A Short Review on Automobile Dashboard Materials

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Abstract. Day by day Automobile sector is going through new innovative trends in all aspects like design, appearance, performance and economy. While choosing an automobile for personal use, customer always look for aesthetics, economics and safety measures. First and far most part of an automobile that appears before user, is the dashboard. It acts as console for various components and holds the sense pleasantness of occupant space. In this paper a brief review of various types of material used in the making of dashboard is taken into account on the basis of detailed literature survey. Various types of dashboard are discussed along with their manufacturing methods. Ideal properties of a dashboard material are also taken into consideration. Testing techniques for dashboard materials are mentioned thereafter. Finally the concerns with the dashboard materials are highlighted.

1. Introduction
Automobile industry plays very important role in the economy of any country. The number of vehicles in India drastically increased by 700 times from 1951 to 2015 [1]. It is expected that globally automotive industry should work on advanced technological trends [2].Nowadays one of the main criterion for selection of personal vehicle are environmental concerns and driving comfort along with financial gains. The dashboard is one of the vital part of an automobile as it consoles many components to keep driver aware of their performance and condition for better driving comforts. It affects vehicle’s structural integrity and enhances the sales appeal [3, 4]. Besides interfacing between driver and vehicle, dashboard contributes to some vital functions like aesthetics, active and passive safety, ergonomics, and object containment [5]. In early stages dashboard used to have only steering wheel and ignition switch, slowly on demand, variety of improvement in materials, product quality, appearance, and services have been seen [6].

2. Dashboard Types
As per the main characteristics and production techniques dashboards are classified as Stiff, Covered, and Foamed Dashboard. Stiff dashboard are used for the lower segment cars. Foamed dashboards have good aesthetics and touch where a soft layer is used between support and covering. Covered dashboard are intermediate solution between stiff and foamed, includes covering of an embossed material on stiff dashboard. Design wise the dashboards are classified as Monolithic and Decomposed. When the body is a single piece, it is called Monolithic and when more than one piece, it is called Decomposed. Today former is difficult to find due to availability of hybrid option having outer foamed and inner stiff part. The types of dashboards and their characteristics can be summarized as a table of figure 1 [5].
Figure 1. Features of stiff, foamed and covered dashboards. [5]

3. Dashboard Making
Stiff dashboard is made by injection moulding. For Covered dashboard, the support is covered by Vacuum Thermo-forming process. In Foamed dashboard, first the support is put into the foaming mould then the support surface is joined with the mould by flaming or plasma treatment. Lastly a pre-heated material is injected and after necessary reaction time and foam formation, de-moulding can be done. Other technique is the slush molding process. At the end, finishing and trimming for air vents etc. is performed. Sometime infiltration of support by waxing can required to remove excess foam [5].

4. Requirement of an Ideal dashboard material:
The dashboard material should be long lasting and must be resistant to wear and tear. The dashboard surface should remain scratch proof and glossy. It should be ecofriendly and hazards free. It must be sustainable to the vibration. It must be light weight for better fuel efficiency. The dashboard must be resistant to the thermal stress with proper strength, optimum stiffness, and adequate resilience. The surface of dashboard must have smooth hand-feel and pleasant visual effect along attractive pattern with proper design tolerance and no internal stress [7]. They should also be ultraviolet (UV) resistant. In addition, they must withstand higher thermal stresses with higher interior temperatures due larger and flatter windscreens [3]. The dashboard maker need to consider the exposure to sunlight and temperatures up to 130°C, also the weight and cost [8].

5. Materials used in dashboards
Initially dashboards were made of wood or metal which is now undesirable due safety, cost and appearance issues [9]. Plastics Used in Dashboards are listed in table of figure 2 [3].
Polypropylene (PP)  | High heat resistance, superior to that of polyethylene (PE)  | Helps maintain a cohesive material theme throughout the interior of the vehicle through use of the same base material in different parts like pillar covers, door panels, and IP. As these parts are in constant contact with each other, use of PP enables them to withstand temperature cycles.  

