BODY IN WHITE

What is BIW ?

- BIW term stands for Body In White
- It is the stage in automobile where body shell structure sheet metal components are welded together in weld shop just before painting
- Why it is called white, while it is grey in color as a primer:
  - In early years car shell structure were kept in white color before assembling suspension, engine. It is kept white to give a color choice to customer. Now term remains the same and refers to the welded sheet metal structure.
- BIW design is always driven by aesthetic, aerodynamic and cost criteria

Requirements of BIW structure:

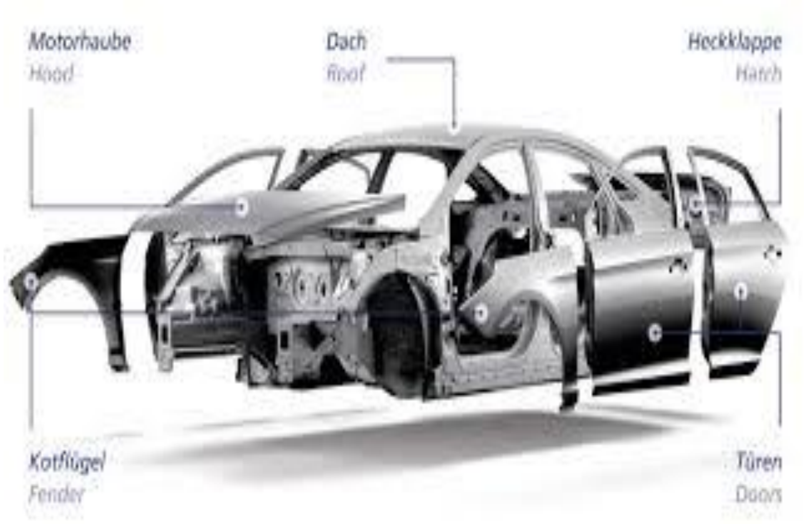
- Comfortable space
- Strength & stiffness
- Low weight material
- Corrosion resistant
- Aerodynamic & good appealing structure: BIW joinery defines the exterior and interior look.

- Sufficient space for packaging and provisions made for inner trim and aggregates
- Pedestrian and occupant protection during roll over accident
- Structure should support
  - All interior parts like dashboard, trims, seats, etc..
  - All exterior components like front bumper, rear bumper, fenders, mirrors, etc.. mounted on structure in means of mounting brackets and nuts on the BIW

- **Monocoque construction (Chassis in built in Body)**
  - Chassis is inbuilt with BIW itself and there is no separate chassis
  - Used in all the passenger cars and to some extent in utility vehicles
  - Wheels and suspension are directly mounted to BIW

BIW Types

- **Body on Frame Construction**
  - Body is mounted on a separate chassis / frame
  - Used in utility vehicles, trucks, buses
  - Wheels and suspension are mounted on chassis



BIW Components

- A,B,C,D Pillars
- Dashboard mounting panel
- Windscreen & Rear Window rail
- Cant rail
- Roof structure
- Side Sill
- Upper quarter panel or window
- Front longitudinal member (acts as chassis)
- Front cross member
- Front & rear Valance
- Scuttle
- Firewall
- Floor, seat & Boot pan
- Front & rear Spring tower
- Central Tunnel
- Front & Rear Wheel arch
- Toe Board
- Heel Board

BIW Materials

- Nowadays automobile sector is driven by light weighting key to next generation product development using cost-effective alternative material like aluminium, composite materials in high end cars due to their several advantages. It will become popular in low end vehicles as well in coming years.
- BIW accounts @ 50% weight of vehicle and having a scope to reduce the weight by means of alternative materials.
- Steel is always favored by automobile industries due to its simplicity in fabrication, but in last several years fuel prices are rising and recycling regulations are coming into force therefore it becomes need to reduce weight of vehicle.

Materials used in BIW are listed as below:

- **Steel**
- **Aluminium**
- **CFRP (Carbon fiber reinforced plastic)**

Properties	Steel ASTM A36	Aluminium	CFRP
Density (g/cm3)	7.85	2.7	1.8
Young's modulus	200		220
Tensile strength GPa	1.88		2.48
Elongation %	0.1-0.3		0.5-2.0

Material	Advantages	Disadvantages
Steel	Amenable to high-speed fabrication technologies Inexpensive material Good engineering properties; tailorable Valuable offal - "Waste" has market value Many suppliers, largely indigenous	Relatively high density Corrosion - necessitates expensive processing
Aluminium	Different forming techniques Less dense Compatible with current steel practice More recyclable, in principle, than RP/C Glut on the market Corrosion resistant	Different forming techniques Less stiff Just different enough to be difficult Nastier primary extraction processes Relatively expensive Incompatible with steel fastening
CFRP	Parts consolidation opportunities Primary / secondary weight savings Low investment costs Increased design flexibility	Materials and labor intensive process Long cycle times Non-traditional manufacturing technology

