

# EDGE TREATMENTS OF SHEET METALS

BY  
PATIL BHUSHAN A

Guide  
Prof V P BAPAT

Industrial Design Centre  
IIT Bombay

1998

MSR-

श्री. वी. व्ही. जयराव

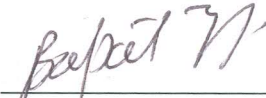
L. D. G. LIBRARY

18th PD/ 96-98 Batch

## APPROVAL SHEET

The Special project entitled , "*Edge Treatments Of Sheet Metals*", by **Patil Bhushan Arun** (96613012) has been approved for the degree of Masters Of Design.

Guide

  
\_\_\_\_\_  
**Prof V P Bapat.**

## *Acknowledgment*

I express my sincere gratitude to Prof. V. P. Bapat, for all the guidance he gave me throughout the project. Apart from valuable guidance in subject matters; his encouragement, degree of freedom, appreciations helped a lot to complete the task.

I also thank Prof. M. S. Kulkarni, MIT Pune, who gave me valuable feedback at the intermediate stages.

Also I am very thankful to Tansen Chaudhari, a Ph.D. Student (mechanical-design, IIT Bombay) for his timely guidance and the constructive criticism while doing the project.

I extend my thanks to all the IDC staff and my colleagues for giving me the timely and suitable instructions.

**Patil Bhushan Arun.**

1. Introduction
2. Creation of edges
3. Coatings on sheet metal
4. Metallurgy of corrosion
5. Evaluation of case studies
6. Design guidelines
7. Designer's contribution towards edges

-references

---

---

## Introduction

At present one can see lot of use of the sheet metal for the various product assemblies. Though commodity and engineering plastics have contributed a lot towards replacing the metals used in products, for specific applications like heat, stresses, durability and some stringent working conditions one has to go for the metals. As a product designer most of the times we deal with the use of sheet metals for designing the parts and components for the assemblies.

During design stages always the designer specifies or take for granted some of the materials for construction of the final product which will come in the market. For this material selection designer has to be really keen about the materials and their behaviour in practice. Also he should be able to judge the material's susceptibility and durability. To decide in advance these factors the designer should take into account some guidelines which will help him to take a decision.

As far as the product designer is concerned most of the times he used to deal with sheet metal as a construction material. For the designer to specify the material for any component he should know the limitation and advantages of the material for getting maximum utility of service of the product and material from this selection.

Purpose of this topic is to set guidelines for the designer which enhance

---



the designers knowledge of what he can do to reduce the very high cost of failures caused by wrong material selection or wrong design of the components. As design is the first stage in the launch of any product, if proper care is taken to select the material and to design the component taking into account the properties of the material, lot of cost can be saved, rather than curing the mistake after the product goes in production.

So from economy, life, efficiency point of view designer always should have some guidelines in his hand as basis for selection of materials here especially sheet metals.

Majority of the sheet metal components are either stamped, formed, bent, etc. or designed with some special techniques like edge foldings, denting, drilling etc. Whenever one go for metals as the choice, main consideration which attracts the attention from the product design point of view is the treatments given to the open edges of sheet metals, as lot of problems like;

- edges are the starting points of corrosion

- open sharp edges in assemblies can happen to be the cause of some injury

- edges are the major areas from design point of view to give strength





and shape to the sheet metal component

-open sharp edges are neither aesthetically appealing nor adopted as design feature in the product

-at the edges the anticorrosive coatings also become inefficient because of nonuniform thickness of the coat,

are associated with the open edges. So during this topic the edges are given the major concern.



## Creation of Edges

As discussed for design of any part with sheet metal always an attention should be given to the edges but the questions which arise are why the edges are created, is there any possibility to avoid the edges.

As all sheets are cut from the rolled sheet stock always the edges are going to be present so one can't avoid the edges totally. So the only option is to treat the edges in such a way that the drawbacks of the edges can be eliminated or reduced.

Some of the reasons why the edges are created in sheet metal are;

- cutting
- shearing
- punching and blanking
- drilling
- etc.

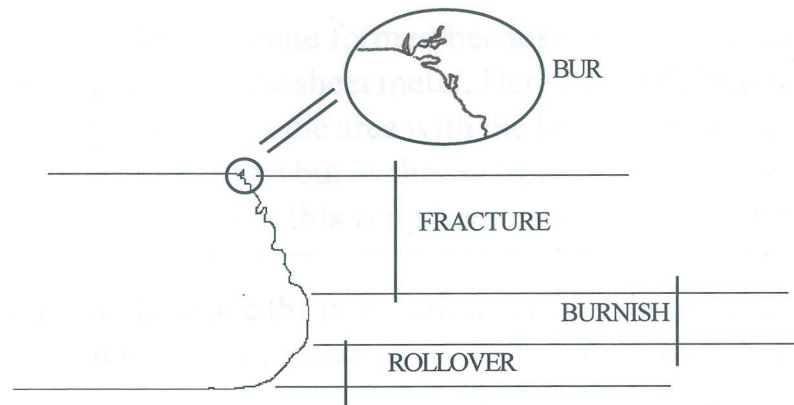
Because of all such operations the sharp edges are created in the product, and all such operations are essential to give the product form to the sheet.

In all these operations the formed edges if seen under microscope are not uniform in the direction of cutting, lot of irregularities can be seen on the cut or sheared surfaces. Due to these irregularities at the cut surfaces more area is available for the interaction with the atmosphere and because of higher susceptibility for corrosion at such edges, the edges corrode faster than the remaining surface of the sheet.

---

After magnifying the cut edges the profile which we see have differentiable zones viz. bur, fracture, burnish, rollover and these zones interact in different manner with the atmosphere so the corrosion rates at each zones also are different and dependent on area, reactivity of the opened metal grains with the atmosphere.

**Magnified profile of the cut or sheared edge\*:**



From the above figure various zones and their relative areas can be revealed. At the first zone bur is formed while cutting this is the area where lot of irregularities are created and also the working stress (cold or hot working) levels in the formed bur also is not uniform so highest rates of corrosion are found at this zone. At the fracture, burnish and rollover zones the the irregularities are more or less uniform for that particular zone. Next table gives the total picture of each zone and it's susceptibility to corrosion.

\*ref. 'Techniques of Pressworking Sheet Metal' by Eary and Reed. Article-Penetration Chapter 1.



Zone	Description
Bur	this is the most sensitive zone for the starting of corrosion as here the grains are more open and reactive to the environment. Also the surface irregularities are maximum at this area.
Fracture	this is the zone formed because of impact action of the punch on the sheet metal. Here a tearing like action takes place, this is the area with the lesser number of the surface irregularities but as the surface area of this zone is maximum at this zone higher corrosion can be seen.
Burnish	at this zone the punch almost traverses a straight line path, resulting into least number of surface irregularities.
Rollover	this is the zone where the punch head releases the sheet metal surface, but the punch continues to roll over the cut edge of the sheet metal. At this region the rate of corrosion is least as here almost no surface irregularities are formed and the surface can almost be similarised to the plane sheet metal surface.



\*ref. 'Techniques of Pressworking Sheet Metal' by Eary and Reed. Article-Penetration Chapter 1.