Thermoplastic olefin (TPE-O or TPO)  | Low gloss and density  
High stiffness and toughness  
Recyclability  | Can be easily injection-molded to form various parts in IP—is used more as skin of PP foam in recent vehicles.  

Acrylonitrile butadiene styrene (ABS)  | High impact strength and toughness due to rubber from polybutadiene  
High resistance to chemical stress cracking due to acrylonitrile  
Easy processability  | High degree of versatility as ratio of A, B, and S can be varied, enabling its use in pillars, IP, and door panels.  

ABS/PC blend  | Can be easily processed  
High heat deflection temperature  
Can produce many different surface types  | Available in four different grades: general purpose, high flow, blow molding, and low gloss. Currently used in Jeep Cherokee and Audi A4 (B5) models.  

Polyvinyl chloride (PVC) (often used with ABS)  | High price/property ratio  
High flame retardancy  | Can be blended with ABS to form sheets used for making skin of IP covers, though TPO can be an equally good alternative.  

Styrene-maleic anhydride copolymers (SMA)  | Excellent heat resistance compared to typical polystyrenes  | Can be reinforced with glass fiber to enhance heat resistance, and with rubber to prevent plastic from becoming too brittle. Are used in IP in BMW 3 and 5 series and in Fiat Coupé, covered with polyurethane foam.  

Polyurethanes  | High impact strength under low temperatures  
High temperature stiffness, preventing heat sag  | Polyether polyols have been used to form instrument and door panels via reaction injection molding (RIM). Energy-absorbing polyurethane foam, with semiclosed cell structure, has been added to pillars and door panels, enabling better protection of passengers in case of side impacts.  

**Figure 2.** Plastics Used in Dashboards [3]
prone areas of an automobile dashboard. Engineering filled polypropylene (EFPP) is used to make one-piece dashboards [10].

The significant characteristics of mainly used plastic in the dashboard making can be seen from table of figure 3 [5].

| Characteristics                      | Polyolefin base polypropylene |
|--------------------------------------|-------------------------------|
|                                      | Copolymer base | Copolymer 25/30% talc | Copolymer for dashboard | Copolymer glass reinforced | PC + ABS | ABS thermoplastic reinforced |
| Specific weight (g/cm³)              | 0.89±0.92       | 1.11±1.17            | 0.97±1.00              | 1.10±1.13                  | 1.11±1.14 | 1.15±1.18                     |
| Coefficient of expansion (10⁻⁴ °C)   | 110 50±70       | 50±60                | 40±70                  | 75±85                      | 30±50      |
| Moulding shrinkage %                 | 1.5±2.0         | 0.8±1.1              | 0.8±1.2                | 0.4±0.8                    | 0.6±0.7   | 0.2±0.3                      |
| Residual cam %                       | /               | 23±32                | 14±12                  | 20±32                      | /          | 15±17                        |
| Modulus of elasticity (N/mm²)        |                 |                      |                        |                            |            |
| a 20 °C                              | 4000            | 2500                 | 1650                   | 4600                       | 1900       | 6500                         |
| a 30 °C                              | 7500            | 1                    | 7000                   | 2500                       | 5500       | 3600                         |
| Isod impact strength (kJ/m²)         |                 |                      |                        |                            |            |
| a 20 °C                              | 6               | 4±7                  | 13                     | 12                         | 45         | 0.65                         |
| a -30 °C                             | /               | 2.5                  | 3.5                    | 3.5                        | 3.5        | 0.4                          |
| Distorsion temperature under load (1.8 Mpa) °C | 60 | 65 | 60 | 140 | 160 | 105 |

Figure 3. Major characteristics of commonly used dashboard plastics [5].

