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STRATEGIC ANALYSIS OF RECENT DEVELOPMENTS IN AUTOMOBILE ENGINEERING AND TECHNOLOGY

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Abstract

Automotive engineering is a department of applied science, which deals with designing, developing, and production ground automobiles. Vehicle improvement is an interdisciplinary optimization trouble issue to many layout criterions, which are frequently struggle with each different. In the development of a new automobile, foremost layout criterions are defined due to gasoline consumption, car protection, crashworthiness, and durability, journey comfort, dealing with behaviors, ergonomics, and aerodynamics and NVH principles. The competitive nature of car industry forces original equipment manufacturers (OEMs) to make important selections among these design parameters.

Keywords: - NVH, OEMs, Industry, Climate Changes, NHTSA

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INTRODUCTION

Due to environmental and power concerns, gas intake is the foremost layout parameter. Transportation nevertheless depends on fossil fuels. In 2016, gas and diesel contributed 92% of the overall energy used in transportation. The use of bioethanol and biodiesel is ready %5. The contributions of Herbal gasoline and power are 3% and 1%, respectively. All over the world, 67% of worldwide oil is consumed for transportation. By 2050, a 70% growth in oil demand and a 130% rise in CO2 emissions are predicted. It is envisioned that those emission values could boom global common temperature by way of 6°C, which might also bring about irreversible climate trade. Intergovernmental Panel on Climate Change (IPCC) gives that CO2 emissions have to be decreased by 85% to maintain the boom inside the worldwide average temperature to underneath 2°C. For sustainable transport and decreased CO2 emissions, the use of opportunity fuels, electric powered and hybrid cars are promoted (Taylor, 2010; Heberle et al., 2012; Chang et al., 2017). In reality, the sale of fossil gas motors is deliberate to be phased out in the close to future. Norway introduced that the use of fuel and diesel cars can be banned with the aid of 2025 (The Independent, 2017). France and Britain plan to prohibit the sale of fossil gas cars by 2040 (Environs, 2017) Current research on complete electrical motors and hybrid electric vehicles goals to limit the electricity call for of automobile and to optimize the strength control strategy. In these automobiles the powertrain is replaced through electric automobiles, power electronics, capacitors and battery systems. The electrical device dynamically interacts with the mechanical elements of the automobile. This interplay has to be optimized situation to the overall performance and power consumption.

Either equipped with internal combustion engines or electric powered cars, the fashion is to construct lighter and greater energy efficient automobiles. Lightweight substances are one of the foremost research subjects in car engineering. Although a spread of different substances, such as glass, plastics, rubber, and special fibers are used inside the creation of an automobile, the big contribution to the overall weight is made by way of metals. In order to reduce the thickness of sheet metals, advanced excessive power steels are developed (Nehru’s et al., 2014; Hardwick & Totteridge, 2016). To lessen the entire weight, aluminum and magnesium alloys also are used in the production of vehicle bodies (Gecko, 2014; Hirsch, 2014; Joust & Krajewski, 2017). When as compared to the options, low-carbon metallic has advantages of low price, ease of manufacturing, extensive availability, use of present manufacturing centers and layout flexibility. Recent studies offers some other opportunity lightweight materials, which includes novel polymers (Lye & Choi, 2015) and natural fiber bolstered composites (Srinivas et al., 2017).

Autonomous car technology objectives to reduce site visitor’s accidents and to lessen power intake and air pollution (Bagloee et al. 2016) Autonomous vehicle era has different ranges, as cautioned through National Highway Traffic Safety Administration (NHTSA, 2013). The highest level is defined as Level 4, i.E., the vehicle drives itself without a human motive force (Anderson et al., 2014). Autonomous vehicle era interacts with other technology, inclusive of automotive electronics, Human-device interaction (HMI) systems, vehicle networks and automotive protection (Fleming, 2015). To reduce the computational value, fault-tolerant characteristics, and modularity of the whole gadget, extraordinary machine architectures are presented inside the literature (Jo et al, 2014). It continues to be no longer clear who may be responsible, whilst an independent car crashes. Hence, self-reliant car generation is likewise a proper challenge for legislative law (Geist Feld, 2017).

Yet every other vital subject matter in automotive engineering is noise, vibration and harshness (NVH). The mechanism of noise and vibration is the identical within the manner that each of them arise thru oscillatory motions. In vehicles, the resources and potential solutions are very comparable for indoors and exterior noise. Exterior noise problems, including pass-through-noise and traffic noise are regulated because of regulation. On the alternative hand, interior noise great and comfort come into question in particular because of customer expectations and opposition among OEMs (Sheng, 2012). New developments, including utilizing lightweight substances and reducing the thickness of sheet metals outcomes in negative noise and vibration pleasant. Electrical and hybrid vehicles introduce lesser-recognized and specific varieties of NVH problems (Cao et al., 2016).

In the ultimate decade, car electronics swiftly have become the predominant driving force in new car tendencies (Ribbons, 2017). Beside the industry leaders, Google, Tesla, Lucid and Apple also race for electric powered self-sustaining car market (Fleming, 2015). The new tendencies in car electronics, together with independent vehicle era, human gadget interaction, car networks and car safety require a wholly one-of-a-kind system structure and development process than are pursued nowadays for OEMs. In this bankruptcy, recent tendencies in automobile engineering are addressed. New traits and directions for future studies are mentioned.

ELECTRIC AND HYBRID VEHICLES

Electric vehicles can be labeled into 3 sorts as tabulated in Table 1: hybrid electric powered cars (HEVs), plug-in electric automobiles (PHEVs) and complete electric powered motors (FEVs). HEVs are ready with an internal combustion engine (ICE) and an electric powered motor. In these motors, the primary source of strength is an ICE that runs on fossil or alternative fuels. In HEVs, the electrical motor uses electricity within the battery, that's provided via regenerative braking and thermoelectric mills (Hartley et al., 2010). HEVs are designed for gasoline efficiency and coffee emissions (Penang & Bannister, 2017). As wonderful from HEVs, PHEVs may be plugged in to an electric electricity supply to rate the battery. Different varieties of hybrid device configurations, which include collection, parallel and complete hybrid systems are being used within the enterprise (Hanna et al, 2014). The Frisker Karma is an instance of a chain gadget PHEV. The Toyota Prius, the Chevy Malibu and the Honda Insight are some examples of parallel hybrid structures, which can be commercially available. In the parallel hybrid system, the electric motor and ICE can perform collectively or personally. Full hybrid machine is a aggregate of collection and parallel hybrid structures. The configuration of a complete hybrid machine and Toyota Prius II powertrain system are proven in Figure 1 and Figure 2, respectively. In this machine, tools container, alternator and starter motor are changed with the aid of electric powered motor and generator. In this configuration, strength splitter device acts as a 2d differential.

Table 1. Types of electric and hybrid vehicles

Vehicle type	**Powertrain**	**Battery charging**
Hybrid electric vehicle (HEV)	ICE + electric motor	Internal
Plug-in hybrid electric vehicle (PHEV)	ICE + electric motor	Internal + external
Full electric vehicle (FEV)	Electric motor	External

FEVs do no longer have an ICE; the electricity is furnished through electric motor(s) most effective. Due to environmental and power issues, those zero-emission vehicles are gaining expanded interest. To update the traditional fossil fuel cars, FEVs need to meet some expectations, like high electricity, excessive torque and an inexpensive variety. Beside a most advantageous electricity control method, the important thing capabilities for FEVs are the electrical motor and the battery (Darrell et al., 2014). Permanent magnet (PM) electric automobiles are the maximum green alternatives (Bolder, 2014). These vehicles are prepared with uncommon-earth everlasting magnets, like samarium cobalt and neodymium-iron-boron magnets. Samarium cobalt magnets offer better working temperatures (up to 500°C) than neodymium-iron-boron magnets (Long et al., 2008). On the opposite hand, neodymium-iron-boron magnets offer the most performance. However, the usage of uncommon- earth permanent magnets must be decreased in terms of sustainability (Steven, 2015). Important physical residences of the everlasting magnets may be observed within the Standard: MMPA-0100 (MMPA, 2000).