Aluminium

In body structure aluminum can provide a weight savings of up to 50 percent compared with the mild steel structure

Today, it's use in vehicles is increasing because it offers the fastest, safest, most environmentally friendly and cost-effective way to increase performance, increase fuel economy and reduce emissions keeping / increasing safety and durability norms

Nowadays, aluminum has achieved second alternative to steel as the most used material in vehicles

ALUMINUM ALLOYS DESIGNATIONS:

ALLOY TYPES	ALLOY	TENSILE STRENGTH (MPa)	ELONGATION %	PROPERTIES	APPLICATIONS
WROUGHT ALLOYS					
Al of 99% minimum purity	1XXX	70-185		Strain hardenable Exceptionally high formability, corrosion resistance, and electrical conductivity Readily joined by welding, brazing, and soldering Extremely high corrosion resistance and formability	Electrical conductors Chemical process equipment Foils Decorative finishes
Copper	2XXX	2119: 505 2024: 520		Heat treatable High strength, at room and elevated temperatures Usually joined mechanically, but some alloys are weldable Not as resistant to atmospheric corrosion as several other series so usually are painted or clad for added protection	2119: Fuel tanks 2119: Welding wires 2024: pistons, rivets for aircraft construction
		190-430			
Manganese	3XXX	3003: 110 3004: 180		High formability and corrosion resistance with medium strength Readily joined by all commercial procedures Have excellent corrosion resistance, and are readily welded, brazed, and soldered	3003: Foil 3003: Roofing sheet 3004: Al-Mn-Mg: Manufacturing beverage cans
		110-285			
Silicon	4XXX			Heat treatable Good flow characteristics, medium strength Typical ultimate tensile strength range: 175 to 380 MPa Easily joined, especially by brazing and soldering excellent flow characteristics	

Magnesium	5XXX	5005: 125 5456: 310 125-350	Strain hardenable Excellent corrosion resistance, toughness, weldability; moderate strength Building and construction, automotive, cryogenic, and marine applications Representative alloys: 5052, 5083, and 5754 excellent corrosion resistance en in salt water high toughness even at cryogenic temperatures They are readily welded by a variety of techniques, even at thicknesses up to 20 cm	5005: Transportation structural plates 5456: Large tanks for petrol, milk, grain Pressure vessel Architectural components
Magnesium and silicon	6XXX	6063: 245 6013:415 125-400	Heat treatable High corrosion resistance, excellent extrudibility; moderate strength Readily welded by GMAW and GTAW methods Great extrudability, making it possible to produce in single shapes relatively complex Highest tensile and compressive stresses.	6005: Satellite dish 6009: Car body, Electric train 6063: Large water pipe 6061: Structural component (Building structure) 6013: Aircraft, automotive, recreation applications, Extruded sections
Zinc	7XXX	220-610	Heat treatable Very high strength; special high-toughness versions Mechanically joined Not considered weldable by commercial processes and are regularly used with riveted construction Atmospheric corrosion resistance less than 5xxx and 6xxx alloys, hence usually coated	7039: Aircraft construction 7005: Post box, Light weight military bridge 7075: Component in motorcycle
Others (Li, Sn, Fr, Fe, etc.)	8XXX	120-240	Heat treatable High conductivity, strength, and hardness Iron and nickel provide strength with little loss in electrical conductivity	8001 - Nuclear energy installations 8011 - Bottle caps 8017: Conductors Soft bearings forged helicopter component of aluminum-lithium alloy (8090-T852) Lithium in alloy 8090 for aerospace applications

