles or once a year, whichever comes first. In early 2019, the manual was changed to say: "your Tesla does not require annual maintenance and regular fluid changes," and instead it recommends periodic servicing of the brake fluid, air conditioning, tires and air filters.

In last three months, we saw a sudden fall in Tesla share value as well as the problems related to the huge prices of importing Tesla cars in various middle income level countries. So Tesla is now working to make the cars affordable for buyers by setting up its production factories in such countries so that the cost of import will be saved.

Tesla is now working hardly on their new upcoming projects in order to maintain its position in global markets.

Collaboration Room

In the collaboration room where company investors and their engineers will sit and talk about company current status and decide upon further action to be taken.

In Tesla, engineers will talk about the user queries and their reviews on their site. Then they will talk about the error and make them correct. Tesla is purely working for people's benefits. They are helping us to express ideas, connect to others, and build toward a future limited only by your imagination. Their frictionless communications platform is the only one that started with video as its foundation, and we have to set the standard for innovation ever since. That is why they are a intuitive, scalable, and secure choice for large enterprises, small businesses, and individuals alike.

Bill of Materials

Vehicle batteries

Tesla was the first automaker to use batteries containing thousands of small, cylindrical, lithium-ion commodity cells like those used in consumer electronics. Tesla uses a version of these cells that is designed to be cheaper to manufacture and lighter than standard cells by removing some safety features; according to Tesla, these features are redundant because of the advanced thermal management system and an intumescent chemical in the battery to prevent fires.

Motors

Tesla makes two kinds of electric motors. Their oldest currently-produced design is a three-phase four-pole AC induction motor with a copper rotor (which inspired the Tesla logo), which is used as the rear motor in the Model S and Model X. Newer, higher-efficiency permanent magnet motors are used in the Model 3, Model Y, the front motor of 2019-onward versions of the Model S and X, and is expected to be used in the Tesla Semi Class 8 semi-truck. The permanent magnet motors increase efficiency, especially in stop-start driving.

Lithium Cells

Panasonic Energy Company President Naoto Noguchi presented Tesla CTO JB Straubel with the first lithium-ion cells from Panasonic's facility in Suminoe-ku, Osaka, Japan. On January 7, 2010, Tesla and battery cell maker Panasonic announced that they would together develop nickel-based lithium-ion battery cells for electric vehicles. The partnership was part of Panasonic's $1 billion investment over three years in facilities for lithium-ion cell research, development and production.

Beginning in 2010, Panasonic invested $30 million for a multi-year collaboration on new battery cells designed specifically for electric vehicles. In July 2014, Panasonic reached a basic agreement with Tesla to participate in battery production at Giga Nevada.

Tesla and Panasonic previously collaborated on the manufacturing and production of photovoltaic (PV) cells and modules at the Giga New York factory in Buffalo, New York. The partnership started in mid-2017 and ended in early 2020, before Panasonic exited the solar business entirely in January 2021.

Spodumene Concentrate

In September 2020, Tesla signed a sales agreement with Piedmont Lithium to buy high-purity lithium ore for up to ten years, specifically to supply “spodumene concentrate” ('SC6') from Piedmont's North Carolina mineral deposit to Tesla.

Digital Mock-Up

Digital Mock-Up or DMU is a concept that allows the description of a product, usually in 3D, for its entire life cycle. Digital Mock-up is enriched by all the activities that contribute to describing the product. The product design engineers, the manufacturing engineers, and the support engineers work together to create and manage the DMU. One of the objectives is to have an important knowledge of the future or the supported product to replace any physical prototypes with virtual ones, using 3D computer graphics techniques. As an extension it is also frequently referred to as Digital Prototyping or Virtual Prototyping. These two specific definitions refer to the production of a physical prototype, but they are part of the DMU concept. DMU allows engineers to design and configure complex products and validate their designs without ever needing to build a physical model.