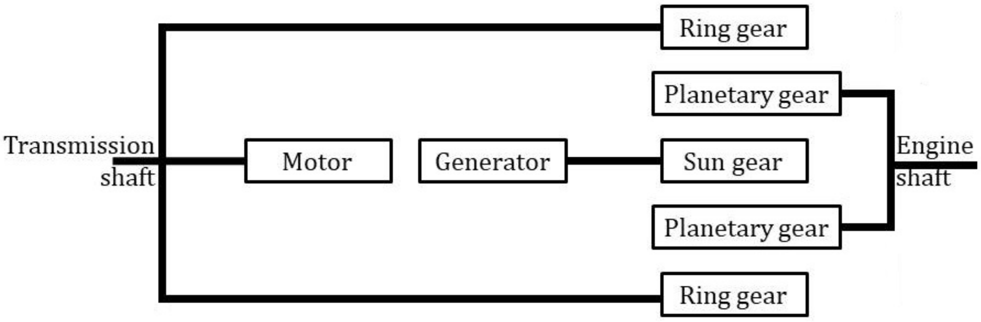


Figure 1. The configuration of a full hybrid system

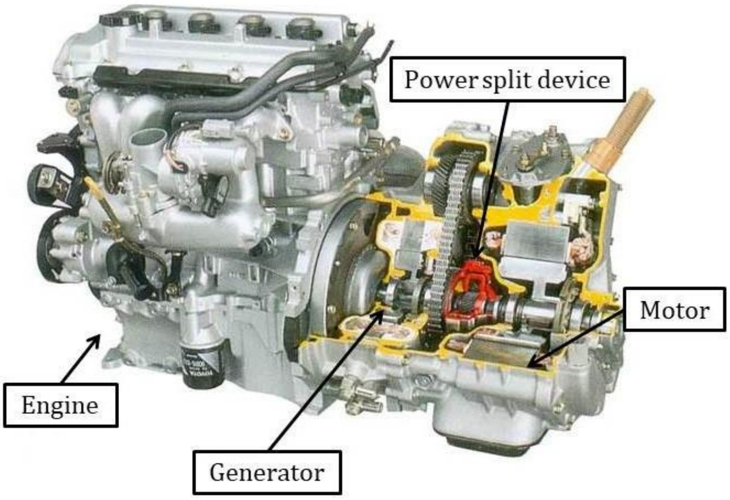


Figure 2. Toyota Prius II hybrid powertrain (Courtesy of Toyota Motor Co.)

To be hired in electric and hybrid automobiles, a variety of electric cars are advanced in recent years. More than a hundred distinctive electric powered cars can be determined in contemporary cars. Most commonplace styles of electric cars available inside the market are DC cars, multi-section AC induction vehicles, permanent magnet (PM) synchronous automobiles (or brushless AC automobiles), switched reluctance (SR) automobiles and brushless direct contemporary (BLDC) cars (Hashemnia & Asabi, 2008 De Santiago et al., 2012; Yıldırım et al., 2014; Kumar & Jain, 2014). The choice of electric motor type is important. In order to compete against the fossil fuel automobiles, a FEV has to efficaciously satisfy the following criteria:

- High torque cost
- Minimum torque ripple manage
- Low velocity hill climbing
- Overload and fault tolerant functionality
- Instant acceleration
- High pace cruise
- High efficiency over a huge torque-velocity range
- Regenerative braking gadget
- Operational controllability
- Temperature management

Table 2. Evaluation of electric motors used in the vehicle industry

Criteria	DC motor	AC induction motor	PM motor	SR motor
Power density	E	C	A	D
Efficiency	E	C	A	B
Speed	F	B	A	A
Torque density	E	D	A	C
Torque ripple	D	B	C	E
Overload capability	E	C	B	C
Controllability	A	A	C	E
Reliability	E	A	C	B
Service time	D	A	C	B
Maturity	A	B	C	D
Size and weight	E	C	B	C
Manufacturability	E	A	E	C
Cost	D	A	E	C

*DC: direct current, AC: alternative current, PM: permanent magnet, SR: switched reluctance

DC electric vehicles have high torque values at low speeds. They are strong and reliable, but the presence of mechanical commutators and brushes limits high motor velocity as a result of high friction. DC electric motors have a few other drawbacks, like low efficiency and high fee upkeep. Since the cited drawbacks broadly speaking originate from commentators, everlasting magnet brushless DC automobiles are evolved. They have high energy density, and they do not require protection. These automobiles provide excessive performance over a wide torque-velocity range.

Multi-section AC induction automobiles have important advantages, which includes high reliability, extensive torque-pace range, long service time, low torque ripple and occasional fee. The traits of these cars can be in addition advanced thru direct torque manipulate techniques (Bermudez et al., 2017).

Yet any other promising era is the switched reluctance (SR) electric powered motor. The top notch advantages of SR electric vehicles are: high performance over a extensive torque-speed range, smooth temperature management, excessive overload and fault tolerant functionality. A comparison of electric motor kinds is given in Table 2 (Zeraoulia et al, 2006; Kumar & Jain, 2014). The foremost traits of the electric vehicles used inside the automobile enterprise are graded from ‘A’ to ‘F’, wherein ‘A’ means the nice. Nevertheless, extraordinary OEMs make use of various styles of electric motors of their new models. Some examples of FEVs available in the market are tabulated in Table three. Switched reluctance vehicles aren't but widely used in FEVs. In those motors, torque is generated as a result of the appeal between the iron rotor and the electromagnet. Recently, many one of a kind design issues are provided in the literature to utilize the switched reluctance vehicles in electric vehicles (Moreno-Torres et al., 2016; Zhu et al., 2017; Diko et al., 2017, Gan et al., 2017).

Table 3. Examples of FEVs available in the market (2017)

OEM	Model	Electric motor	Power (kW)	Range (miles)
Tesla	Model 3	Induction motor	175	220-310
Tesla	Model S	Induction motor	235-345	400
BMW	i3	Induction motor	125	81-114
Mercedes-Benz	B-Class Electric	Induction motor	132	87
Lucid	Air	Induction motor	300-745	240-315
Toyota	RAV-4	Induction motor	115	103
Nissan	Leaf	Induction motor	80	124-155
Citroen	C-Zero	PM motor	49	93
Chevrolet	Bolt	PM motor	150	238
Ford	Focus Electric	PM motor	107	117
Hyundai	Ioniq	PM motor	88	124
Jaguar	I-Pace	PM motor	295	300
Kia	Soul EV	PM motor	81	93
Volkswagen	e-Golf	PM motor	100	125