CAST ALLOYS

Al of 99% minimum purity	1XX.X			Contain larger alloying elements such as Si and Cu results in in a largely heterogeneous cast structure. Second phase material Elongation & strength, especially in fatigue, of most cast products are relatively lower than wrought products	
Copper	2XX.X	415 -550	5-10	Heat treatable sand and permanent mold castings High strength at room and elevated temperatures; some high-toughness alloys Approximate ultimate tensile strength range: 130 to 450 MPa (20–65 ksi) Castability is limited by tendency to microporosity & hot tearing so it is suited to investment casting.	Strongest 201.0-T6 in aerospace Suitable for highly stressed Components in machine tool construction In electrical engineering (pressurized switchgear castings) Aircraft construction
Silicon with added copper and} or magnesium	3XX.X			Heat treatable sand, permanent mold, and die castings Excellent fluidity, high-strength, and some high-toughness alloys Approximate ultimate tensile strength range: 130 to 275 MPa (20–40 ksi) Readily welded Widely used because flexibility provided by high Si & its contribution to fluidity, plus their response to heat treatment, which provides a variety of high-strength options. Cast by sand or die casting, investment castings, & newer thixocasting and squeeze casting	319.0 and 356.0/A356.0 for sand and permanent mold casting 360.0, 380.0/A380.0, and 390.0 for die casting 357.0/A357.0 for squeeze/forge cast Thixoformed A356.0-T6 inner turbo frame for the Airbus family Gearbox casing for a passenger car in alloy pressure die cast 380.0
Silicon	4XX.X			Non-heat-treatable sand, permanent mold, and die castings Excellent fluidity, good for intricate castings Approximate ultimate tensile strength range: 120 to 175 MPa (17–25 ksi) Good castability & weldability due to its eutectic composition and low melting point of 700 °C moderate strength with high elongation before rupture and good corrosion resistance	Suitable for intricate, thin-walled, leak-proof, fatigue-resistant castings Parts for typewriter and computer housings and dental equipment Critical components in marine architectural applications
Magnesium	5XX.X			Non-heat-treatable sand, permanent mold, and die castings Tougher to cast; provides good finishing characteristics Excellent corrosion resistance, machinability, and surface appearance Approximate ultimate tensile strength range: 120 to 175 MPa (17–25 ksi) 512.0 & 514.0 have medium strength & good elongation & suitable for components exposed to seawater	Watch body Kitchen utensils
	6XX.X				Unused series
Zinc	7XX.X			Heat treatable sand and permanent mold castings (harder to cast) Excellent machinability and appearance Approximate ultimate tensile strength range: 210 to 380 MPa (30–55 ksi)	Furniture Garden tools, office machines, and farming and mining equipment
Tin	8XX.X			Heat treatable sand and permanent mold castings (harder to cast) Excellent machinability Bearings and bushings of all types Approximate ultimate tensile strength range: 105 to 210 MPa (15–30 ksi) With combine 7xx.x, 8xx.x alloys are relatively hard to cast, so used only where superior surface finish & relative hardness are important	For parts requiring extensive machining and for bushings and bearings
Others	9XX.X				

5183
5: principal alloying element ch has been added to the aluminum alloy (describes the aluminum alloy series)
1: Indicates that it is the 1st modification to the original alloy 5083
83: arbitrary numbers given to identify a specific alloy in the series
A356.0
A: Modification of alloy.
3: silicon plus copper and/or magnesium series
56: alloy within the 3xx.x series
.0: indicates that it is a final shape casting (.0) and not an ingot (.1 or .2)

NAMED ALLOYS:

APPLICATIONS IN AUTOMOBILE:

Frame: 5182 or 5754 sheet or, for space frame designs, 6063 or 6061 extrusions
External body sheet panels where dent resistance is important: 2008, 6111.
Inner body panels: 5083, 5754
Bumpers: 7029, 7129
Air conditioner tubes, heat exchangers: 3003
Auto trim: 5257, 5657, 5757
Door beams, seat tracks, racks, rails, and so on: 6061, 6063
Hood, deck lids: 2036, 6016, 6111
Truck beams: 2014, 6070
Truck trailer bodies: 5456
Wheels: A356.0 or formed 5xxx sheet
Housings, gear boxes: 357.0, A357.0

Alclad	Aluminium sheet formed from high-purity aluminium surface layers bonded to high strength aluminium alloy core material
Birmabright	(aluminium, magnesium) a product of The Birmetals Company, basically equivalent to 5251
Duralumin	(copper, aluminium) Magnalium
Magnox	(magnesium, aluminium)
Silumin	(aluminium, silicon)
Titanal	(aluminium, zinc, magnesium, copper, zirconium) a product of Austria Metall AG. Commonly used in high performance sports products, particularly snowboards and skis.
Y alloy, Hiduminium, R.R. alloys: pre-war nickel-aluminium alloys	Used in aerospace and engine pistons, for their ability to retain strength at elevated temperature.

ADVANTAGES FOR USE IN AUTOMOBILE:

Recycled at record levels: At the end of a vehicle’s life nearly 90 percent of the aluminum, on average, is recycled.Energy efficiency: Compared with a fleet of traditional steel vehicles, aluminum use saves the equivalent of 108 million barrels of crude oil in energy.Safer: Pound for pound, aluminum can absorb twice the crash energy of mild steel. Larger crush zones can be designed without corresponding weight penaltiesLower weight vehicle has better acceleration, better braking and better handling

LIMITATIONS OF USE:

- Low modulus of elasticity, requires stiffening
- Inferior wear, creep, & fatigue properties compared to steel
- High energy requirement for its extraction from ore
- Oxides can make joining rather difficult
- Welding is done in inert gas atmosphere
- Pitting corrosion