### **End grain attack**

For the study of sheet metal edges, one has to know the phenomenon of the end grain attack at the edges. End grain is defined as the surface perpendicular to the direction of rolling\*. During rolling of sheets at the mill, nonmetallic inclusions which are inherently present in the metal are elongated in the direction of rolling.

As the ingot is rolled, the ingot is successively broken down (rolled) to smaller and smaller thicknesses. During such action, nonmetallic inclusions are rolled out to thinner and thinner sections. When the sheet or plate has been rolled to the proper gage, the nonmetallic inclusions have been rolled into long "stringers", all in the direction of rolling.

When the end grain is exposed to a strong corrodent, end grain attack starts at areas where stringers are exposed on the sheet or plate end and can aggressively proceed into the sheet. Most of the irons have sulphide inclusions inside the ingots these are the main source for triggering the corrosion at the end grains.

As a designer reviews his equipment designs, he should be alert to possible exposed end grains in the equipment intended for service in the practical environment. He can specify on his drawings where he desires end grain protection and how that can be achieved. One simple solution to prevent



---

\* all the sheets are produced by rolling in the rolling mills. Here direction of rolling is concerned with the production method of sheet metal stock.



end grain attack is to cover the end grain totally with the welding material, as the welding metal is not susceptible to such an attack; this is called buttering of the end grains. But the major drawback of this method is we can adopt this method at the cost of losing the aesthetic value of the product, also this is not suitable from the mass production and economy point of view.

All the...  
prin...  
atmo...  
in each...  
adhe...  
Org...  
Of the...  
from r...  
of org...  
cra...  
cle...  
C...



## Coatings on Sheet Metals


The use of the protective coatings is one of the main methods of corrosion control available to the designers. This type of protection is particularly important for carbon steels. Some of the coatings used for the sheet metals are;

- organic coatings
- electroplating
- conversion coatings
- flame spraying
- glass lining

All the above coatings are suitable to prevent the surface corrosion. The principle of corrosion protection in each method is preventing the atmospheric interaction with the sheet metal. But the degree of protection in each of the above mentioned method is different because of different adhesion and porosity of the protective films.

### **Organic coatings ( Industrial coatings - paint films)**

Of the above listed coatings these are the mostly used coatings. Also from the designer point of view, the designer has only to specify the type of organic coating he desires to select for his design. For applying this coating the surface preparation by either of the methods like, abrasive cleaning, steam cleaning, flame cleaning, solvent bath cleaning etc. or the combination of one or two such methods, should be done for the effective



working of the protective film. The coatings are given in three layers viz. primary coat, intermediate and top coat.

### **Designing for protective coatings**


To assure the that the design of the structure or part is amenable to coating, following guidelines can be beneficial while designing.

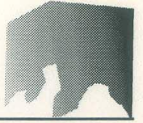
1. Eliminate sharp corners.
2. Avoid design which will collect water and debris.
3. During design specify the removal of the rough surfaces by sanding, grinding, or other means.
4. At the edges at least specify the different coating type or extra coat of the same coating as a preventive measures at the most susceptible areas.

### **Electroplating**

Electroplating is accomplished by making the part to be plated the cathode while the material to be coated is made anode. During the reaction the anode dissolves out and get uniformly plated on the cathode. Generally nickel, chromium, cadmium, zinc are some of the metals used for coating on the ferrous sheet metals.

---





Coating	Use
Nickel	Used for prevention against marine, rural and industrial atmospheres.
Chromium	For exterior uses like automobile bumpers and boat hardware.
cadmium	Used for steels, to protect the atmospheric attack. Springs are generally cadmium coated for protection against corrosion and abrasion.
Zinc	zinc is important at or near the sea where close fitting parts like hinges, joints are present.

**Conversion coatings**

These are the coatings applied on the metal surfaces by the chemical reaction of the sheet metal surfaces with the suitable chemical solutions. For steels phosphate, chromate coating are found suitable. These can be applied by spraying, wiping or by electrolyte immersion method. This type coating can be adopted for the components with relatively shorter life spans and where economy matters.





This chapter mostly deals with:

### **Flame spraying**

This coating method creates a deposit on a surface to be coated by heating the powder of the substance to be coated. This powder adheres to surface after spraying the hot powder on the surface.

Applications-These include repair build ups of worn parts, high-temperature-resistant coatings for rockets and jet aircraft, automotive exhaust mufflers, etc.

### **Glass lining**

Glass fused onto metallic surfaces are used today in chemical and food industries, as well as others, because of resistance to wide variety of chemicals and corrosives.

These are the some of the techniques used for coating on metals. Designer depending upon the type of the requirement decides or selects the type of coatings required for his design. As mentioned earlier the main problem associated with all these type of coating is because of the lesser film thickness of the coating film at the edges the corrosion attack starts at the edges. Also the lesser adherence at the sharp edges add to failure of the film at the edges.



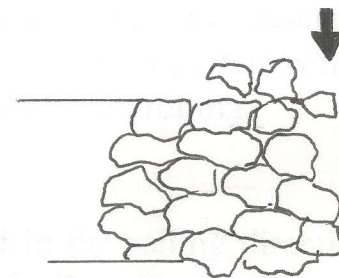
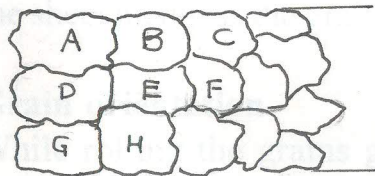
## Metallurgy of Corrosion

This chapter mostly deals with ;

- why the sheet metal edges get corroded?
- why with some modifications the edges get protected?
- what type of modifications are necessary to reduce the edge corrosion?

### Microstructure of edges

If the edge of the sheet metal is magnified then one can very well predict the reason why the corrosion attack starts from the edges in sheet metals. In the microstructure of metals the two basic factors which plays the important role are the grain orientation and the intergranular attraction. Below the general view of the magnified sheet metal edge is shown,





From the above grain structure, for the edge grains A and G the intermolecular cohesive forces as compared to the surface and undersurface grains viz. B, D, H and E, F; are very less. Because of this the freedom for the electrolyte action of dissociation of metal to metal ions and electrons at the edge grain is more as compared to surface and undersurface grains.

One additional factor which assist in corrosion action at the sheet metal edges is the grain structure at the edges is not uniform if the edge is formed by cutting or shearing the sheet. As discussed earlier the cut edge has lot of surface irregularities and those too differ from region to region e. g. bur has the maximum susceptibility to environmental attack than the fracture or burnish zones.

These are the basic reasons why the edges are more susceptible to to corrosion attack. Again the factor which is more important while studying the sheet metals is the grain orientation while hot rolling.

### **Grain orientation**

While rolling the grains get elongated in the rolling direction and get deformed permanently in the direction of rolling. During the rolling action the grains set themselves so as to suit the rolling direction. This orientation



---

\* Here the cutting and shearing action both are the cold working processes while in hot rolling the grains during curing have a sufficien freedom to orienet themselves accordingly.






gives a stability to the edge grains during deformation into sheet form. But when the sheet is cut or sheared\* in the direction perpendicular to the direction of rolling, at the newly formed edges due to lot of surface irregularities and weak cohesive forces between the edge grains the corrosion susceptibility is more.