Among the techniques and technologies which make this possible are:

- The use of light-weight 3D models with multiple levels of detail using lightweight data structures such as JT XVL and PDF allow engineers to visualize, analyze, and interact with large amounts of product data in real-time on standard desktop computers.
- Direct interface to between Digital Mock-ups and PDM systems.
- Active digital mock-up technology that unites the ability to visualize the assembly mock-up with the ability to measure, analyze, simulate, design and redesign.

Prototype Development

A prototype is a draft of a product that gives you the ability to explore your idea and demonstrate features before investing in the product's complete development. A prototype can range from a detailed drawing with pen and paper to a fully working version of the product.

Prototyping usually goes through a series of phases. A designer typically sketches a few ideas, often on paper or even on a napkin, before prototyping begins. Although the number of stages may vary, there are usually five prototype stages, followed by the final matured version of the product:-

Appearance Model: This may be a series of finely detailed drawings or a model made of foam or cardboard to demonstrate how the product will look.

Proof of Concept: This is an assembly of components to demonstrate how the product will work. It often doesn't resemble the finished product at all.

Alpha Prototype: A finely crafted, early version of the product.

Beta Prototype: An enhanced version of the product that closely resembles how the final product will look and work. Software companies often refer to this as beta testing.

Pilot Production: A limited run using normal production equipment to be used for fine-tuning of the product and production procedures.

Matured Product: The final version of the product that is ready to ship to customers.

Design for Environment

The world cannot reduce CO2 emissions without addressing energy generation and consumption. And the world cannot address its energy habits without directly reducing emissions in the transportation and power sectors. This issue is Tesla's entire reason for existing. We are focused on creating a complete power and transportation ecosystem from solar generation and energy storage to all-electric vehicles. The first step in our Master Plan was to build an all-electric sports car (the Tesla Roadster) to prove that people didn't need to compromise performance, speed or comfort to drive all-electric. From there, we designed the world's first-ever premium all-electric sedan from the ground up, Model S, our Model X SUV, and an affordable vehicle for the mass market, Model 3. As part of Master Plan, Part Deux, we introduced Tesla Semi, an all-electric truck that delivers massive savings in energy costs, performance, efficiency and reliability.

Over 550K Tesla vehicles have been sold, and they have driven over 10B miles to date, resulting in a combined savings of over 4M metric tons of CO2. This is the equivalent of saving emissions from being released into the environment from over 500K ICE vehicles with a fuel economy of 22 miles per gallon (MPG).

Tesla's Supercharger network — the fastest and most extensive charging network in the world has delivered over 595 Giga watt hours (GWHs) of energy, saving the equivalent of over 75M gallons of gasoline. That's enough gasoline for the average ICE vehicle with a fuel economy of 22 MPG to travel round trip from Los Angeles to New York City over 290K times.

Marketing Collateral

Marketing collateral is any media material used to promote the sales a company's products or services. This includes everything from print materials like posters, brochures, sales promotion banners, product data sheets and flyers to digital content like website content, catalogs and e-magazines. Anything you can use to communicate your company's brand message is considered marketing collateral.

One rarely cited reason is the company's remarkable sales strategy. Let's look at the marketing strategy of Tesla Inc.:-

A Tesla showroom is a place to experience the vehicles rather than to buy them. In fact, you couldn't buy one there even if you wanted to; you need to do it online. If you've indicated in the store that you're interested in purchasing a vehicle, you'll receive details via email about how to order it online.