CR Grade (Cold rolled low carbon steel equivalents)
As per IS 513

Grade	Quality	C %	Mn %	S%	P%	Hardness (HR)	YS (MPa)	% Elongation	Bend radius	Applications	Recommendation
CR1	Ordinary	0.15	0.60	0.040	0.050	65	280	28		Bent components with light drawing (For enameling and lacquering)	
CR2	Drawing	0.12	0.50	0.035	0.040	55	240	32		Component with medium drawing (not suitable for plating) Side panels Bonnet center Reinforcement assembly quarter pillars	Moderate forming Easily weldable by all processes
CR3	Deep draw	0.10	0.45	0.030	0.025	55	220	34		Components involving moderate stretching and drawing Inner components and structural elements Panels Structures Reinforcement assembly Hinges	Moderate forming Easily weldable by all processes

CR4	Extra deep draw (Al Killed)	0.08	0.40	0.030	0.020	50	210	36	For electro-plating Back door inner Reinforcement sub assembly hinge pillar	Moderate to high drawing Easily weldable by all processes
CR5	IF	0.06	0.25	0.020	0.020	45	180	38	Components with very difficult drawing Oil pans Chambers Wheel arches Fenders Crash member Front, inner & outer panel closing pillars & reinforcements	Excellent formability & drawability Easily weldable by all processes

HR Grade: Hot rolled low carbon steel equivalents
HR: As per IS 1079

Grade	**Quality**	**C%**	**Mn%**	**S%**	**P%**	**Micro Alloy**	**Hardness (HR)**	**TS (MPa)**	**% Elongation**	Bend radius	**Applications**
HR1	Ordinary	0.15	0.60	0.040	0.050	-	65	440	28		Used for formed structural members and for general engineering purpose
HR2	Drawing	0.12	0.50	0.035	0.040	-	55	420	32	0.5 t	Drawing quality used where drawing , forming welding involved
HR3	Deep draw	0.10	0.45	0.030	0.025	-	55	400	34	close	
HR4	Extra deep draw (Al Killed)	0.08	0.40	0.030	0.020	-	50	380	36	close	Structural Forming and Flanging
HR5	Micro-alloyed Dual phase	0.16 0.16	1.6 2.0	0.020 0.05	0.020 0.02	0.20 0.15	45	360 590	38		

Aspects of Aerodynamic

It can be defined as the science of air in motion

Terms used in Aerodynamic study:

Importance of aerodynamic:

The constant need for

- **Better fuel economy**
- **Improved road holding and stability for a vehicle**
- **Reduction in wind noise level ,**
- **Greater vehicle performance ,**

Aerodynamic drag:

It includes-

- **Profile drag:**
  - **Contributes about 57% of the aerodynamic drag.**
  - **Cd = D / 0.5 ρAV2**
    - **D-aerodynamic drag force measured in wind tunnel**
    - **ρ- density of air**
    - **A- frontal c.s area of the body**
    - **V- vehicle speed in km/hr**
- **Lift induced drag: Contributes about 8% of total aerodynamic drag caused by vortices formed at side and downwind**
- **Friction drag: Makes 10% of the aerodynamics drag**
- **Interference drag: Contributes about 15% of the aerodynamics drag caused by projection mirrors, badges, handles, axles**
- **Cooling and ventilation drag: Contributes about 10% of the aerodynamics drag, caused by ducting and radiators**

To improve Cd , designers may make the following changes :
Round the edges of the front end
Tune the grille and fascia openings
Tune the wheel openings
Place spats(small spoilers) in front of the tires to reduce turbulence
Tune the size and shape of the outside mirrors and their attachment arms
Reshape the water channel on the A- pillars
Adjust the front fascia and air dam to reduce drag under the vehicle
Add side skirts
Tune the deck height, length and edge radius
Install a rear spoiler
Adjust the angle of the rear window
Tuck up the exhaust system
Use a diffuser to tune air coming off the underside
Install belly pans,' underbody panels that cover components and smooth airflow
Avoiding roof racks
Rolling up your windows and turning on A/C at higher speeds(typically above 35)
Replacing a broken or missing air dam
Lowering your vehicle
Running narrow tires
Choosing smoother wheels.
Reduce your vehicle's aerodynamics by :
Adding wider tires
Lifting it – "an inch of increased ride height degrades the Cd by about 10 drag counts (.01)".
Choosing more open wheel design (although open wheel promote better brake cooling)
Installing a bug shield and adding a rear spoiler in some cases.
Front bumper / splitter:
Rear Diffuser:
Vortex generators: Causing the Laminar Air Traveling Over the Roof to Become Turbulent

Aerodynamic is the study of forces and the resulting motion of objects through the airDrag is a force caused by an object moving through air
Lift and down force:
Lift and down force are opposite, downforce acts downward and lift acts upward
The shape of the under-body creates an area of low pressure between the bottom of the car and the road surface

BIW Design Challenges

- Lightweight construction
  - Enabling use of light metals and composite materials results in improved fuel efficiency
  - Vehicle body determines the price of vehicle both directly and indirectly. Body represents 50 to 70 % of the total cost of the vehicle directly, indirectly the life of the vehicle can influence the price
- Cost efficient design
  - Reduced investment and operating costs
  - Increased efficiency and cost reduction
- Manufacturing process
  - Minimize operations steps for final component
  - Reduce material wastage
  - Process flexibility with all possible variants
  - Selection and adoption of new manufacturing technologies for simpler and effective operations
- Right product at right time
  - Attaining the right concept within shortest time to reach to customer with new innovative ideas
  - Time taken to complete the overall design of a new model of a car is determined by the time taken to design the bodywork
- Engine and chassis units are easily replaceable, but serious damage to the body means an end to vehicles life.