Beside the traits of powertrain, battery modeling and charging problems are of prime significance. To improve strength storage structures, many new technologies for batteries, extremely-capacitors, and exceptional conducting magnetic systems were advanced. Energy density, reliability, life time and safety are the key design criterions in battery modeling. Among the others, lithium-ion batteries are the most promising excessive power storage devices. A type of lithium-ion batteries, which includes lithium cobalt oxide (LCoO2, LCO), lithium manganese oxide (LiMn2O4, LMO/Spinel), lithium iron phosphate (LiFePO4, LFP) and lithium nickel–manganese–cobalt oxide (LiNi1-y-zMnyCOzO2, NMC) are used in FEVs. Although the studies to improve lithium-ion batteries are occurring, it's far recognised that those batteries are about to reach their theoretical gravimetric electricity density restriction, that is 265 Wh/kg (Chen et al., 2012; Barchans et al., 2012; Footie et al., 2016). To enhance the range in keeping with hour of FEVs, strength garage systems with higher electricity density values are required. Lithium-sulphur (Li-S) battery is an first rate opportunity, which gives higher power density values, a better thermal control, advanced safety and lower fee. The theoretical gravimetric strength density of Li-S battery is two, 500 WH/ kg (Nazir et al., 2014). To make use them in FEVs, similarly research is wanted on fee behavior of Li-S batteries (Prop et al., 2016). Yet every other alternative is the lithium-air kind batteries, which have an energy density price of 11,000 Wh/kg (AL ankus, 2017). This price makes feel whilst as compared with the energy density of gas. The theoretical electricity density of gasoline is 13,000 Wh/kg. After losses, the practical energy density values of fuel and lithium-air battery are the same; it is 1, seven-hundred Wh/kg (Girishkumar et al, 2010) The difficulties for the sensible implementation of lithium-air batteries nonetheless need to be similarly investigated (Tan et al., 2017). For solid nation lithium-air batteries, there are still many critical challenges that have to be overcome, which include low unique capacity, low round-experience efficiency, bad price capability, and restrained cycling overall performance (Xu et al., 2017).

AUTOMOTIVE LIGHTWEIGHT MATERIALS

The use of light-weight substances in automobiles is first come into question inside the motorsport region. The Lotus Type 7 Elite of 1957 is the first quantity-manufacturing car ever constructed with fiberglass monologue construction. Using fiberglass, the reduce weight of the automobile is reduced to 660 kg. In 1963 and 1965, the Lotus driving force gained Formula One Grand Prix. In the subsequent years, the burden of the race motors is decreased constantly to acquire higher overall performance. In 1981, McLaren revolutionized the development of racing motors with the creation of Formula One’s first carbon fiber monologue production.

Today’s fantastically aggressive automobile market demands effective, stronger and more secure automobiles with lighter body-in-whites (BIWs). Lightweight vehicles show off better fuel efficiency and emissions overall performance. The correlation between the light-weight substances and the gasoline efficiency is step by step realized by way of the car users. OEMs evolved fuel-efficient powertrains and light-weight BIWs to meet the customer expectancies. Although electric vehicles do not want answers for fuel efficiency and emission values, they must additionally had been constructed the usage of light-weight materials as a way to atone for their heavy batteries. To lessen the full weight of motors, excessive strength steels (HSS), aluminum (Al), magnesium (Mg), glass fiber composites and carbon fiber strengthened polymer (CFRP) are used as opposed to low-carbon metallic (Taube & Luo, 2015, Pervez et al., 2016). Examples of some vehicles constructed the usage of lightweight materials are tabulated in Table four.

Table 4. Examples of some vehicles constructed using lightweight materials (2017)

Vehicle	BIW material	Curb weight (kg)
Audi A8L	Al	2,205
Mercedes-Benz SL	Al + HSS +Mg	1,740
Honda Acura NSX	Al	1,725
Cadillac CT6	Al + HSS	1,660
Tesla Model3	Al + HSS	1,609
BMW i8	Al + CFRP	1,567
Jaguar XE	Al + HSS	1,520
Chevrolet Corvette	Al	1,495
BMW i3	CFRP	1,195

*Al: aluminum, HSS: high strength steel, Mg: magnesium, CFRP: carbon fiber reinforced polymer

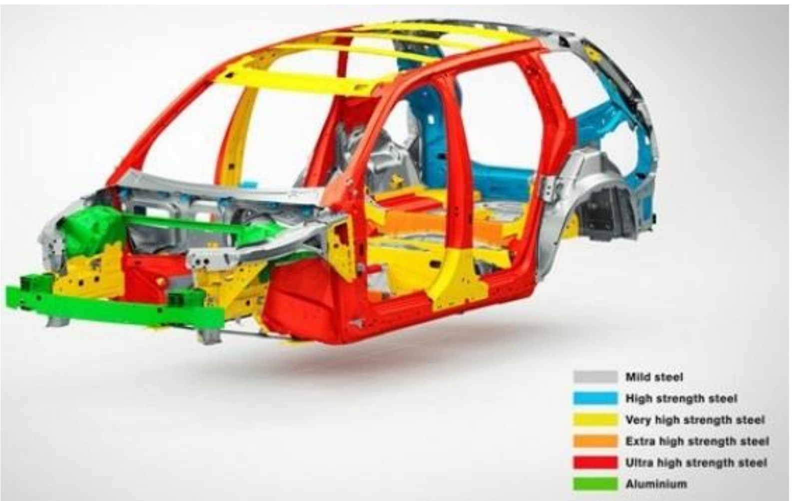
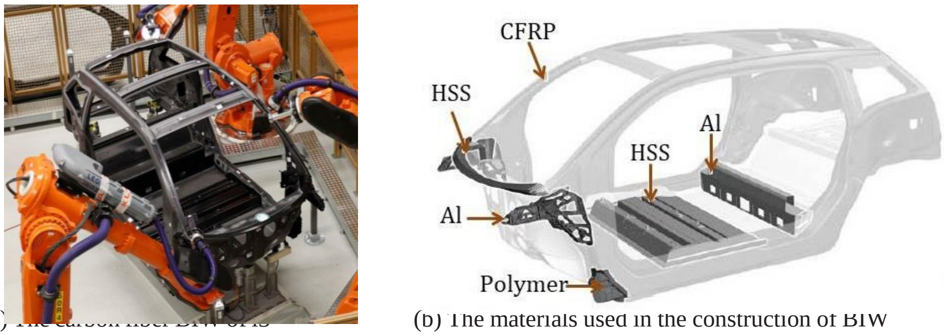


Figure 3. The materials used in new XC90 (Courtesy of Volvo Car Corporation)

Mg alloys are presently used by numerous agencies, specifically in solid components. The low creep residences, corrosion conduct and operating at improved temperature restrained more use of Mg in automotive packages (Kumar et al., 2015). Aluminum alloys are desired thanks to their noticeably low fee, ease of producing and suitable corrosion resistance (Hirsch, 2014). High overall performance polymers are typically used within the construction of newly advanced motors, consisting of electric and hybrid motors (Lyu & Choi, 2015). High strength metal has been usually utilized in automobiles to lessen the sheet thickness (Grajcar et al., 2012; Li et al., 2016). Volvo Car Corporation preferred to use a spread of high electricity steels and aluminum in the new XC90. In Figure 3, ultra-high power steel (shown in red) is the new-fashioned boron metal, which makes up about forty% of the total body weight (Volvo Car Corporation, 2017).

Due to their high strength to weight ratio, carbon fiber strengthened polymers (CFRP) are of specific interest to the automobile enterprise (Wu et al., 2014; Meek et al., 2016). The BIW of BMW i3 is manufactured from CFRP and lots of fittings are made from recycled or renewable materials. The substances used within the production of the i3 are shown in Figure 4 (BMW AG, 2017).