As far as ferric (iron) materials are concerned, in the atmosphere because of electrochemical reaction the metal get dissociated into metal ions giving out the negative charges ( $e^-$ ) to atmosphere. Thus because of the anodic reaction taking place at the metal it gets corroded, this type of corrosion is called a galvanic corrosion. At the edges because of open grains, the rate of this reaction is higher. Again in such cases the rate of corrosion depends on the extent of interaction of the surrounding environment with the metal, lesser the interaction lesser is the rate. With some design modifications like hemming and seaming this interaction can be minimised to a greater extent.

Following are some of the edge hemmings and flangings used for corrosion protection, while designing designer can select the type of folding as per his requirement or modify his design to reduce the corrosion at the edges.

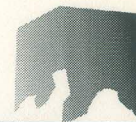



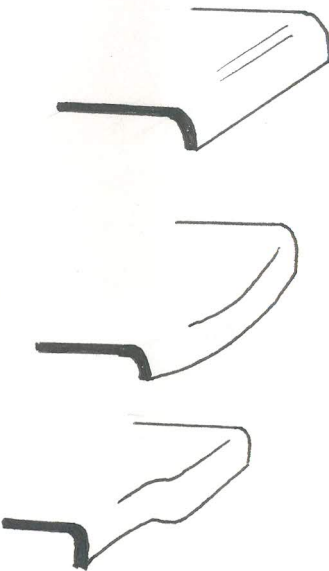


type of fold	typical applications	remark
flattened hem 	Automobile bumpers, tractor front hoods, chairs, openings in the machineries for accesses, etc.	
open hems 	drawers and drawer rails, sliding sheet metal parts,	this type of folds are used for seaming sheet metal components like can seaming.
false wire curling 	buckets openings, lampshades, motorcycle mudguards, hoppers in agricultural equipments, wheel rims of bicycle, sometimes at the flanged edges of sheet metals, etc.	



\* in all the above types the main attention is given to hiding the edge so that the edge has a least interaction with the surrounding environment.

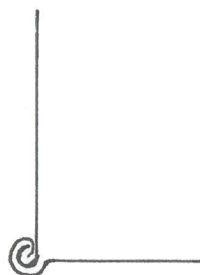


type of fold	typical applications	remarks
<p>wiring</p> 	<p>tollboxes, bicycle mudguards, open edges of the sheet metal containers, etc.</p>	
<p>flanging</p> 	<p>construction panels, tube light holdings, machinery housings, inlet holes for the tanks, lids of the sheet metal containers, etc.</p>	<p>cold working stresses developed at the foldings add to susceptibility of corrosion of the edges.</p>

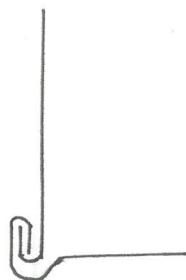


As discussed these are the methods the designer can adopt for the open edges. Similarly while joining or assembling sheet metal components the care is taken that the sheet metal edges hide from the surrounding environment.

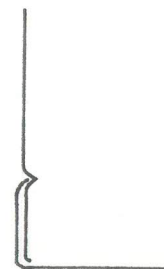
Following are some of the joints used for sheet metal in which the mentioned care is taken into account.



single seam joint

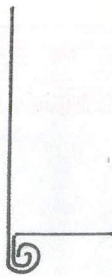


double seam joint



rolled clinch joint

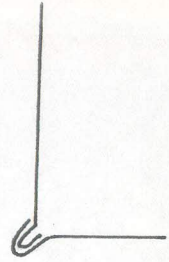




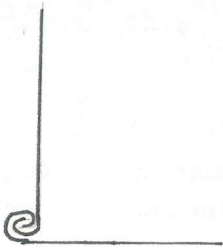
inside curl on joint



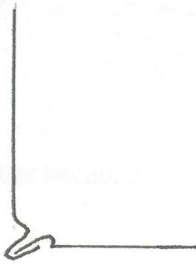
outside curl on joint



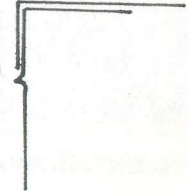
squeezed seam for cans



flanged joint



inside single seam joint



slip cover



## Case Study

Case 1.

C- sectional channel details

( corrosion at the cut edge - close up)

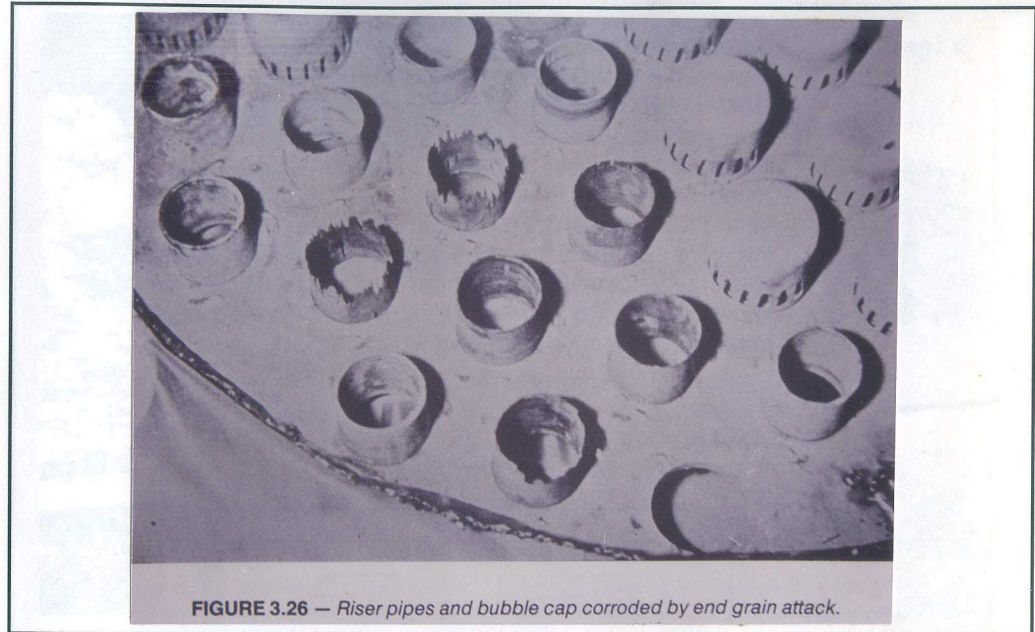


Description- The intergranular fracture because of adverse corrosion effect initialised from the edges can be seen in this case.