Concept design process

Product proposal & planning: Team of marketing evaluates product need & feasibility of product in market and finalizes product proposal document

Product concept definition:
Requirements consideration of customer, legislative, organization

Business case:
Target market, manufacturing, costing strategically considered for business case preparation

Design Gate Review 1:
To review product concept sheet

CFT team formation:

Benchmark:
Competitive vehicle are bench-marked to to target weight & cost

Preliminary design concept:
Engineering converts customer, legislative, organization requirements into technical features

Feasibility drawing:
Drawing release for feasibility study

Make / buy:
To finalize design manufacturing & assembly process at supplier and OEM end

PPAP (Production part approval process) plan

Prototype build:
Preliminary concept evaluation, feasibility & testing

Design Gate Review 2:
Prototype issues & action plan

Production drawings:
Drawings released for tooling part development

Legislative certifications:
AIS, CMVR, Homologation requirement fulfilled

Design Gate Review 3:
DVP, part development plan, test reports, facility plan

Pilot batch production:
Design improvements based on pilot batch feedback

Design Gate Review 4:
Technical clearance

Start of production

Design Gate Review 5:
Technical clearance

Ergonomics

Following human factors should considered while designing seat:
Riding comfort
Visibility
Location
Ease of control
H point

Occupant space envelope creation:
By considering above points envelope can be created and analyzed the comfort for occupants

Terms used in Ergonomic study:

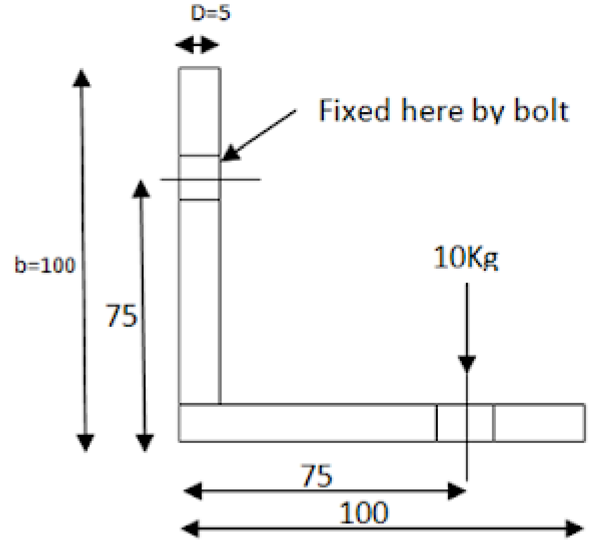
Transverse plane: means a vertical plane perpendicular to the longitudinal plane of the vehicle
Longitudinal plane: means a plane parallel to the median longitudinal plane of the vehicle
R point: Seating reference point represents seating position
Theoretically hip point used while designing a vehicle and more specifically relative location of the dummy's hip point, when the seat is set in the rearmost and lowermost seating position
H-point (Hip point):
This pivot center of the torso and thigh of the three-dimensional H-point machine used for actual H-point determination. It is located on the center-line of the device which is between the H-point sight buttons on either side of the H-point machine.
Recommended H position:
H point, as defined by its co-ordinates, lies within a square of 50 mm side length with horizontal and vertical sides whose diagonals intersect at the "R" point
Design set back angle:
ranges from 10° to 30° depending on the vehicle type
Recommended 15 degrees

Indian Anthropometric Male data

Standards:
Determination of H point:
FMVSS 202
ECE 17
IS 13749:

Measurement (cm)	P5	P50	P95
Standing	156.3	167.5	178.7
Sitting	79.7	86	92.2
Sitting eye ht	68.6	74.8	80.6
Weight	45.7	63	85.4

Material selection and optimization



L shaped bracket

Force	10 Kg
Breadth (b)	100 mm
Depth (d)	5 mm
Perpendicular distance to the neutral axis (y)	2.5 mm
The area moment of inertia for this section = I = (bd^3)/12 =	1042 mm4
Maximum bending moment M= F x d =	750 kg-mm
Bending stress = f = M.y/ I =	1.8 kg/mm2

If we consider a steel with yield strength is 25 kg/mm2, then we can see that stress is substantially low , so we have the chance to further reduce the thickness

Sheet Metal Design

While designing components top priority is for function and second is for cost effective manufacturing process selection.