(a) The carbon fiber BIW of i3 (b) The materials used in the construction of BIW

Figure 4. The materials used in BMW i3 (Courtesy of BMW AG)

Substances, it's far feasible to reduce the total weight of a automobile as much as %45 (Mascara et al., 2015). With a Using light-weight affordable fee and relatively low technical threat, general weight of a automobile may be decreased at the order of 30%. To lessen the whole weight through 40%, carbon fiber and magnesium need to be significantly used within the creation of a complete automobile. A weight reduction of forty five% and more would require a few specific designs within the digital equipment and interior components of the automobile. Weight discounts and fee increases of the usage of light-weight materials are tabulated in Table five. Cost issues have up to now frequently prohibited the usage of lightweight substances (Heuss et al., 2012). Thus, attributable to value boom, OEMs typically use light-weight substances in the luxury automobile section (see Table 4). However, a massive price decline is anticipated in lightweight materials over the following decades (Holmes, 2017; Faruk et al., 2017).

Table 5. Weight reductions and cost increases of using lightweight materials

Lightweight material	Weight reduction (%)	Cost increase (%)
Carbon fiber	50-70	570
Magnesium	30-70	150
Aluminum	30-60	130
Ultra-high strength steel	15-25	125
Fiberglass	25-35	120
High strength steel	10-28	115

Currently, electric cars are fitted with large batteries; for example, the batteries in the Nissan Leaf and Tesla Model S weigh 300 kg and 544 kg, respectively. Battery weight is projected to be reduced as battery technology advances. Because of their particular energy values, lithium-sulphur (2,500 Wh/kg) and lithium-air (11,000 Wh/kg) batteries can lower the total weight of electric cars.

AUTOMOTIVE NOISE AND VIBRATION

Noise and vibration studies in the context of vehicle acoustics are commonly classified in different frequency regimes, such as low-frequency (20-200 Hz), mid-frequency (200-600 Hz), and high-frequency (600 Hz and beyond), and handled using various methods, such as experimental, computational, and hybrid considerations. One of the most essential study areas in the vehicle development process is interior and outside noise. Although the origins and possible remedies for interior and external noise are fairly similar, the major driving forces are not. Legislation regulates outside noise concerns such as pass-by noise and highway noise (ISO 362-1:2015). Interior noise quality and acoustic comfort, on the other hand, are mostly impacted by consumer expectations and OEM rivalry Vehicle indoors noise is made from each random history noise, which originates specially from road and wind inputs and discrete engine frequency components superimposed on the historical past noise (Jha, 1976). The frame-in-white (BIW) is the most complex vibratory system of a vehicle because of its huge variety of degree of freedom (DOF) (see Figure 5), and it's miles the principle a part of the noise evaluation analysis, considering the fact that it is the structure, which subsequently radiates the sound strength perceived by way of occupants. It is thought that the highest level of the dynamic reaction of a trimmed frame lies over the 70-two hundred Hz band for an ordinary passenger automobile prepared with an internal combustion engine (ICE) (Pried & Jha, 1970). In the sense of the human notion, the historical past noise is the determining parameter for the loudness of the inner noise, while the discrete frequency additives are the principle reason for the demanding experience (Shin et al., 2009). Although the excitation degree of different harmonics varies with engine pace, most essential resonances in the stated band are typically excited by way of only first few harmonics of the ICE (Labor & Priest, 2007). Deterministic element primarily based strategies, like finite element (FE) and boundary detail (BE) strategies are nonetheless the most appropriate strategies for predicting low-frequency noise and vibration (Fuchs et al., 2016). Statistical power evaluation (SEA) is usually utilized in high frequency regimes (Gurr et al., 2015). The design of mid-frequency variety is greater difficult. In this variety, the modal density values aren't excessive sufficient to provide you with an answer the usage of the SEA approach. On the other hand, the modal density values are not low sufficient to allow nicely-separated modes to conform, while deterministic strategies are hired. To cope with the mid-frequency issues, an expansion several strategies have been offered in the literature (Schaefer et al., 2017; Tiedemann et al., 2017; Yin et al., 2017).

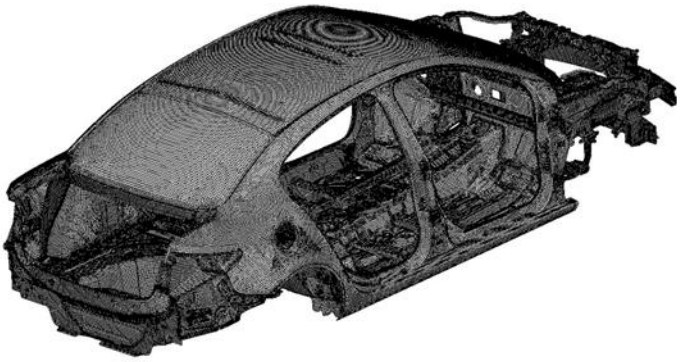


Figure 5. Finite detail version of the BIW used in vibrio-acoustic evaluation (>3 million DOF)

Experimental strategies, which include switch path analysis (TPA) and experimental modal analysis (EMA), are extensively utilized in NVH research (Octave, 2016). Experimental research isn’t most effective vital for verification, however in addition they complement the computational model, particularly for damping homes. Damping effect is embedded inside the complicated frequency reaction functions measured within the framework of a TPA look at, and it's far needed to be analyzed inside the put up processing step. Effects of damping, motives and methods to research them are mentioned in a latest look at (Oktav et al., 2017a).

The presence of extra cavities influences the vibro-acoustic models (Lee et al., 2011). It is shown that the presence of trunk hollow space substantially reduces the acoustic Eigen frequency of the first acoustic mode (Oktav et al., 2017b). When the trunk cavity and the cabin cavity are coupled acoustically, the openings that are designed as countermeasures to trunk lid slam noise behave as Helmholtz resonators, which regulate the acoustic mode shapes.

The resources of indoors and outside noise problems are special in full electric motors (FEVs). For the outdoors case, predominant noise assets that make contributions to skip-by way of-noise are ICE, intake gadget, exhaust device and tire/street device in traditional motors (Braun et al., 2013). The outside noise of FEVs especially consists of powertrain noise such as using motor and gearbox, tire noise and wind noise (Cao et al., 2016; Tousignant et al., 2017). Compared with the traditional vehicles, the sound pressure ranges of the pass-through-noise and site visitors’ noise for FEVs are a whole lot lower.

In contrast to conventional fossil gasoline automobiles, FEVs are an awful lot quieter underneath low-pace (underneath 30 km/h) running situations, such that pedestrians cannot observe their presence. In 2010, the Pedestrian Safety Enhancement Act (PSEA) requested the National Highway Traffic Safety Administration (NHTSA) to make a protection trendy requiring a warning sound for pedestrians to be emitted by way of all styles of electric and hybrid motors. A test widespread, specifically J2889/1-measurement of minimal noise emitted with the aid of avenue vehicles, is usually recommended by way of the Society of Automotive Engineers in 2011 (SAE Standard J2889-1: 2011). This fashionable is followed by way of NHTSA, as nicely (Konet et al., 2011). In accordance with the pointers, today electric powered and hybrid vehicles emit caution sounds to alert pedestrians to their presence.

Electric motor noise consists of aerodynamic, electromagnetic and mechanical noises (DuPont et al., 2013; Gurav et al., 2017). Aerodynamic noise, that's predominant at higher motor speed, regularly arises around the fan or an equal system. As a result of switching operation of the energy electronic converter feeding the motor, electromagnetic noise is generated in the electric powered power gadget. The mechanical noise, which on the whole originates from the stator, is predominant on the intermediate speed of the powertrain.