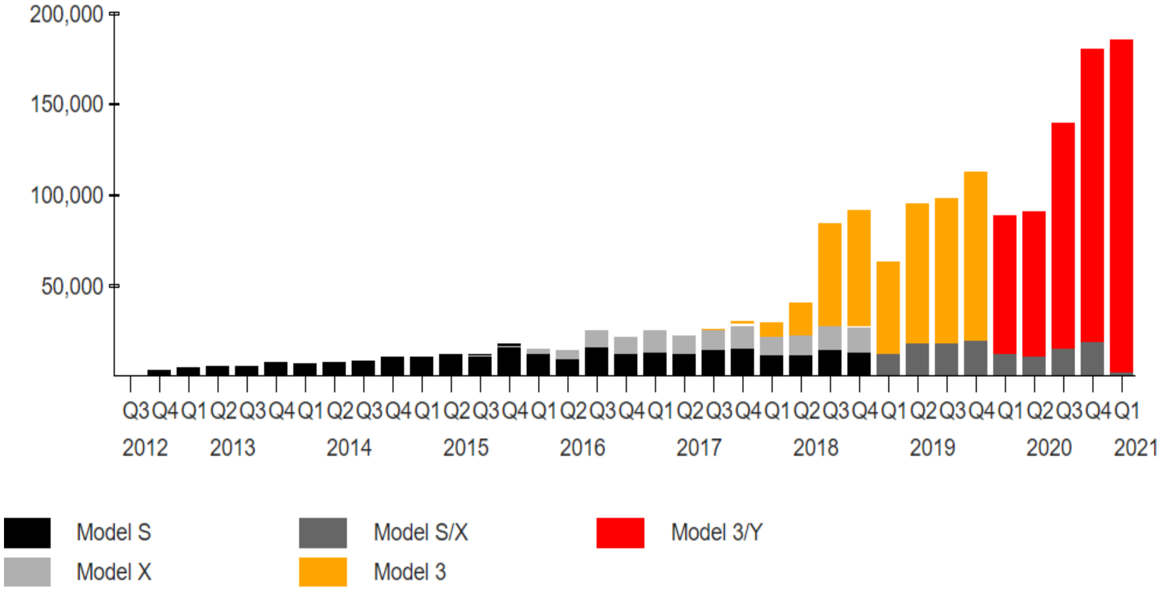
When you step inside a Tesla store, it's incredibly reminiscent of another tech giant's retail locations; Apple. And that's no accident. In 2010, Tesla recruited George Blankenship from Apple to lead the company's retail experience. He was the Vice President of Real Estate for Apple from 2000 to 2006. He explained that the purpose of a Tesla showroom isn't to sell, but to educate consumers about why an electric vehicle is a better choice for them.

In keeping with its sales strategy, in any one of these Tesla retail locations, there are no typical salesmen. Instead, there are product specialists and brand ambassadors who don't receive commission for each sale they generate. This frees them up to ensure that they can give consumers the very best experience possible. Also, as Tesla's vehicles are made to order, there is no inventory that must be sold as fast as possible.

Tesla CEO Elon Musk has also revealed his master plan for making electric cars which is as follows:-

“So, in short, the master plan is:

1. Build sports car.
2. Use that money to build an affordable car.
3. Use *that* money to build an even more affordable car.
4. While doing above, also provide zero emission electric power generation options.”



Sales of various Tesla electric cars from 2012-2021

Virtual testing and Validation

A recent statement by Tesla Inc. CEO Elon Musk has auto insiders wondering if the electric car maker has found a better way to test and validate vehicles, or if it is embarking on a risky new course.

In the statement made on an exclusive investor-only call last week, Musk reportedly suggested that the beta test phase of the company's moderately-priced Model 3 EV is being shortened, and that its "early release candidates" are already being built on production tooling. According to various electric car websites, such as Elektrek, Tesla engineers used sophisticated design-for-manufacturability analytics, enabling them to limit the number of pre-production iterations of the vehicle. The result is that the quality of the so-called "release candidates" is higher than it was for the company's earlier products, the Model S and Model X.

Tesla has conducted various tests like drop resistance, toughness, deformation, impact resistance, friction, motion test, stiffness, heating and ventilation on its electric cars and their cars passed all the tests and met the customers expectations.

Jeff Hickenthier, the quality inspector of Tesla Inc.

CHAPTER 3

DIGITAL MANUFACTURING

Digital Manufacturing

Digital Manufacturing is an approach involving people, process/practice, and technology that uses PLM information to plan, engineer, and build the first instance of a product; ramp that product up for volume production; and produce, monitor, and capture for other aspects of the lifecycle the remaining instances of that product's production using the minimum amount of resources possible.