(Cross sectional thickness of the C- channel 4mm )

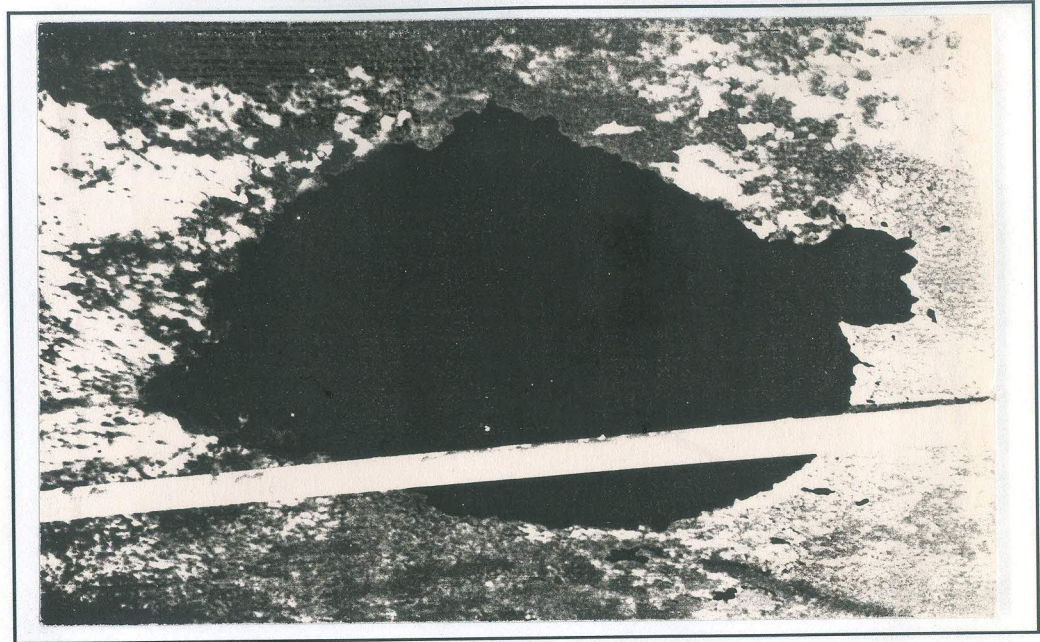
### Case 2.

Test specimen of sheet metal risers, some with closed caps, some with folded edges, some open as it is, subjected to corrosive environment simultaneously.



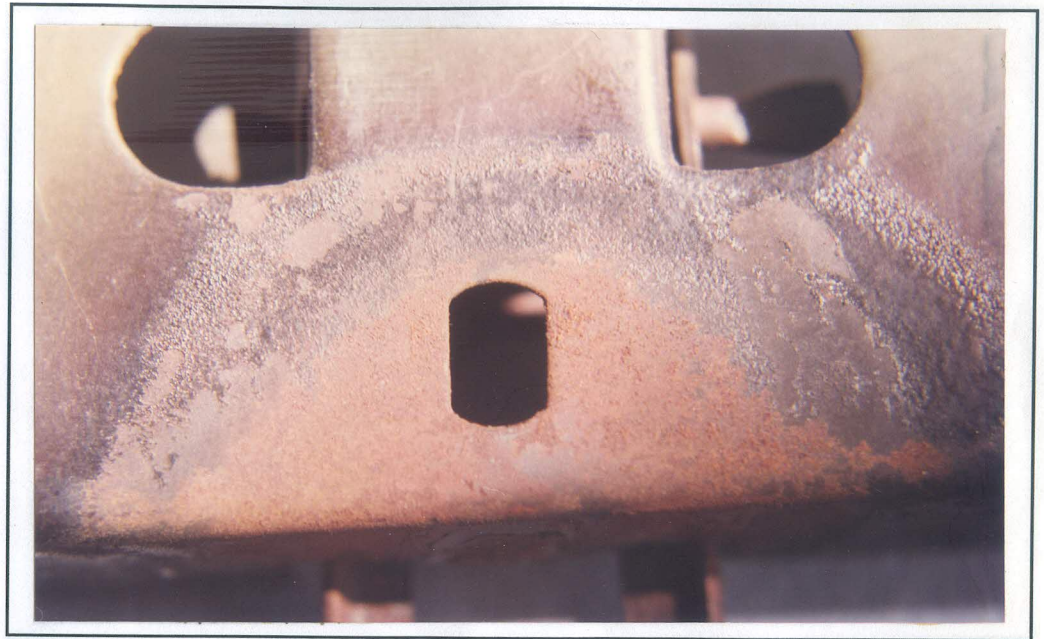
Description- Here due to the corrosion action almost all the open edges get eaten up, while risers with closed lids or with some edge treatment like seaming, hemming etc. get survived because of hidden edges from the corrosive environment.

Case 3.  
Water storage tank opening  
(Circular opening)



Description-Because of having the open edge , the tank opening got uniformly corroded through out the open edge.

### Case 4. Drilled/punched sheet metal component



Description- In the lower punched hole because of the edge corrosion attack area nearby get corroded while at upper 2 flanged openings due to the hidden edges the lesser corrosion is seen.

## Case Study

Case 5.

Specimen having painted surface with flanging at one edge and at the central circular opening.



Description- In this three regions - the corroded edge, noncorroded flanged hole, noncorroded flanged edge are clearly seen. Here the paint coat also has failed to stop the corrosion attack at the open edge.

## Case Study

Case 6.

A cut piece of the bicycle mudguard, one side seen with wiring type of edge treatment.



Description- Here due to wiring done at the longitudinal edge the corrosion attack almost got inhibited while at the other edge because of no edge treatment a severe edge corrosion attack is observed.

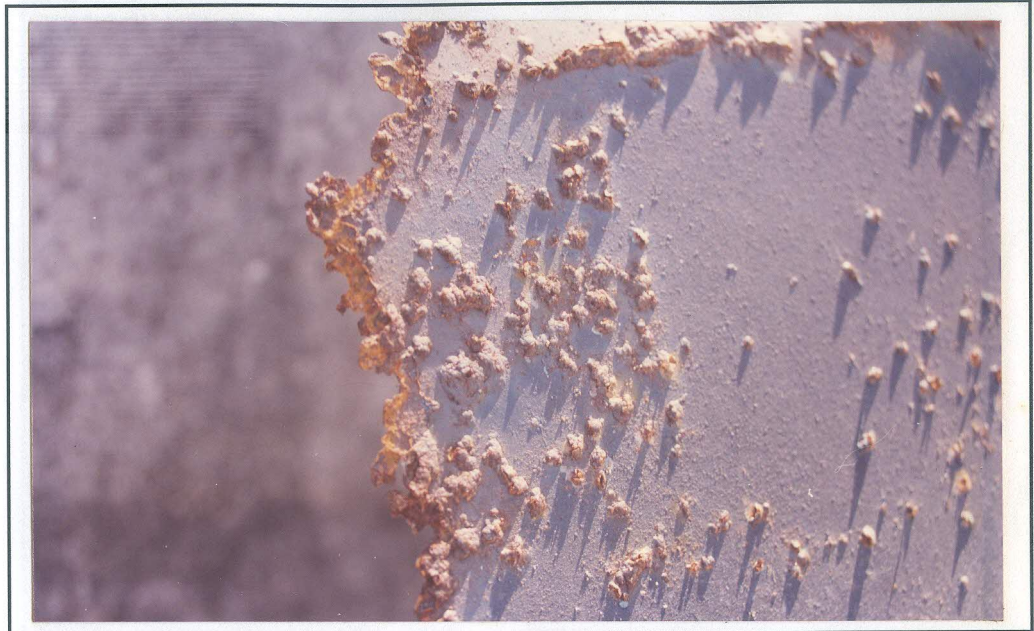
Case 7.  
Sheet metal hinge  
(electroplated)



Description- With the electroplating also at the edges as the coat thickness is less the coat fails first.