Lennström et al. (2013) studied the relationship among the psychoacoustic metrics, the threshold of detecting the tones and the perceived annoyance in FEVs. Ma et al. (2017) used the measured A-weighted sound strain degree and 6 psychoacoustic parameters, particularly loudness, fluctuation energy, tonality, roughness, articulation index, sharpness, to describe the noise samples for goal assessment of sound first-class of a FEV. Using the statistical correlation of the noted six psychoacoustic parameters, Swart & Becker (2017) investigated the purchaser delight metric for FEV sound signatures. Critical NVH problems of FEVs are the excessive-frequency noise of the electric driveline and the vibrations of the auxiliary power unit and the air conditioner compressor (Guo et al., 2016). Chandrasekhar et al. (2017) investigated the torque ripple and whine noise in FEVs. They concluded that additional research are required to apprehend the function of the amplitude and section of cutting-edge harmonics and the complicated interaction of torque ripple and radial magnetic forces. Diez-Ibarbia et al. (2017) in comparison the effectiveness of two experimental techniques, particularly transfer route analysis (TPA) and operational switch course evaluation (OTPA) methods, using a FEV The look at reveals that the electrical motor paths have a main effect inside the low- and medium-frequency range, even as the suspensions paths are the foremost supply of noise inside the high-frequency variety. In every other observe, its miles shown that the shape-borne noise from the tire-road excitation acts as a first-rate contributor to the general indoors noise level, and the contributions from the electrical motor are exceedingly insignificant (Cao et al., 2016). As the above discussion indicates, FEVs showcase one-of-a-kind demanding noise issues, even though they're plenty quieter than the conventional motors. As understood from the literature, there may be no agreed method yet for the prediction and assessment of the noise tiers of FEVs, and therefore in addition research is wanted.

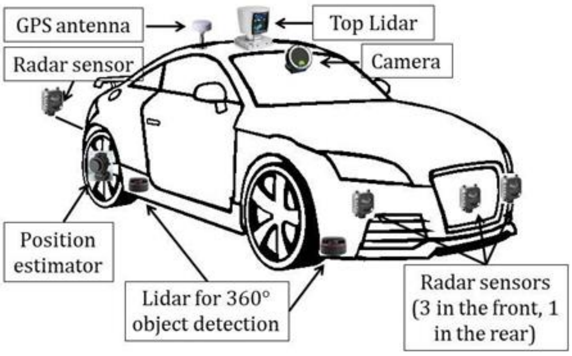
AUTOMOTIVE ELECTRONICS

Today modern-day cars are prepared with an extensive variety of sensors and microprocessors, several cyber-physical modules, an expansion of digital manage gadgets, in-vehicle conversation networks, and several hundred megabytes of software (Schulze et al., 2016; Ray et al., 2017). Automobiles aren't any extra just mechanical devices like within the beyond. They are unexpectedly becoming remaining electronic devices on wheels. The new tendencies in automobile electronics, which includes self-sustaining riding, in-vehicle infotainment, and software program architecture of complete electric powered automobiles require a completely one of a kind vision (Tummel et al., 2016). The journey to self-sufficient automobile era is begun with the improvement of collision-avoidance/warning and active cruise manage structures. Actually, those structures require automation of vehicle longitudinal/lateral manipulate tasks (Valid & Eskandarian, 2003). Then, it's far observed that those systems may be synthesized with the others to attain greater. OEMs and records technology groups have made a full-size funding in the commercialization of autonomous vehicles (Zheng et al., 2015). It is expected that those motors can be available on the market via 2020.

The sensors and technologies utilized in a self-sufficient car are shown in Figure 6. An self-sufficient vehicle should precisely recognize its location. GPS antennas utilized in those motors provide the place information as much as centimeter accuracy. The automobile need to be capable of make decision on a way to reach the determined destination. To acquire this, the Liar (light detection and varying) is hired. Liar illuminates a pulsed laser light and creates a 3-D map of the surroundings the usage of the reflected pulses. The automobile has to locate pedestrians, other cars, kerns, lanes, crosswalks and velocity bumps, as well (Zhu et al., 2017). In order to face those demanding situations, a high resolution digital, radar sensors and advanced using algorithms are hired.

Although many developments are executed, greater demanding situations are ahead for autonomous riding. The riding behavior of a self-sustaining vehicle is notably affected by the surrounding cars, different transferring items and environmental conditions. To clear up the trouble, vehicle-to-automobile (V2V), vehicle- to-pedestrian (V2P), vehicle-to-infrastructure (V2I), car-to-network (V2N), or in short car-to- the whole lot (V2X) conversation is needed. V2X verbal exchange improves avenue safety, availability of infotainment offerings and the performance of transportation systems. V2X communique structures require extraordinarily low latency with a completely high reliability, especially for the safety-related programs. V2X conversation must interface with the in-car community (Touchy et al., 2015). Ethernet will offer the spine for the following generation of in-car networks. Currently, the communique is primarily based on IEEE 802.11p, i.E., a protocol to add wi-fi access in vehicular environments. V2X need to fulfill stringent reliability, low latency, high records charges and larger communique variety even within the high dense road scenarios. Current research are focused at the evolution of LTE V2X and the rising 5G V2X technologies (Umar et al., 2016; Chen et al., 2017; Ashraf et al., 2017).

Figure 6. Sensors and technologies used in an autonomous vehicle



CONCLUSION

Although it is taken into consideration a conventional industry, it need to be remembered that the worldwide car enterprise has been the single greatest engine of the economic growth all over the international (Marche et al., 2014). Total 2017 worldwide light automobile income is expected to attain 93.5 million devices (IHS Market, 2017). The manufacturing of FEV will represent just % zero.7 of latest vehicle deliver globally in 2017. However, because of environmental and electricity issues, the decline of fossil gas automobile income percentage are accelerating faster, than anticipated. After greater than one hundred years of selling fossil fuel cars, the worldwide car industry now has to reshape itself to respond to the electric revolution. In the past decade, the worldwide automobile enterprise is grown by % 30. However, over the equal length, electronics and semiconductors are grown two and three fold, respectively (Strategy Analytics, 2017). The automotive industry has to keep up with these developments. In the next decade, most effective the OEMs which might be innovating in electric and self-sufficient automobile technologies could be the global leaders of the car enterprise.

REFERENCES

1. ADiez-Ibarbia, M. Battarra, J. Palenzuela, G. Cervantes, S. Walsh, M. De-la-Cruz, S. Theodossiades, L. Gagliardini, "Comparison Between Transfer Path Analysis Methods on an Electric Vehicle," *Applied Acoustics*, 118:83- 101, 2017.

2. A. Fotouhi, D.J. Auger, K. Propp, S. Longo, M. Wild, "A Review on Electric Vehicle Battery Modelling: From Lithium-Ion toward Lithium–Sulphur," *Renewable and Sustainable Energy Reviews*, 56:1008-1021, 2016.

3.A. Fuchs, E. Nijman, H.H. Priebsch, editors, "Automotive NVH Technology," Springer International Publishing, ISBN: 978-3-319-24053-4, 2016.

4.A. Grajcar, R. Kuziak, W. Zalecki, "Third Generation of AHSS With Increased Fraction of Retained Austenite for the Automotive Industry," *Archives of Civil and Mechanical Engineering*, 12(3):334-341, 2012.

5.A.I. Taub, A.A. Luo, "Advanced Lightweight Materials and Manufacturing Processes for Automotive Applications," *MRS Bulletin*, 40(12):1045-1054, 2015.

6.A. Mascarin, T. Hannibal, A. Raghunathan, Z. Ivanic, J. Francfort "Vehicle Lightweighting: 40% and 45% Weight Savings Analysis: Technical Cost Modeling for Vehicle Lightweighting," Idaho National Laboratory, Report No. INL/EXT--14-33863, USA, 2015.