The manufacturing function can be simplified into the following stages are:

1. Manufacturing the first one (Producing the first product).
2. Ramp up (Ramp up production).
3. Manufacturing the rest (Producing or building the rest of the products).

Manufacturing First Component

Manufacturing the first product is the first stage of the manufacturing process. The manufacturing function is completely responsible for defining the process that actually manufacture the product. There are various areas where digital manufacturing can be employed at this stage as follows :-

♦ Process, planning and reuse.

♦ Machine tool, fixture development and process.

♦ Robotics and PLC simulation and programming.

♦ Ergonomics.

<u>Process Planning and Reuse</u>: Process planning is a preparatory step before manufacturing, which determines the sequence of operations or processes needed to produce a part or an assembly.

• In a company like Tesla Inc. where manufacturing and production is the main objective, this process planning step plays a major role.

• Reusable processes are the manufacturing equivalent of reusable parts in the design and engineering function. In Tesla Inc. reusability is a main factor because it helps them to recycle parts and saves money, material, energy and time.

• The outputs of the process planning step are: route sheet and operations sheet. A route sheet is a document which lists the exact sequence of operations needed to complete the job. Route sheets are useful for production planning.

• Below is an example of a routing and characteristics sheet of one of the products of Tesla Inc.:-

Daily Powerwall Home Battery

TESLA

The Daily Powerwall is a wall-mounted battery pack intended for residential or commercial use. It is a rechargeable lithium-ion battery pack designed to provide energy storage for home backup power, load shifting, solar self-consumption, or any high throughput applications. The battery pack's electrical interface is provided by an isolated bi-directional DC/DC converter intended to provide a constant power DC link for integration with solar grid-tie DC/AC inverters.

Electrical Specifications

Power, continuous & peak	3.3 kW
Energy*	6.4 kWh
DC Voltage	350V-450V
DC Current, continuous & peak	9.5 A
Insulation Coordination	Overvoltage Category III on a 277/480V system
Round Trip Efficiency (Beginning of Life)*	92.5% (for a 400V-450V DC bus)

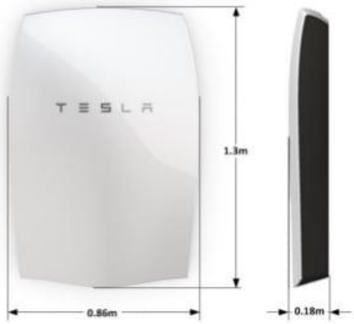
*Values provided for 25°C, 2kW charge/discharge power

Environmental Specifications

Operating Temperature	-20°C to 50°C Humidity: <95% condensing
Storage Conditions:	
<24 hours	-30°C to 60°C, <95% RH
<1 month	-20°C to 45°C, <95% RH
<12 months	-20°C to 30°C, <70% RH non-condensing, SOE: 50% initial
Altitude	3000m
Impact Rating	IK09
Ingress Rating	IP35 & NEMA 3R (full Pack) IP67 (battery Pod)

Mechanical Specifications

Dimensions	L: 1300 mm W: 860 mm D: 180 mm
Weight	95 kg



Version 1.2

<u>Machine, tool, fixture development and process:</u> There are two different cases of this:-

- The first case is when the machines and tools are given.
- The second case is when the machines and tools are to be designed and built as part of the manufacturing process.

In Tesla Inc. the main products are bicycles and they are manufactured after the parts are designed.

The company uses simulation software to test and make improvements in product and this in return saves us time, energy and material.

Robotics and Programming work: The programming work and automation is completely involved in all the vehicles of Tesla mainly in the Autopilot and Full-self driving system. Some of the key points are discussed below:-

Hardware

Build silicon chips that power our full self-driving software from the ground up, taking every small architectural and micro-architectural improvement into account while pushing hard to squeeze maximum silicon performance-per-watt. Perform floor-planning, timing and power analyses on the design. Write robust, randomized tests and scoreboards to verify functionality and performance. Implement compilers and drivers to program and communicate with the chip, with a strong focus on performance optimization and power savings. Finally, validate the silicon chip and bring it to mass production.