## Case Study

### Case 8 Edges of a painted specimen.



Description- Failure of a painted film at the edges become a starting point for corrosion.

## Case Study

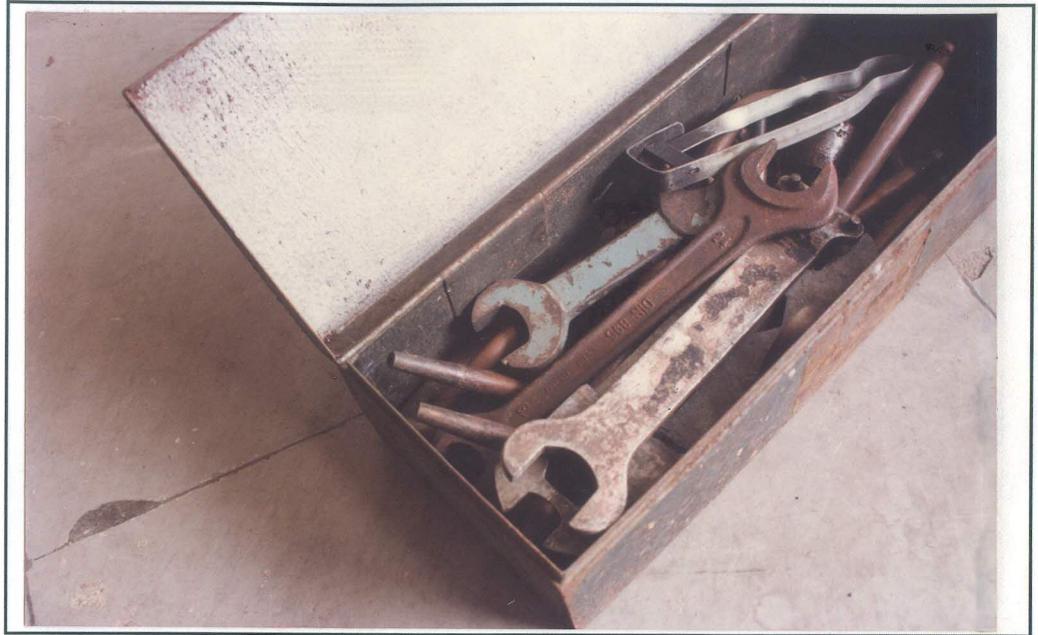
Case 9.  
Welded sheet metal joint at the edge



Description- Because of unsealed joint the open edge comes in contact with surrounding environments and leads to destruction. Also at the openings due to no edge treatment corrosion attack can be seen.

## Case Study

Case 10.  
Tool box



Description- Because of wiring at the open edges, though corrosion has shown it's effect on surface the edges get protected from the environmental attack.

Case 11.  
A machine hopper.



Description- Here at the hopper end the lower edge get unintentionally protected while the open edges can be redesigned from the point of view of preventive corrosion measures.

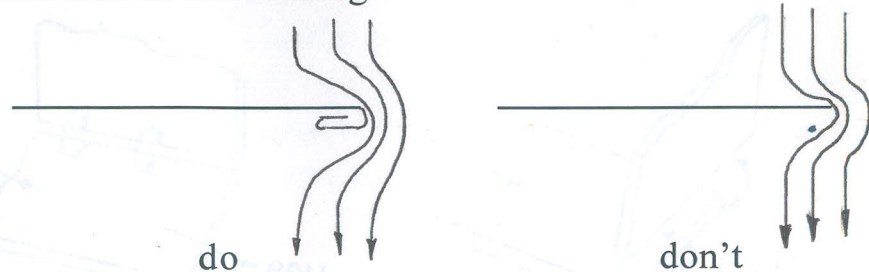
## Evaluation of Case Studies

From the cases studied one can very well include ,

1. For sheet metals the edges are the most sensitive zones from the point of view of corrosion attack.
2. The cases in which the edges are given some attention like seaming, curling the edges one can see that a lesser rates of corrosion are seen at these edges.
3. From the cases concerned with coating the sheet it can be very well conclude that at the edges because of comparatively lesser coating thicknesses, the corrosion attack starts from the edges.
4. In the cases of open sheet metal edge to edge joints if the joints are not given with proper seamings the joints starts corroding and get weakened after ages.
5. At drilled or punched sections also the coatings are found inadequate to resist the environmental attack
6. In case of sheet metal edge flanging if the flanging is done with cold working the stresses developed become the assisting factors for corrosion.

## Design Guidelines

1. As far as possible hide the open sheet metal edges. Preferably, by joints (welded or riveted) should utilise the top edges. This is because seaming
2. Wherever possible modify the design so that the edges have least interaction with the surrounding.

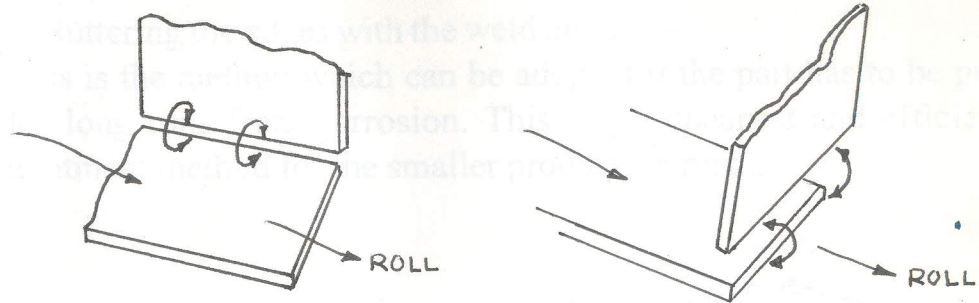


3. If coating type protections is to be adopted then the design should specify the additional thickness of the coat at the edges in addition to the type of coating method. Especially in electroplating the edges should be rounded of for adequate coating at the edges.

4. If the sharp edges are unavoidable then some sacrificial plates can be added at the edges if possible to deviate the corrosion attack from the main sheet metal edge. This is quite often used method for underground and under sea sheet metal components.