This can be achieved in design by:
•Keeping part simple
•Lesser material yield
•Consideration of minimum manufacturing stages

OBJECTIVES OF SHEET METAL DESIGN:

•**Function:** Most low stress (and many high stress) components requiring moderate stiffness can be created from sheetmetal. Sheetmetal is particularly effective for parts that function as containers, chutes and gates, but can effectively be used for mounting brackets as well.

•**Attachment method:** Sheetmetal parts are typically joined by welding, riveting or via fasteners.

DESIGN TIPS

•**Study Manufacturing process available**

•**Shape:** Use simple shapes such as straight cuts, bends, and punched holes. Whenever possible, avoid internal cuts, curved cuts, and close-fit holes

•**Simple:** Complex sheetmetal parts are difficult to manufacture using tooling available. Typically, complex sheetmetal parts can be broken down into multiple simple parts

•**Material specification:** Choose a optimum material and thickness

•**Tolerances:** In modern industry parts are made using high precision CNC lasers and bending equipment. However, sheetmetal features are generally cut by aligning the layout lines by eye, so design sheetmetal parts to have large feature tolerances.

•**Order of operations:** The order of forming operations is important for sheetmetal parts. Holes and cuts must be created prior to bending. The bending sequence can typically be performed in only one or two ways. Be familiar with the available tooling and processes and do not design parts that cannot be fabricated using the available tooling in lab.

RECOMMENDATIONS:

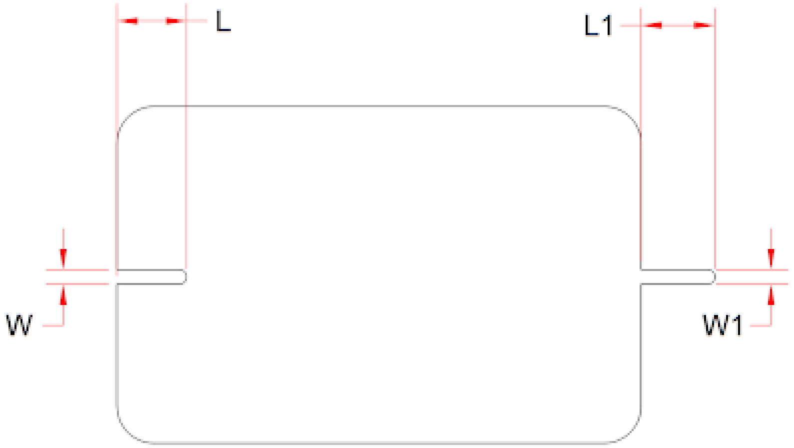
BLANKING:

W = 1.5 mm minimum

W1 = Minimum sheet thickness

L = Maximum up to 5 X W

L1 = Maximum up to 5 X W



BIW CAE Analysis

Different load conditions are considered for BIW, chassis, engine mount, axles and steering

INERTIA RELIEF (Calculate stress / strain for BIW): Used for analyzing the unconstrained structures
Stress analysis on a free structure that is accelerating
Applied forces and torques are balanced by inertial forces induced by an acceleration field

GRAVITY ANALYSIS (for Body, engine)

STATIC (Displacement / stresses (Linear & Non Linear) for monocoque chassis):
Used to determine displacements, stresses under static loading conditions. Both linear and nonlinear static analyses. Non-linearity can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

MODAL (Calculate Natural freq. and mode shapes of structure):
Study of the dynamic properties of structures under vibrational excitation.
(Calculate the natural frequencies and mode shapes of a structure)
It uses the mass and stiffness of a structure to find the various periods at which it will naturally resonate

BUCKLING (Buckling load and shape of monocoque chassis):
Used to calculate buckling loads and determine buckling mode shape. Both linear buckling and nonlinear analuses are possible.

HARMONIC (Fatigue / cycle / dynamic analysis of engine mount, axle, steering)
Used to determine the response of a structure to harmonically time varying loads
A harmonic load is a cyclic load such as the composite wave

TRANSIENT (Fatigue / cycle / dynamic analysis of engine mount, axle, steering)
Used to determine the response of a structure to arbitrarily time varying loads. All nonlinearities mentioned under static analysis above are allowed.

JOINING METHODS:

RESISTANCE SPOT WELDING (RSW):

•Spot welding is often selected for joining sheet metal fabrications, stamping and assemblies because it is fast, reliable and economical. However, numerous design considerations can affect the quality and cost of the weld, among them: size of the spot weld, accessibility, positioning, materials and thicknesses being joined, and the number of spots needed to attain the desired strength.

•Often, spot welding is the method of choice for assembly of entire enclosures, cabinets and multi part assemblies.