Polyurethane is a versatile material most commonly used in the automobile industry for making dashboard. Polyurethane, due to excellent shock absorption capacity to ensure the safety of riders [11]. Polyester can be used as a thermoset resin with vinyl ester as natural fiber composites in dashboards [12]. Natural fibers such as kenaf, hemp, flax, jute, and sisal with thermoplastic and thermoset matrices can be used for making of an automobile dashboard due to less weight, cost, and CO2, and recyclability [13]. PVC blend with ABS acts similarly as PVC with plasticizer, but, the ABS doesn’t evaporate so the dashboard becomes long lasting [14]. The Quality Function Deployment analysis results proposed the used of ABS, PC, styrene maleic anhydride, and PP for the car dashboard [15]. Polypropylene (PP), Acrylonitrile-butadiene-styrene (ABS), Styrene maleic anhydride (SMA), Polyphenylene Ether (PPE), and Polycarbonate (PC) are the materials commonly used in an automobile dashboard [16]. The rubber like properties of ABS along with resistant to weather and some chemicals, and good impact resistance favors its use in car dashboards [17]. ABS gives the dashboard a shiny, impervious surface and provides resilience even at low temperatures [18]. Natural-fiber composites of thermoplastics and thermosets have been used by car makers for dashboards [19]. Composite with the empty water sachet as a matrix and carbonized palm kernel shell (CPKS) particulate with iron fillings as reinforcing medium could be used to produce a car dashboard due to impact strength and low density [20]. BMW used 20% long glass fibre reinforced polypropylene (PP) to replace two-component dashboard in Borealis [21]. Nissan now uses plastic fiber from used bottles in sound insulation layers of dashboards [22]. For Transit range,
Ford are making an innovative single piece dashboard from Polypropylene Composite Materials and Alloys (PCMA) with reinforcement of glass and filling of talc. Delrin 517 acetal homopolymer from Du Pont has been used for long life of interior components like dashboard. It is ultraviolet resistant, reduces chalking of surface, and retains the gloss and colour [23]. Instead of polyethylene, different carrier materials and fillers such as boron nitride and graphite are used into the dashboard, which shown noticeable reduction in surface temperature [24]. BMW also using into dashboards, wood which is sustainably grown for its i3 electric car [25]. Composite of Polyscope styrene maleic anhydride (SMA) copolymer are also used in dashboards [26]. Composite material reinforced with glass fiber or carbon fiber / epoxy matrices can be used for dashboard making due to at least 60% weight reduction [27]. PA410 incorporated with carbon and glass-based materials and conventional epoxy resins have been checked for the use in dashboard making [28]. ABS, polycarbonate alloys, polycarbonates, polyester, and polypropylene are commonly used materials for dashboard applications [29]. Polypropylene (PP), due to its cost, is a common material for dashboard [30]. Natural fibre reinforced composites (NFRCs) has been proven as an alternative to glass and carbon fibre reinforced polymer composites in dashboards due to weight reduction and low cost [31]. Fiber composites of glass-fiber and carbon fiber performed better than an aluminum alloy in terms of environmental and economic performance in automobile interiors such as dashboard [32]. GRP composites of polyester matrix shown improved mechanical properties and with higher crush force efficiency of an automobile dashboard [33]. Renewable materials composites have been popularly used in dashboards [34]. Daimler Chrysler are producing dashboards using polypropylene and natural fibres [35]. The Super Olefin Polymer, TSOP-5 materials shown up to 18% weight reduction in dashboard [36]. Plastics like Thermoplastics viz. ABS, Polycarbonate (PC), Polymethyl methacrylate or acrylic (PMMA), Polypropylene (PP), Polyvinyl chloride (PVC), Acrylonitrile styrene acrylate (ASA), Styrene maleic anhydride (SMA), Thermoplastic Blends of ABS and Polycarbonate, Polyphenylene oxide (PPO), Thermoplastic Elastomers (TPE-U, and TPE-U) and Thermosets like Polyurethane integral-skin foams, Polyurethane semi rigid foam, and Polyurethane RIM compounds, are used in dashboards [37]. The materials like vinyls and alloys of vinyls, ABS, TPOs, TPEs (Thermoplastic elastomers), polyesters, and TPU (Thermoplastic urethanes) are used in dashboard making. TPO has been used in injection mold dashboards [38]. As an option to fiber glass, composites with non-wood fibers like flax and hemp, as well as cellulosics have been used in automotive industries to produce dashboards [39].