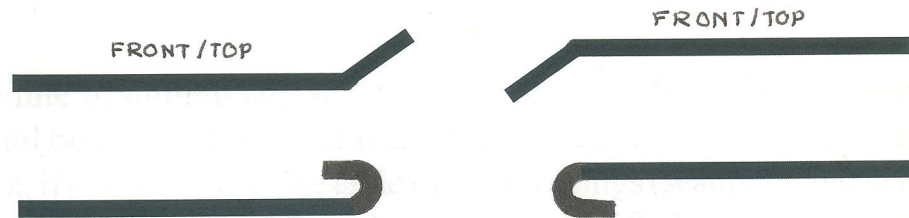
5. When the rolled sheet is cut for manufacturing preferably the joints (seamed or welded) should utilise the cut edges. This is because seaming or welding\* hide the edge totally from the surrounding.



avoid

preferred

6. While designing the sheet metal components keep the underbody surfaces dry; avoid ledges, flanges and pockets where dirt can accumulate and hold moisture.



avoid

preferred

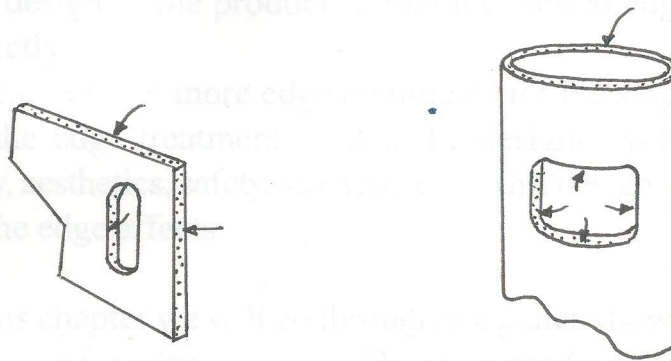
\* Here the welding should be complete i.e. throughout the joint, it should not be spot welded.



7. To avoid the galvanic corrosion dissimilar metals should not be kept in closer proximities. In unavoidable circumstances some insulation gasket can be used at the joints.

8. Buttering the edges with the weld material-

This is the method which can be adopted if the part has to be protected for long runs from corrosion. This is the cheapest and efficient edge treatment method for the smaller production runs.



9. While designing any sheet metal part after designing the component should be checked whether it satisfies the corrosion preventive measures or not, if not then as per the table of edge foldings (seamings and hemmings) the component should be redesigned or modified accordingly.



## Designer's contribution towards edge

As seen till, for any sheet metal product edges are the areas which should be given equal importance as designing the product. The techniques which are available to compensate for the edge effects can't be used always directly as they are specified as. Sometimes these methods should be modified accordingly to suit the product's need, for this the designer has to give his creative contribution for the required modifications.

Product designer's options for modifications -

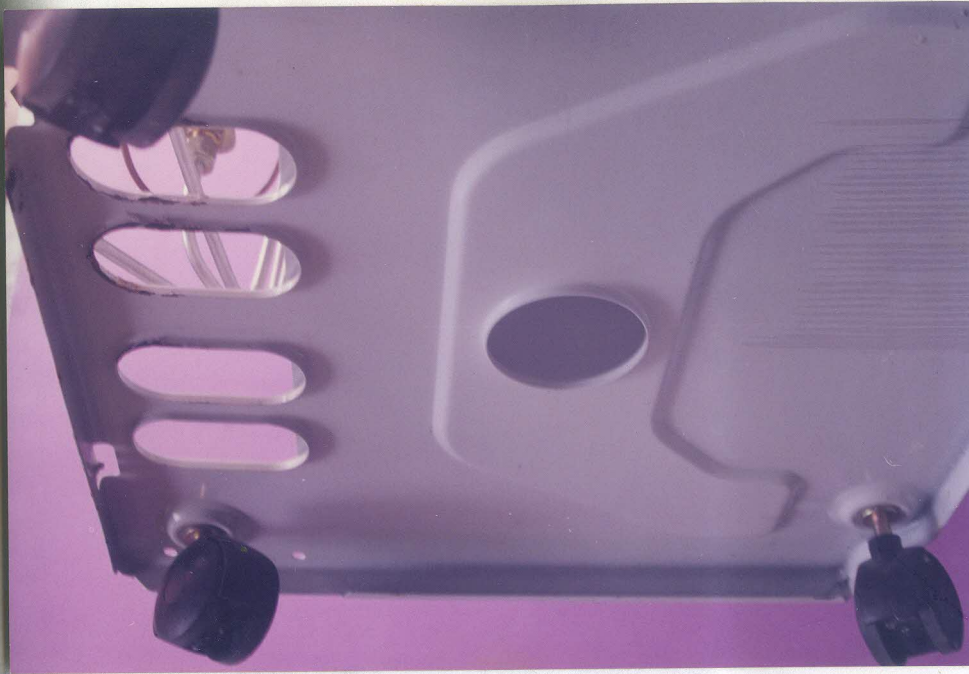
### 1. Design modifications

Change the design of the product so that the chosen edge treatment can be used directly.

### 2. Combination of 2 or more edge treatments for the single edge

3. Modify the edge treatment so that the designer gets the additional functionality, aesthetics, safety, strength, etc. to his design instead of merely restricting the edge affects.

Further in this chapter we will go through the plates showing the methods of compensation for edge effects and how the product designer has given his contribution during implying these methods.

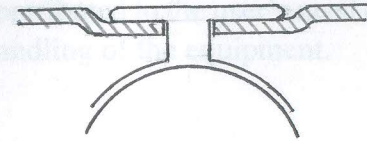


#### Punched cuts

Flanging is done at each punched hole thus the corrosion won't affect the punched die sectional area.

#### Caster fixing

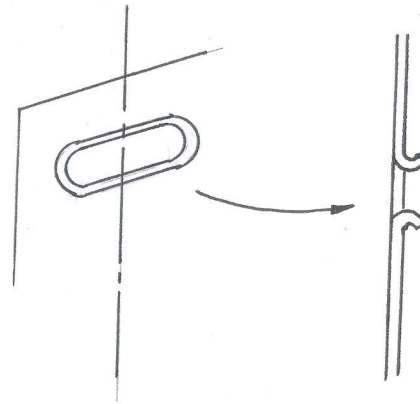
Depression for the caster fixing provided to get the flattened assembled surface at the top.

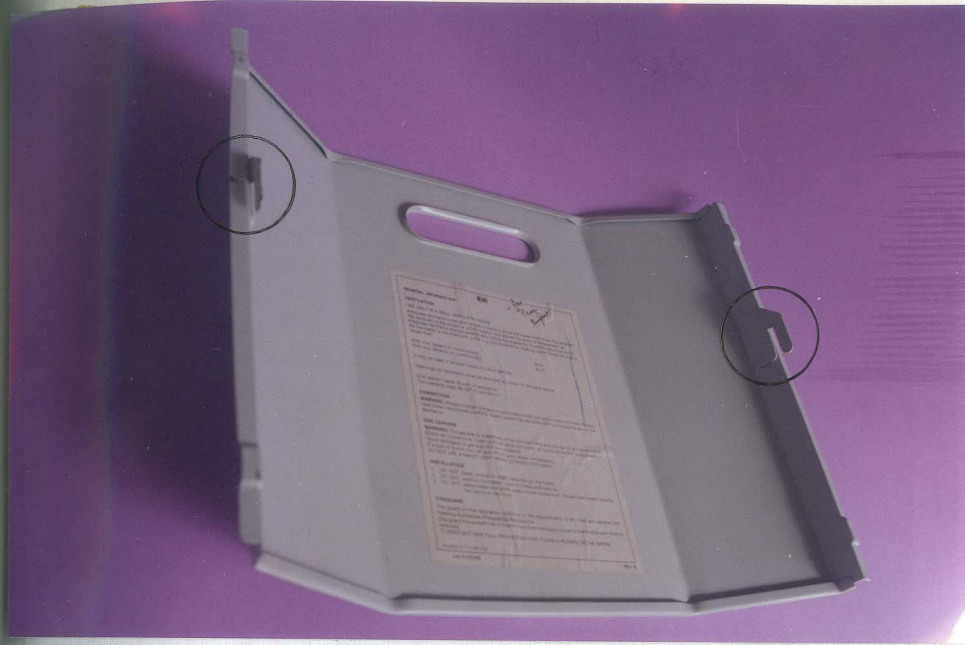




Vertical edge folded inside to reduce the atmospheric interaction with the edge.