•It is always useful to consult with the metal former in the design stage when questions arise regarding the part design, application of spot welding or, control of spot welding cost for a particular design.

•Number of welds, weld size, and location are decided by evaluating strength requirements of application

•Low carbon steel is most suitable for spot welding. Higher carbon content or alloy steels tend to form hard welds that are brittle and could crack

•Aluminum can be welded using high power and very clean oxide free surfaces.

•Aluminum, tin and zinc need special preparation inherent to the coating metals

•Adequate access for spot welding should be considered

•It is best to choose the same spot weld size, to minimize setups and increase throughput.

•The mating parts can be self-jigged for easy location prior to welding. This can be done by lancing one part and locating in a corresponding slot in the other part; or by boss type extrusion, weld buttons, in part locating to a slot in the other. This type of design can often eliminate the need for external fixtures.

•Ideally, equal thicknesses of two sheet metal parts to be joined produces an evenly distributed weld nugget within the two layers. When this is not practical, materials of different thicknesses can also be joined and produce a centered weld nugget by using a larger electrode on the thicker member.

•At a ratio above about 3-to-1 (thickest to thinnest member), spot welding becomes difficult. At this point, another joining method should be considered--for example, projection welding.

DESIGN CONSIDERATIONS FOR SPOT WELDING:

Thickness: Parts to be welded should be equal or the ratio of thicknesses should be less than 3:1.

Minimum weld spacing = 10 x Stock

Center of weld to edge distance = 2 x weld diameter, minimum

Weld to form distance = Bend Radius + 1 weld diameter, minimum

Used for: Normally up to 3 mm (0.125 in) thickness, although parts up to 1/4 in. (6 mm) thick have been successfully spot welded.

Spot-weld diameters: Range from 3 mm to 12.5 mm in diameter

Positioning and Accessibility: Multiple bends impose access restrictions, and special fixtures may have to be designed to handle the parts, if access is not a problem.

Cosmetics: limit spot welding on appearance or cosmetic surfaces. grinding, or filling and grinding, is often required and can double the cost of the welding operation

Plating Spot Welded Parts: Plating drainage must be considered because sometimes electroplating solution gets trapped in assembly residues causes corrosion / manual removal

Positive Location of Workpieces: The mating parts can be self-jigged for easy location prior to welding. It can be achieved by half sheared or extruded cylindrical button and matching hole in the mating part

Spot Welded Fasteners: Nuts located by holes are typically within ±0.15 mm of the original hole location. Preferred to use same size weld nut and studs to reduces set ups

Limited space: Specifying one weld can produce a stronger bond than two spots

Single size: Specify only one size throughout an assembly in the interest of manufacturing economy

Weld Size and Strength: Weld size (nugget diameter) is slightly less than the diameter of the impression

Minimum contour radius:

Thicknes	Minimum contour radius for welded surface (mm)
1.5	160
1.7	200
2.5	230

•**Recommendation and strength of RSW:**

Material Thickness mm	Electrode Dia. mm	Zonal dia expected mm	Minimum overlap mm	Spot spacing mm	Shear strength (Al 5052-H34)	Shear strength Steel 70KSI	Shear strength Stainless steel 90KSI
0.25	3.0	2.5	10.0	19	70	130	170
0.53	5.0	3.0	11.0	19	120	320	470
0.79	5.0	4.0	11.0	25	240	570	800
1.02	6.5	5.0	13.0	25	340	920	1270
1.27	6.5	5.5	14.0	25	510	1350	1700
1.57	6.5	6.5	16.0	31	720	1850	2400
1.98	8.0	7.5	17.5	38	940	2700	3400
2.39	8.0	8.0	19.0	46	1180	3450	4200
2.77	8.0	8.0	20.5	56	1380	4150	5000
3.18	10.0	8.5	22.5	64	1620	5000	6000
4.57	10.0	9.0	25.0	64	1720	5300	6600

SPOT WELD PROCESS IRREGULARITIES:
Extra welds
Cold weld: does not produce weld button, no fusion
Extra welds: increases manufacturing costs and cycle time
Whiskers: it may damage transducer during ultrasonic inspection
Distortion: angle of displacement of sheet surfaces from normal plane not allowed more than 25 degrees
Thinning: should not more than 30% of metal stackup thickness
Trim edge deformation
Indentation: depression on sheet surface
Surface eruption: Upsurge of metal surface adjacent to weld imprint
Spatter
Crack: characterized by sharp tip
WELD TEMPLATE

An inspection device used to evaluate weld location. Templates are typically created by plotting the weld spot location on plot paper as defined by the weld design

OTHER PROCESSES USED FOR BIW ASSEMBLY:
MIG welding:

- Weldable materials are carbon steels, low-alloy steels, stainless steel; 3000, 5000, and 6000-series aluminum alloys; and magnesium alloys
- Other alloys that can also be MIG-welded via special methods include 2000 and 7000-series aluminum alloys; high-zinc-content copper alloys, and high-strength steels.