7.A. Oktav, "Experimental and Numerical Modal Analysis of a Passenger Vehicle," *International Journal of Vehicle Noise and Vibration*, 12(4):302-313, 2016.

8.A. Oktav, Ç. Yılmaz, G. Anlaş, "Transfer Path Analysis: Current Practice, Trade-Offs and Consideration of Damping," *Mechanical Systems and Signal Processing*, 85:760-772, 2017a.

9.A. Oktav, Ç. Yılmaz, G. Anlaş, "The Helmholtz Resonator Effect of the Trunk Cavity in the Acoustic Response of a Sedan," SAE Technical Paper No. 2017-01-1842, 2017b.

10.A.P. Hardwick, T. Outteridge, "Vehicle Lightweighting Through the Use of Molybdenum-Bearing Advanced High-Strength Steels (AHSS)," *The International Journal of Life Cycle Assessment*, 21(11):1616-1623, 2016.

11.A. Vahidi, A. Eskandarian, "Research Advances in Intelligent Collision Avoidance and Adaptive Cruise Control," *IEEE Transactions on Intelligent Transportation Systems*, 4(3):143-153, 2003.

12.B. Fleming "Advances in Automotive Electronics," *IEEE Vehicular Technology Magazine*, 10(4):4-13, 2015.

13.BMW i3, homepage of BMW AG, 2017, https://www.bmw.com/en/all-models/bmw-i/i3/2016/at-a-glance.html, (accessed on July 30, 2017)

14.C. Barchasz, F. Molton, C. Duboc, J.C. Leprêtre, S. Patoux, F. Alloin, "Lithium/Sulphur Cell Discharge Mechanism: An Original Approach for Intermediate Species Identification," *Analytical Chemistry*, 84(9):3973-3980, 2012.

15.C. Gan, J. Wu, Y. Hu, S. Yang, W. Cao, J.M. Guerrero, "New Integrated Multilevel Converter For Switched Reluctance Motor Drives In Plug-In Hybrid Electric Vehicles With Flexible Energy Conversion," *IEEE Transactions on Power Electronics*, 32(5):3754-3766, 2017.

16.C. Ma, C. Chen, Q. Liu, H. Gao, Q. Li, H. Gao, Y. Shen, "Sound Quality Evaluation of the Interior Noise of Pure Electric Vehicle Based on Neural Network Model," *IEEE Transactions on Industrial Electronics*, (in press), 2017.

17.D. Dorrell, L. Parsa, I. Boldea, "Automotive Electric Motors, Generators, and Actuator Drive Systems with Reduced or No Permanent Magnets and Innovative Design Concepts," *IEEE Transactions on Industrial Electronics*, 61(10):5693-5695, 2014.

18.D.J. Swart, A. Bekker, "The Investigation of a Consumer Satisfaction Metric for Electric Vehicle Sound Signatures," The Journal of the Acoustical Society of America, (in press), 2017.

19.D. Lennström, T. Lindbom, A. Nykänen, "Prominence of Tones in Electric Vehicle Interior Noise," International Congress and Exposition on Noise Control Engineering, 15-18 September 2013, Innsbruck, Austria, 508-515, 2013.

20.D.S. Kumar, C.T. Sasanka, K. Ravindra, K.N.S. Suman, "Magnesium and Its Alloys in Automotive Applications–A Review," *American Journal of Materials Science and Technology*, 4(1):12-30, 2015.

21.Environews Nigeria 2017, http://www.environewsnigeria.com/carbon-neutrality-france-sets-2040-datephase-fossil-fuel-powered-vehicles/ (accessed on July 07, 2017)

22.F. Marchiò, B. Vittorelli, R. Colombo, “Automotive Electronics: Application & Technology Megatrends,” *40th European Solid State Circuits Conference (ESSCIRC 2014),* 22-26 September 2014, Venice, Italy, 23-29, 2014.

23.F. Nehuis, S. Kleemann, P. Egede, T. Vietor, C. Herrmann, “Future Trends in the Development of Vehicle Bodies Regarding Lightweight and Cost,” Innovative Design, Analysis and Development Practices in Aerospace and Automotive Engineering, Springer, New Delhi, 13-21, ISBN: 978-81-322-1870-8, 2014.

24.G. Girishkumar, B. McCloskey, A.C. Luntz, S. Swanson, W. Wilcke, “Lithium− Air Battery: Promise and Challenges,” *The Journal of Physical Chemistry Letters*, 1(14):2193-2203, 2010.

25.G. Sheng, “Vehicle Noise, Vibration, and Sound Quality,” SAE International, Warrendale, ISBN: 978-0-7680-3484-4, 2012.

26.H. Konet, M. Sato, T. Schiller, A. Christensen, T. Tabata, T. Kanuma, “Development of Approaching Vehicle Sound for Pedestrians (VSP) for Quiet Electric Vehicles,” *SAE International Journal of Engines*, 4: 1217-1224, 2011.

27.H. Zhu, K.V. Yuen, L. Mihaylova, H. Leung, “Overview of environment perception for intelligent vehicles,” *IEEE Transactions on Intelligent Transportation Systems*, (in press), 2017.

28.I. Boldea, L.N. Tutelea, L. Parsa, D. Dorrell, “Automotive Electric Propulsion Systems with Reduced or No Permanent Magnets: An Overview,” *IEEE Transactions on Industrial Electronics*, 61(10): 5696-5711, 2014.

IHS Markit 2017, http://news.ihsmarkit.com/news-releases

30 ISO 362-1: 2015: Measurement of noise emitted by accelerating road vehicles–engineering method–Part 1: M and N categories. International Organization for Standardization. 2015.

31.J.B. Dupont, P. Bouvet, J.L. Wojtowicki, “Simulation of the Airborne and Structure-Borne Noise of Electric Powertrain: Validation of the Simulation Methodology,” SAE Technical Paper No. 2013-01-2005, 2013.

32.J. Biedermann, R. Winter, M. Wandel, M. Böswald, “Energy Based Correlation Criteria in the Mid-Frequency Range,” *Journal of Sound and Vibration*, 400:457-480, 2017.

33.J. De Santiago, H. Bernhoff, B. Ekergård, S. Eriksson, S. Ferhatovic, R. Waters, M. Leijon, “Electrical Motor Drivelines in Commercial All-Electric Vehicles: A Review,” *IEEE Transactions on Vehicular Technology*, 61(2):475-484, 2012.

34.J. Hartley, A. Day, I. Campean, R.G. McLellan, J. Richmond, “Braking System for a Full Electric Vehicle With Regenerative Braking,” SAE Technical Paper 2010-01-1680, 2010.

35.J. Hirsch, “Recent Development in Aluminum for Automotive Applications,” *Transactions of Nonferrous Metals Society of China*, 24(7):1995-2002, 2014.

36.J.M. Anderson, K. Nidhi, K.D. Stanley, P. Sorensen, C. Samaras, O.A. Oluwatola, “Autonomous Vehicle Technology: A Guide for Policymakers,” Rand Corporation, ISBN: 978-0-8330-8398-2, 2014.

37.J. Wu, O.A. Badu, Y. Tai, A.R. George, “Design, Analysis, and Simulation of an Automotive Carbon Fiber Monocoque Chassis,” *SAE International Journal of Passenger Cars-Mechanical Systems*, 7: 838-861, 2014.