Handle  
Flanging done as a functional requirement but here to go for flanging instead of using some other treatment is a product designers decision. Selection of this treatment has contributed to the user's need of safety handling of the equipment.





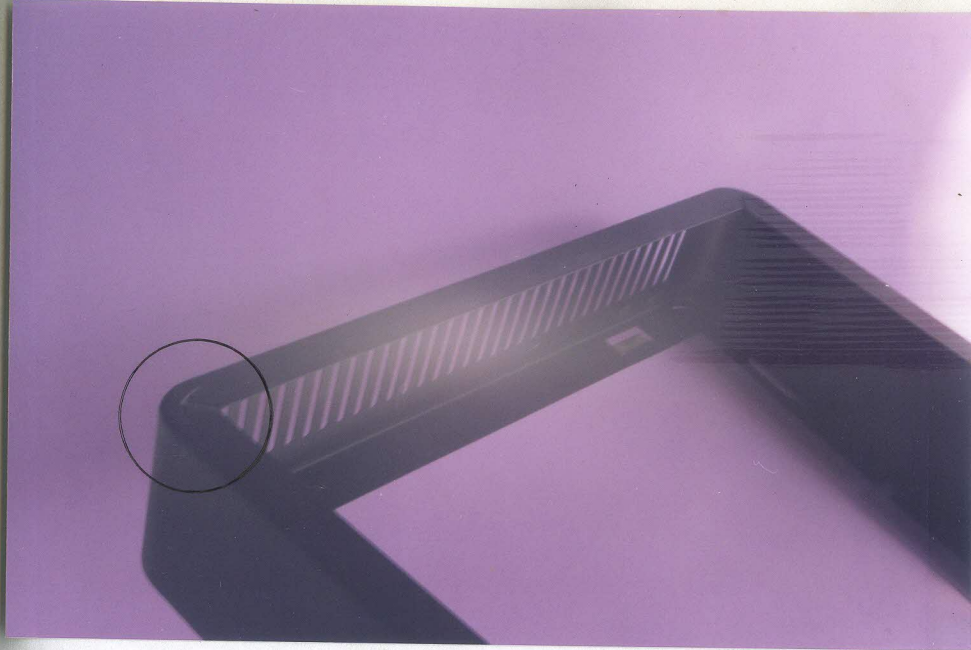
In this picture we can see the designer has added an extra item instead of creating the item with the same parent component. Here addition of extra item has maintained the continuity of the treatment provided and prevented the creation of new edges which will result in becoming the propagation points for corrosion.

Handle, bottom and top edges also are given due attention while designing the component.



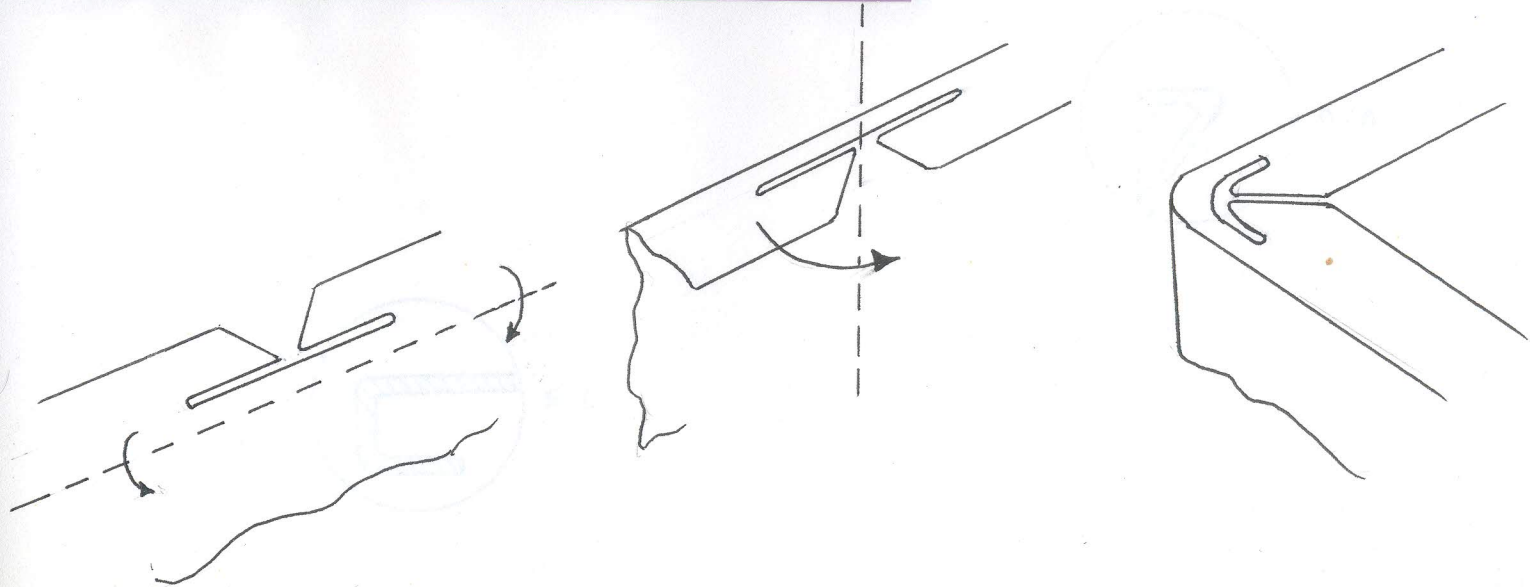
In this component all the edges are folded inside such that after assembly no edge will protrude out of the product surface. Here the treatment is decided by taking the whole product in consideration rather than considering an individual component alone.