TIG welding
Projection Welding:

- A refinement of resistance spot welding is resistance projection welding (RPW).
- It makes use of projections previously formed on the workpiece to reduce the power required to make a resistance weld
- Thicker sections can be joined more readily than in RSW. Other advantages include reduced shunting effects, closer weld-to-weld spacing and welding of workpieces with smaller flanges

Laser welding

- high initial investment

BIW Manufacturing Process

STAMPING MACHINES

Mechanical and hydraulic presses are commonly used for press operation due to *wide range of sizes, tonnage capacities, stroke lengths, and operating speeds.*

Mechanical presses are suited for:
•Blanking parts at high speed
•Automatically fed with a short feed length
•Shallow drawing
•Work requiring an easily controlled depth of stroke
Hydraulic presses are suited for:
•Deep drawing
•Short runs with frequent die changes
•Blanking with a form, or coin
•Lower speed high tonnage blanking with long feed lengths
•Work requiring repeatable pressure

DESIGN FOR STAMPING:

To finalize optimized stamping process it is the responsibility of product designer and die designer to:
1.Simplify the design suitable for die design or combination of operations
2.Design a components such that it will combine the components in case of tailor welded blanks
3.Reduce depth of component to avoid number of draw operations
4.Minimize number of operations required to finish the components
5.Process to be choose for stamping depends on the design and complexity of component
6.Usually blanking, drawing, piercing, forming, notching, trimming, hemming operations are largely used in automotive stamping applications

SHEET METAL PREPARATION FOR PRESS OPERATION:

- Normally sheets are supplied in the form of rolls for mass manufacturing.
- To make components the sheets are cut down into the correct shape of component called as 'Blank'.

SHEET METAL FORMING OPERATIONS

There are several processes involved in making final component from raw material. For understanding purpose these are divided into three classifications:

- Shearing process (Cutting material)
  - Punching
  - Blanking
  - Perforating
  - Parting
  - Notching
  - Lancing
  - Nibbling
  - Slitting
  - Tailor welded blank
  - Shear Spinning
- Forming process (Bending and stretching)
  - Bending
  - Stretching
  - Drawing
  - Re-draw
  - Roll forming
  - Explosive forming
  - Hydro forming

Finishing process (to maintain surface and geometry quality)
- Trimming / laser trimming
- Flanging / Cam flanging
- Hemming
- Part off
- Beading

However, for manufacturing ease and to combine dies die designer can combine the operations as suitable for final components.

DEFECTS & TEST METHODS FOR FORMABILITY OF SHEET METALS

Yield point elongation :

Stress strain marks can be eliminated by reducing sheet 0.5 to 1.5% thickness

Anisotropy:

It is caused by thermo-mechanical processing of sheet
(Types: Crystallographic anisotropy / Mechanical fibering)
These strains are used in determining the normal and planar anisotropy of sheet metal

Grain size:

Grain size effects mechanical properties & surface appearance due to stretching and drawing
The coarser the grain the rougher the appearance

Cupping test:

Determine the formability of sheet metals

FORMING DEFECTS IN SHEET METALS

1.Earing or planer anisotropy:

- Edges of drawn cups may be wavy due to varying properties in different directions, this phenomenon is called earing

2.Wrinkling in flange:

- Due to compressive buckling in circumferential direction

3.Wrinkling in wall:

- When a wrinkled flange is drawn into the cup or if the clearance is very large, resulting in a large suspended region

4.Tearing:

- Because of high tensile stresses that cause thinning and failure of the metal in the cup wall
- Tearing can also occur in a drawing process if the die has a sharp corner radius

5.Surface scratches:

- Can be seen on the drawn part if the punch and die are not smooth or if the lubrication of the process is poor

6.Spring back:

- After plastic deformation there is an elastic recovery this recovery is called spring back

7.Necking:

- Thinning abruptly in narrow area

8.Stretching:

- Extension of sheet surface along all directions

CAUSES OF DEFECTS

•Less Blank holder pressure
•Die cavity depth and radius
•Friction between the blank, blank holder, punch and die cavity
•Clearances between the blank, blank holder, punch and die cavity
•Blank shape and thickness
•Final part geometry
•Punch speed

HOW TO AVOID DEFECTS IN DIE DESIGN

•Forming analysis
•Forming limit diagram simulation
•Draw ratio selection
•Proper blank holding pressure
•Provision of draw beads for helping flow of material

Future Developments

- New technology developments and innovations driven by:OEM
- Customer requirements
- Government and global legislation (environmental and safety demands)
- Supplier (operational benefit, volume)

In future OEM's will use a wide variety of new materials to meet new weight requirements