38.J. Xu, J. Ma, Q. Fan, S. Guo, S. Dou, “Recent Progress in the Design of Advanced Cathode Materials and Battery Models for High-Performance Lithium-X (X= O_2, S, Se, Te, I_2, Br_2) Batteries,” *Advanced Materials*, 29: 1606454, 2017.

39.J. Zhu, K.W.E. Cheng, X. Xue, Y. Zou, “Design of a New High-Torque-Density In-Wheel Switched Reluctance Motor for Electric Vehicles,” IEEE Transactions on Magnetics, (in press), 2017.

40.K. Jo, J. Kim, D. Kim, C. Jang, M. Sunwoo, "Development of Autonomous Car - Part I: Distributed System Architecture and Development Process," *IEEE Transactions on Industrial Electronics*, 61(12):7131-7140, 2014.

41.K. Propp, M. Marinescu, D.J. Auger, L. O'Neill, A. Fotouhi, K. Somasundaram, G.J. Offer, G. Minton, S. Longo, M. Wild, V. Knap, "Multi-Temperature State-Dependent Equivalent Circuit Discharge Model for Lithium-Sulfur Batteries," *Journal of Power Sources*, 328:289-299, 2016.

42.K.S. Stegen, "Heavy Rare Earths, Permanent Magnets, and Renewable Energies: An Imminent Crisis," *Energy Policy*, 79:1-8, 2015.

43.K. Srinivas, A.L. Naidu, M.R. Bahubalendruni, "A Review on Chemical and Mechanical Properties of Natural Fiber Reinforced Polymer Composites," *International Journal of Performability Engineering*, 13(2):189-200, 2017.

44.K. Zheng, Q. Zheng, H. Yang, L. Zhao, L. Hou, P. Chatzimisios, "Reliable and Efficient Autonomous Driving: The Need for Heterogeneous Vehicular Networks," *IEEE Communications Magazine*, 53(12):72-79, 2015.

45.L.F. Nazar, M. Cuisinier, Q. Pang, "Lithium-Sulphur Batteries," *MRS Bulletin*, 39(5):436-442, 2014.

46.L.J. Li, L.B. Pan, R. Ge, F. Fang, "Updates for Development and Applications of Automotive High Strength Steel," Advanced High Strength Steel and Press Hardening: Proceedings of the 2nd International Conference (ICHSU2015), World Scientific, 14-19, ISBN:978-981-3140-61-5, 2016.

47.L. Kumar, S. Jain, "Electric Propulsion System for Electric Vehicular Technology: A Review," *Renewable and Sustainable Energy Reviews*, 29:924-940, 2014.

48.M.A. Hannan, F.A. Azidin, A. Mohamed, "Hybrid Electric Vehicles and Their Challenges: A Review," *Renewable and Sustainable Energy Reviews*, 29:135-150, 2014.

49.M. Bermudez, I. Gonzalez-Prieto, F. Barrero, H. Guzman, M.J. Duran, X. Kestelyn "Open-Phase Fault-Tolerant Direct Torque Control Technique for Five-Phase Induction Motor Drives," *IEEE Transactions on Industrial Electronics*, 64(2): 902-911, 2017.

50.M. Diko, P. Rafajdus, P. Makys, V. Vavrus, J. Makarovic, J. Saitz, "Design and Parameter Analysis of Short-Flux Path Switched Reluctance Motor in Electrical Vehicles," IEEE International Conference on Environment and Electrical Engineering (IEEE 2017), 06-09 June 2017, Milan, Italy, 2017.

51.M.E. Braun, S.J. Walsh, J.L. Horner, R. Chuter, "Noise Source Characteristics in the ISO 362 Vehicle Pass-By Noise Test: Literature Review," *Applied Acoustics*, 74(11):1241-1265, 2013.

52.M. Geistfeld, "A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation," *California Law Review*, 17(09), 2017.

53.M. Holmes, "Lowering the Cost of Carbon Fiber," *Reinforced Plastics*, (in press), 2017.

54.M.I. Ashraf, C.F. Liu, M. Bennis, W. Saad, "Towards Low-Latency and Ultra-Reliable Vehicle-to-Vehicle Communication," arXiv preprint, arXiv: 1704.06894, 2017.

55.MMPA 0100:2000: Standard specifications for permanent magnet materials. Magnetic Materials Producers Association (MMPA), 2000.

56.M. Pervaiz, S. Panthapulakkal, K.C. Birat, M. Sain, J. Tjong, "Emerging Trends in Automotive Lightweighting through Novel Composite Materials," *Materials Sciences and Applications*, 7:26-38, 2016.

57.M.Y. Lyu, T.G. Choi, "Research Trends in Polymer Materials for Use in Lightweight Vehicles." *International Journal of Precision Engineering and Manufacturing*, 16(1): 213-220, 2015.

58.M. Yıldırım, M. Polat, H. Kürüm, “A Survey on Comparison of Electric Motor Types and Drives Used for Electric Vehicles,” *16th International Power Electronics and Motion Control Conference and Exposition (PEMC 2014),* 21-24 September 2014, Antalya, 218-223, 2014.

59.M. Zeraoulia, M.E.H. Benbouzid, D. Diallo, “Electric Motor Drive Selection Issues for HEV Propulsion Systems: A Comparative Study,” *IEEE Transactions on Vehicular Technology*, 55(6):1756-1764, 2006.

60.N. Chandrasekhar, C. Tang, N. Limsuwan, J. Hetrick, J. Krizan, Z. Ma, W. Wu, “Current Harmonics, Torque Ripple and Whine Noise of Electric Machine in Electrified Vehicle Applications,” SAE Technical Paper No. 2017-01- 1226, 2017.

61.N. Hashemnia, B. Asaei, “Comparative Study of Using Different Electric Motors in the Electric Vehicles,” Proceedings of the 2008 International Conference on Electrical Machines (ICEM 2008), 06 – 09 September 2008, Vilamoura, Portugal, 1-5, 2008.

62.NHTSA 2013, Preliminary Statement of Policy Concerning Automated Vehicles, National Highway Traffic Safety Administration, Washington, DC, 1-14, 2013.

63.N. Lalor, H.H. Priebsch, “The Prediction of Low- and Mid-Frequency Internal Road Vehicle Noise: A Literature Survey,” *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, 221(3):245–269, 2007.

64.N. Meek, D. Penumadu, O. Hosseinaei, D. Harper, S. Young, T. Rials, “Synthesis and Characterization of Lignin Carbon Fiber and Composites,” *Composites Science and Technology*, 137: 60-68, 2016.

65.N. Schaefer, B. Bergen, T. Keppens, W. Desmet, “A Design Space Exploration Framework for Automotive Sound Packages in the Mid-Frequency Range,” SAE Technical Paper No. 2017-01-1751, 2017.

66.O.B. Alankuş, “Technology Forecast for Electrical Vehicle Battery Technology and Future Electric Vehicle Market Estimation,” *Advances in Automobile Engineering*, 6(2): 000164, 2017.

67.O. Faruk, J. Tjong, M. Sain, editors, “Lightweight and Sustainable Materials for Automotive Applications,” CRC Press, ISBN: 978-1-3516-4900-1, 2017.

68.P.E. Geck, “Automotive Lightweighting Using Advanced High-Strength Steels,” SAE International, Warrendale, ISBN: 978-0-7680-7978-4 2014.

69.P. Long, Y. Qiuhui, H. Zhang, X.U. Guangliang, M. Zhang, W.A.N.G. Jingdong, “Rare Earth Permanent Magnets Sm2 (Co, Fe, Cu, Zr) 17 for High Temperature Applications,” *Journal of Rare Earths*, 26(3):378-382, 2008.