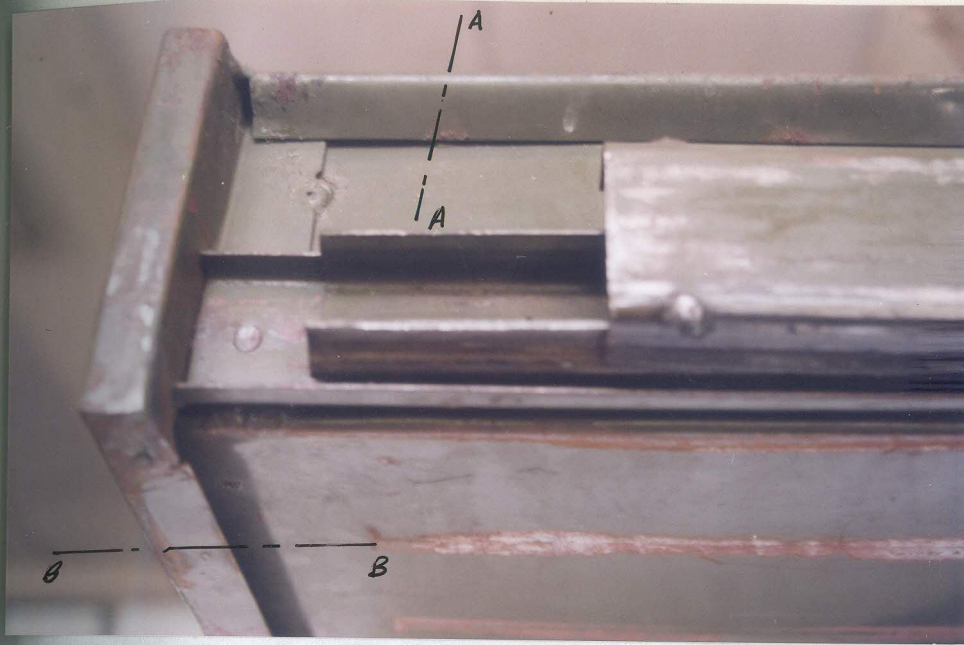
and the manufacturing difficulties involved into production of the component.



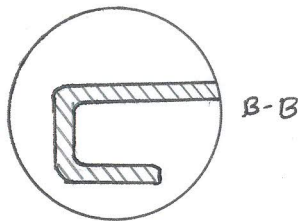
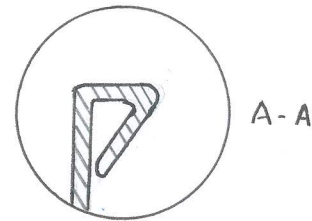
Here we can see the designer has taken a help of single inside fold to hide the edge from the surroundings, but to imply this simple treatment to fold the edge at the corner a special technique has suggested by the designer. This has served the purpose of edge hiding and the manufacturing difficulties involved into production of the component.

them accordingly has played an important role.





In the drawer shown the edges folded in such a way that all the surfaces inspite made up of sheet metal will look like made up of thicker section material. In this product designer has given his contribution for changing the looks of the product from planer to voluminous product, here selection of the edge treatments and modifying them accordingly has played an important role.

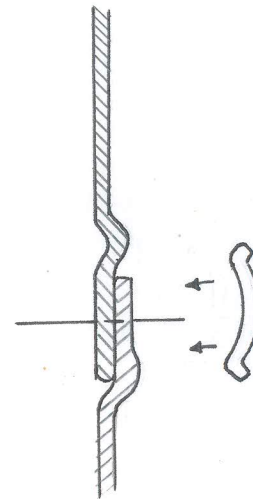


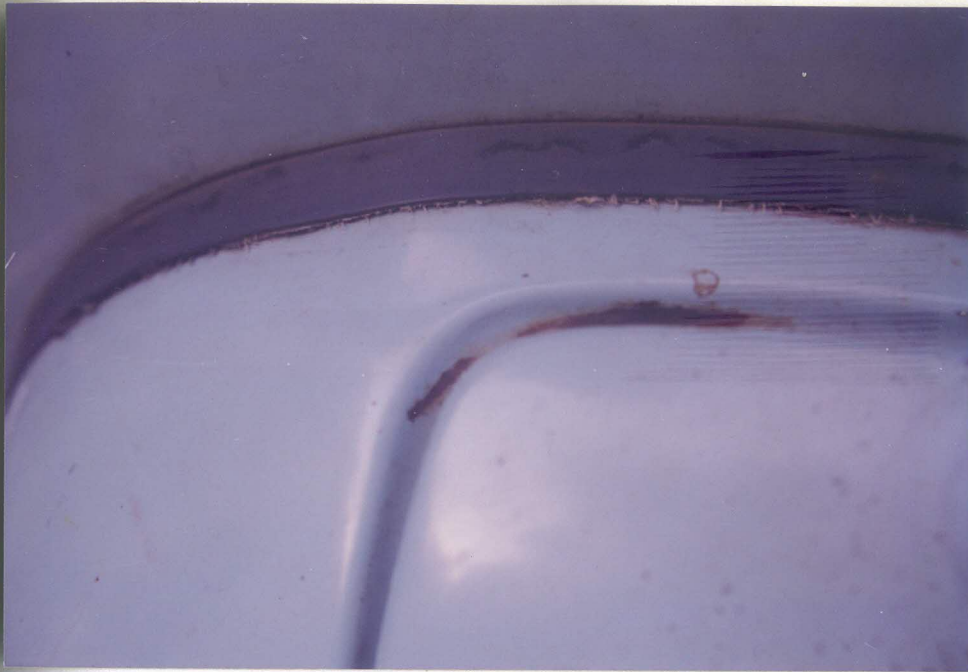


In the picture shown as the circular counter is the functional requirement of the product so the designer has only one option to provide the treatment so that the circularity of the counter doesn't get obstructed. Here the designer instead of demanding for any expensive (from manufacturing point of view) folding treatment has decided to provide a rubber ring which will cover the edge.



In this water geyser the bottom dish is attached to the top with the help of screws but doing this has exposed the circular edge of the bottom dish open to the surrounding. To hide this edge here the designer has added a PVC ring running round the edge, this has added to the aesthetics of the product in addition to mere functional edge treatment.





In this view of the scooter side bumper shown, the two sheet metal components are coming together, which otherwise have a direct edge to edge contact is avoided by adding a rubber gasket at the joint.

Addition of this dissimilar material has sufficed for reducing the galvanic corrosion attack at the edges.

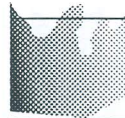


## Conclusion

Finally all that matters in this phase of designing of sheet metal components is the decision of the product designer, which treatment he selects, how he modifies that treatment, so it suits to the concerned product utilitywise and / or lookwise. Instead of taking the corrosion inhibitive measures after the problem is faced, it's a designer's work to predict the concerned problem in advance during the designing phase.

The guidelines given are only the attempt made to attract the designer's attention to the adverse corrosion problems, which are not seen in short duration but get revealed after ages and affect the product severely. So it's a designer's contribution which matters for reducing or enhancing the edge corrosion.

Product designer not only selects the treatment but in addition with the help of his creativity he can modify the treatment for the product he is designing. The treatments are modified in such away that they function not merely for technical factors but in addition add to products overall utility and / or aesthetics.



## Bibliography

Eary and Reed, 1974, '*Techniques of Pressworking Sheet Metal*'  
Prentice - Hall of India (private) Ltd. New delhi.

Ellis D Verink, 1994, '*The Basics*'  
NACE International, Texas.

Harvey P Hack, 1993, '*Galvanic corrosion Test Methods*'  
NACE International, Texas.

E. Beraha, B. Shipigler, 1977, '*Color Metallography*'  
American Society of Metal, Metal park, Ohio.

Douglas C Greenwood, 1961, '*Engineering data for product design*'  
McGraw Hill Book Company. Inc. New York.

Douglas C Greenwood, 1959, '*Product engineering design manual*'  
McGraw Hill Book Company. Inc. New York.

---