Neural Networks

Apply cutting-edge research to train deep neural networks on problems ranging from perception to control. Our per-camera networks analyze raw images to perform semantic segmentation, object detection and monocular depth estimation. Our birds-eye-view networks take video from all cameras to output the road layout, static infrastructure and 3D objects directly in the top-down view. Our networks learn from the most complicated and diverse scenarios in the world, iteratively sourced from our fleet of nearly 1M vehicles in real time.

Autonomy Algorithms

Develop the core algorithms that drive the car by creating a high-fidelity representation of the world and planning trajectories in that space. In order to train the neural networks to predict such representations, algorithmically create accurate and large-scale ground truth data by combining information from the car's sensors across space and time.

Code Foundations

Throughput, latency, correctness and determinism are the main metrics we optimize our code for. Build the Autopilot software foundation up from the lowest levels of the stack, tightly integrating with our custom hardware. Implement super-reliable bootloaders with support for over-the-air updates and bring up customized Linux kernels. Write fast, memory-efficient low-level code to capture high-frequency, high-volume data from our sensors, and to share it with multiple consumer processes— without impacting central memory access latency or starving critical functional code from CPU cycles. Squeeze and pipeline compute across a variety of hardware processing units, distributed across multiple system-on-chips.

Evaluation Infrastructure

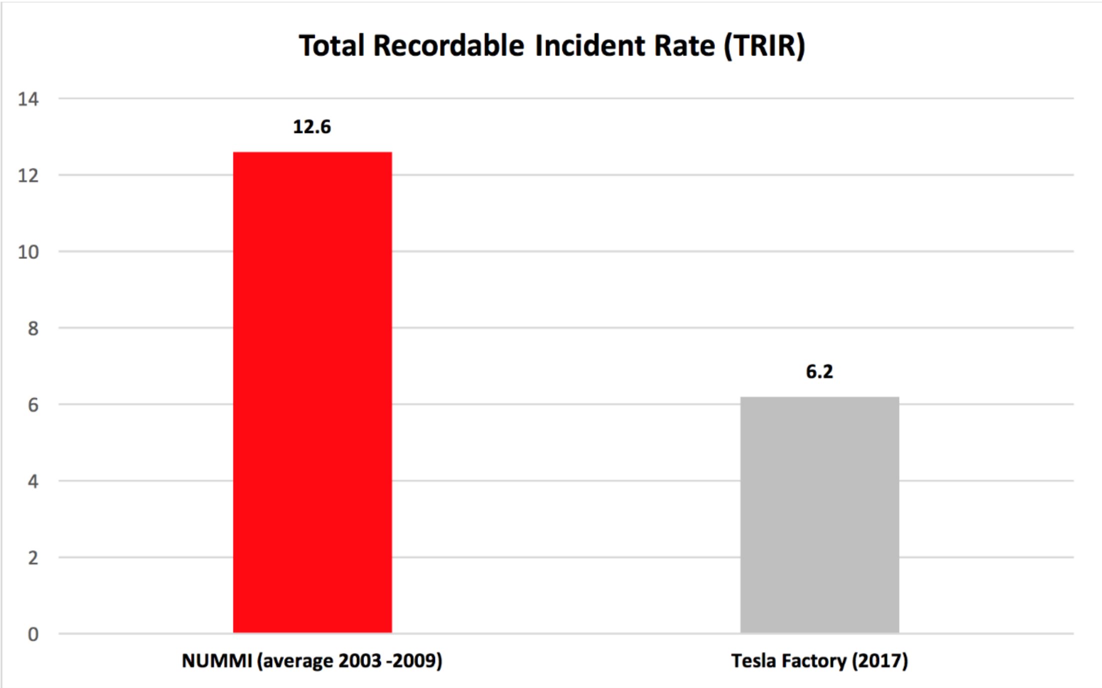
Build open- and closed-loop, hardware-in-the-loop evaluation tools and infrastructure at scale, to accelerate the pace of innovation, track performance improvements and prevent regressions. Leverage anonymized characteristic clips from our fleet and integrate them into large suites of test cases. Write code simulating our real-world environment, producing highly realistic graphics and other sensor data that feed our Autopilot software for live debugging or automated testing.