70.P. Moreno-Torres, M. Lafoz, M. Blanco, G. Navarro, J. Torres, L. García-Tabarés, “Switched Reluctance Drives with Degraded Mode for Electric Vehicles,” Modeling and Simulation for Electric Vehicle Applications, InTech, Chapter 5, 97-124, ISSN: 978-953-51-2636-2, 2016.

71.P. Tan, W. Kong, Z. Shao, M. Liu, M. Ni, “Advances in Modeling and Simulation of Li–Air Batteries,” *Progress in Energy and Combustion Science*, 62: 155-189, 2017.

72.P. Taylor, “Energy Technology Perspectives 2010–Scenarios and Strategies to 2050,” *International Energy Agency, Paris* 74, 2010.

73.R. Guo, C. Cao, Y. Mi, Y. Huang, “Experimental Investigation of the Noise, Vibration and Harshness Performances of a Range-Extended Electric Vehicle,” Proceedings of the Institution of Mechanical Engineers, Part

D: Journal of Automobile Engineering, 230(5):650-663, 2016.

74.R. Gurav, K.D. Udawant, R. Rajamanickam, N.V. Karanth, S.R. Marathe, “Mechanical and Aerodynamic Noise Prediction for Electric Vehicle Traction Motor and Its Validation,” SAE Technical Paper No. 2017-26-0270, 2017.

75.R. Heuss, N. Müller, W. Van Sintern, A. Starke, A. Tschiesner, “Lightweight, Heavy Impact - How Carbon Fiber and Other Lightweight Materials Will Develop Across Industries and Specifically in Automotive,” Advanced Industries: McKinsey & Company, 2012.

76.R. Tummala, K.J. Wolter, V. Sundaram, V. Smet, P.M. Raj, “New Era in Automotive Electronics: A Co-Development by Georgia Tech and Its Automotive Partners,” *Pan Pacific Microelectronics Symposium*, 25-28 January 2016, Hawaii, 1-4, 2016.

77.S.A. Bagloee, M. Tavana, M. Asadi, T. Oliver, “Autonomous Vehicles: Challenges, Opportunities, and Future Implications for Transportation Policies,” *Journal of Modern Transportation*, 24(4):284-303, 2016.

78.SAE Standard J2889-1: International surface vehicle standard: measurement of minimum noise emitted by road vehicles, 2011.

79.S. Chen, J. Hu, Y. Shi, Y. Peng, J. Fang, R. Zhao, L. Zhao, “Vehicle-to-Everything (v2x) Services Supported by LTE-Based Systems and 5G,” *IEEE Communications Standards Magazine*, 1(2):70-76, 2017..

80.S.H. Shin, J.G. Ih, T. Hashimoto, S. Hatano, “Sound Quality Evaluation of the Booming Sensation for Passenger Cars,” *Applied Acoustics*, 70(2): 309-320, 2009.

81.S.K. Jha, “Characteristics and Sources of Noise and Vibration and Their Control in Motor Cars,” *Journal of Sound and Vibration*, 47(4):543-558, 1976.

82.S. Lee, K. Park, S.H. Sung, D.J. Nefske, “Boundary Condition Effect on the Correlation of an Acoustic Finite Element Passenger Compartment Model,” *SAE International Journal of Materials and Manufacturing*, 4:708-715, 2011.

83.S. Ray, W. Chen, J. Bhadra, M.A. Al Faruque, “Extensibility in Automotive Security: Current Practice and Challenges,” Proceedings of the 54th Annual Design Automation Conference, 18-22 June 2017, Austin, Texas, 2017.

84.S. Tuohy, M. Glavin, C. Hughes, E. Jones, M. Trivedi, L. Kilmartin, “Intra-Vehicle Networks: A Review,” *IEEE Transactions on Intelligent Transportation Systems*, 16(2):534-545, 2015.

85.Strategy Analytics 2017, Automotive reports,

86.S. Ucar, S.C. Ergen, O. Ozkasap, “Multihop-Cluster-Based IEEE 802.11p and LTE Hybrid Architecture for VANET Safety Message Dissemination,” *IEEE Transactions on Vehicular Technology*, 65(4): 2621-2636, 2016. https:// www.strategyanalytics.com/access-services/automotive

87.S. Yin, D. Yu, H. Yin, H. Lü, B. Xia, “Hybrid Evidence Theory-Based Finite Element/Statistical Energy Analysis Method for Mid-Frequency Analysis of Built-Up Systems With Epistemic Uncertainties,” *Mechanical Systems and Signal Processing*, 93:204-224, 2017.

88.The Independent 2017, http://www.independent.co.uk/environment/climate-change/norway-to-ban-the-sale-of-all-fossil-fuel-based-cars-by-2025-and-replace-with-electric-vehicles-a7065616.html (accessed on July 30, 2017)

89.T. Priede, S.K. Jha, “Low Frequency Noise in Cars: Its Origin and Elimination,” *Journal of Automotive*

Engineering, 1(5):17-21, 1970.

90.T. Schulze, B. Müller, G. Meyer, editors, “Advanced Microsystems for Automotive Applications 2016: Smart Systems for the Automobile of the Future,” Springer, ISBN: 978-3-319-44765-0, 2016.

91.T. Tousignant, K. Govindswamy, G. Eisele, C. Steffens, D. Tomazic, “Optimization of Electric Vehicle Exterior Noise for Pedestrian Safety and Sound Quality,” SAE Technical Paper No. 2017-01-1889, 2017.

92.U. Eberle, B. Müller, R. Von Helmolt, “Fuel Cell Electric Vehicles and Hydrogen Infrastructure: Status 2012,” *Energy & Environmental Science*, 5(10): 8780-8798, 2012.

93.Volvo XC90, homepage of Volvo Car Corporation, 2017, http://www.volvocars.com/en-ca/cars/new-models/xc90, (accessed on July 30, 2017)

94.W. Enang, C. Bannister, “Modelling and Control of Hybrid Electric Vehicles: A Comprehensive Review,” *Renewable and Sustainable Energy Reviews*, 74:1210-1239, 2017.

95.W. Fleming, “Forty-Year Review of Automotive Electronics: A Unique Source of Historical Information on Automotive Electronics,” *IEEE Vehicular Technology Magazine*, 10(3):80-90, 2015.

96.W.J. Joost, P.E. Krajewski, “Towards Magnesium Alloys for High-Volume Automotive Applications,” *Scripta Materialia*, 128: 107-112, 2017.

97.W.R. Chang, J.J. Hwang, W. Wu, “Environmental Impact and Sustainability Study on Biofuels forTransportation Applications,” *Renewable and Sustainable Energy Reviews*, 67:277-288, 2017.

98.W. Ribbens, “Understanding Automotive Electronics: An Engineering Perspective,” Butterworth-Heinemann, ISBN: 978-0-1281-0434-7, 2017.

99.X. Chen, W. Shen, T. T. Vo, Z. Cao, A. Kapoor, “An Overview of Lithium-Ion Batteries for Electric Vehicles,” Conference on Power & Energy (IPEC 2012), 12-14 December 2012, Ho Chi Minh City, Vietnam, 230-235, 2012.

100.Y. Cao, D. Wang, T. Zhao, X. Liu, C. Li, H. Hou, “Electric Vehicle Interior Noise Contribution Analysis,” SAE Technical Paper No. 2016-01-1296, 2016.

101.Y. Gur, J. Pan, D. Wagner, “Sound Package Development for Lightweight Vehicle Design using Statistical Energy Analysis (SEA), SAE Technical Paper No. 2015-01-2302, 2015.