6. Dashboards Materials testing:
Number of tests available to examine the functionality, reliability, and appearance of the dashboard material on the basis of dimensional stability at elevated temperatures for a certain time period. Noise tests, fatigue tests, and vertical settlements tests are carried after residual deformation. Further the tightening torques test, chemical agents and light resistance tests are performed. Lastly excessive load test, static and movement interference checks, and aesthetics checks are conducted. By the impactor collision tests, the robustness and resilience of dashboard are determined to check the fragile breakages.
Stiffness test is done to assure stiffness on the basis of dynamic stiffness performance. Ageing test also performed by various humidity conditions, carried out in customized climatic chambers [5]. Automotive dashboard are evaluated by FEM modelling with the help of specified structural codes under EEC test 781632. It simulates the impact of head of passenger with the dashboard, which can possibly occur during a front crash, where the variations in stresses are determined [40]. The general mechanical properties of automotive dashboard namely density, Young’s modulus, and tensile strength should be 980-1100 Kg/m$^3$, 2-6 GPa, and 20-30 MPa respectively [41].

7. Dashboard Material Concerns
Painting of Polypropylene is difficult due to the absence of total adhesion, for which the surface must be coated with primers or plasma-treated. The surface obtained by blending ABS with PC can be painted only by promoter medium for adhesion. Soft touch can be get by increasing the thickness, but it can adversely affect the embossing due to crease and troughs. Materials with fare structural performance in
terms of high temperature resistance and higher flexural modulus can be utilized. Material like thermoplastic polyurethane (TPU) has not been used much due to economic reasons. The recyclability of the foamed dashboards is complex as the foam which is made up of a thermosetting material, is not recyclable. If the frequency level of material is increased above 40 Hz, then the resonance caused can result in creaking [5]. The mechanical recycling costs of dashboard materials like polyurethanes are significantly higher compared to the thermal recovery costs [42]. In the dashboard injection moulding process, problems like weld line distortion, buckling deformation, uneven texture, filamentary silver, and color irregularity arises [43]. Shape errors occurs in ABS due to heat shrinkage produced with the additive manufacturing [44]. Defects like squeaks and rattles arises in frictionally incompatible materials like ABS, PC, GFPP and unfilled PP on contacting each other when used in dashboards. These materials also display sharp frictional drops due to adhesive bonds rupture [45]. A major reasons for passenger injuries in vehicles is hard contact with the dashboard. Stiffness control can be a way for reducing such injuries. This can be done by providing PP stiffener ribs between the outer and inner cover [46]. A broad study is always essential to designate and pinpoint the factors influencing the impact performance of dashboard like crucial components spacing, foams, ribbing, impact directions, crush initiators, and stiffness variations etc. It will be helpful for optimizing the dashboard structure [47]. In injection molded dashboard making, defects of weld line, buckling, texture, and color are seen commonly [48]. Problem of using of natural fibers in polymeric composites is the low compatibility between the matrix and the fibers. Nanoparticles can be used to overcome this. It removes surface contaminants and increases surface roughness which improves the surface properties of fiber and provides better bonding [49]. Microbial and bacterial infections are also one of the concerns related to dashboard material. Researches are been carried out to identify suitable antimicrobial agent [50]. The natural fiber are sensitive to moisture and temperature, which can restrict their use in application of automobile dashboard [51].

8. Conclusion
A dashboard in one of the most important part of an automobile aesthetically and functionally. Various types of materials are used for the making of a dashboard. Mostly plastics are used due to its light weight and ease in the mouldability. Polypropylene is the most commonly used material due to characteristics like opacity and aphonicity. Polyurethane is also popular material as it is good in shock absorption. ABS is used for its rubber like properties, resistant to weather and chemicals, and impact. It also gives a shiny appearance to the surface of dashboard. Natural-fiber composites are sometime used for making dashboard and so on. Along with desirable properties these materials also have some limitation like surface treatment, economy, and un-recyclability. Issues related to manufacturing like weld line distortion, buckling deformation, uneven texture, filamentary silver, and color irregularity arises also limits their versatility. Moisture and temperature sensitivity is major restricting parameter of natural fibers used in dashboards. Microbial and bacterial infections problem must also be taken into notice. On the basis of various limitations, there is always scope for researchers to identify and develop a new material for dashboard.

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