Ergonomics: The company is well designed and follows an ergonomic approach so that the employees will have a good environment to work and produce maximum output.

They're taking a proactive approach to safety, which means everything from focusing on ergonomics and having the right safety equipment and controls, to ensuring everyone is constantly thinking about the hazards that can creep into everyday work and how to mitigate them.

Second, Tesla has significantly improved safety in a very short period of time. While Tesla only started building its own cars in volume just over five years ago, it has achieved industry-average safety and is on a short path towards safety that is far better than that.

Between 2016 and 2017 alone, while Tesla's vehicle production increased 20%, both our rate of injuries and the average severity of injuries declined significantly.



When injuries do happen, we must make sure we're taking good care of our people, which is why we've taken a major step forward with our workplace injury Return to Work program.

When an employee is injured at Tesla and unable to perform their normal duties, work restrictions are put in place. In our previous program, when the injured worker was not able to continue working in their regular department, they were assigned to a less demanding job to help accommodate their injury so they can recover. In that situation, the employee was paid the wage that was associated with that new job and they could collect disability or workers compensation payments through our insurance provider to help fill the gap.

Finally, we're continuing to improve our production processes, and we've made significant strides since the days of ramping production of Model X, which wasn't designed for ease of manufacturing.

While we continue to hire and grow our workforce, the number of labour hours needed to complete a vehicle has decreased 33% since early 2016. Previously, it took three shifts with considerable overtime to produce Model S and Model X. Now, even with production of those vehicles having increased in 2017 to 100,000, it can be done with only two shifts and minimal overtime.

Ram Up Production

In business, ramp-up is a term that describes a significant increase in the output of a company's products or services. Essentially, ramp-up implies bringing the company's capacity utilization close to maximum. It can be achieved through substantial capital expenditures or improvements in product development, and triggered by a company entering new markets or geographic locations.

Usually digital manufacturing focuses on removing this stage since this is not economical and most of the companies are not ready to afford for this stage.

Tesla Inc. also use a ramp-up procedure and as compared to the other automobile sector companies, its quite good but as the company proceeds to grow this stage starts to become a vital part. And here digital manufacturing plays a very crucial role.

Manufacturing the rest

Digital manufacturing plays a critical role in manufacturing the first product and attempts to eliminate manufacturing ramp up, it needs to continue to play an instrumental role in manufacturing the rest of the products.

Digital Manufacturing applications are the source of information that can be used to replace wasted time, energy, and material as products continue to flow through the factory. Digital Manufacturing has information about how the products should be manufactured.

It can use that information both to compare against the actual production of products and to capture information about the actual production for use in other stages of the product's lifecycle.

Areas that Digital Manufacturing can play a part in are planning the production in the factories, assisting in the actual production by providing production information as required, monitoring and auditing the production process against the specifications, and capturing exactly how the product was built for future use.

As the first two stages are done this becomes a simpler part of the process however this also requires focus since this stage is more involved in evaluating the product and also it gives space for new ideas to evolve.

Thus **Tesla Inc.** is extremely good at producing products involving high precision and also has a good response to service.

CHAPTER 4

CONCLUSION

Conclusion

Electric vehicles are anticipated to be a key future component of world’s mobility system, helping reduce impacts on climate change and air quality. There is, therefore, an increasing need to understand EVs from a systems perspective. This involves an in-depth consideration of the environmental impact of the product using life cycle assessment (LCA) as well as taking a broader 'circular economy' approach. On the one hand, LCA is a means of assessing the environmental impact associated with all stages of a product's life from cradle to grave: from raw material extraction and processing to the product's manufacture to its use in everyday life and finally to its end of life. On the other hand, the concept of a circular economy considers impacts and in turn solutions across the whole societal system. In a traditional linear economy, products are made, used and then disposed of.

Electric vehicles can be seen as future alternative and this vision is made possible by Tesla.