PROCESS AND FABRICATION OF STAINLESS STEEL EQUIPMENT FOR DAIRY, FOOD AND ALLIED INDUSTRY

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The idea of this topic was seeded in my mind some time back when we were detailing the Quality Assurance for various Dairy Equipments manufactured in our organisation. I was convinced that a hard relook is necessary to reengineer our activities in all spheres connected with stainless steel fabrication, primarily using light sections which are basically used in fabrication of Equipments for Food & Dairy Industry. The opening of Dairy Industry in India with "Operation Flood" of NDDB (National Dairy Development Board) generated a number of manufacturers. The standardisation to some extent on key areas were formulated by NDDB, but detailed fabrication methods were not laid out nor were available in any single source. Therefore with a varied experience in this industry, I thought of enumerating the basic process in manufacturing Stainless Steel Equipments for Food Application.

BASIC MATERIAL

The basic raw materials used in Food/Dairy Industry are mostly AISI304 (IS6911:04Cr18Ni10), AISI304L (IS6911:02Cr18Ni11), AISI316 (IS6911:04Cr17Ni12Mo2), AISI316L (IS6911:02Cr17Ni12Mo2), AISI430 (IS6911:05Cr17) and MS (Mild Steel). The thickness of the materials mostly fall between 1.6 mm to 3mm for storage vessels and 2.5 mm to 6 mm for jacketed pressure vessels. When the pressure range exceeds 50Pa, the thickness goes upto 10 mm. In case of Kitchen Equipments the thickness range is 1mm to 2mm.

AISI304 is used in most of the applications for large storage vessels and where higher corrosion resistance is required AISI 316 is preferred. Most of the vessels are insulated for cold/hot insulation and covered with cladding material SS430/SS304 or mild steel painted.

In Food Engineering application all vessels are cylindrical vertical, horizontal or rectangular in construction. Where height is a criteria Horizontal tanks are preferred and in cases where area is a restriction, vertical construction is preferred. Generally the storage vessels have an inner surface with insulation, or with intermediate jacket and insulated and covered. The pressure in the vessel jacket ranges between 20Pa to 60Pa.

DESIGN FEATURES

As a thumb rule all equipments used in Dairy Industry or in Food Application should have a smooth uniform finish and should avoid any crevices, sharp edges, and must be so designed that all points where the product comes in contact should be easily accessible for cleaning. Therefore all weld joints must be ground and polished. Neck areas should have large radii, around 25mm (Ref : Fig 1).

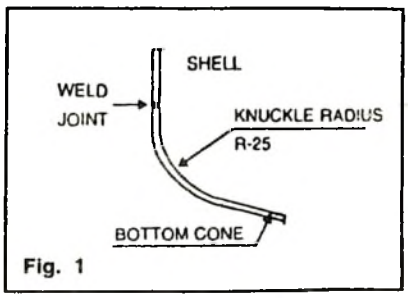


Fig. 1

In agitator designs, preferably bottom supports are to be avoided and should be of top hung type. In unavoidable cases, the bottom supports should be easily cleanable. Wherever MS stiffeners are used

they must not be welded directly to SS and must be fixed with the help of SS cleats (Ref : Fig.2). Directly welding a MS member to SS must be totally avoided.

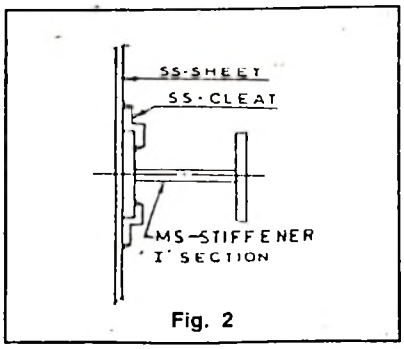


Fig. 2

Desaerator or Airvent, CIP (Cleaning In Place) sprayballs, Sightglass, overflow, no foam inlets, SS adjustable ball feets and ladder are a must for all storage vessels. (Ref : Fig.3).

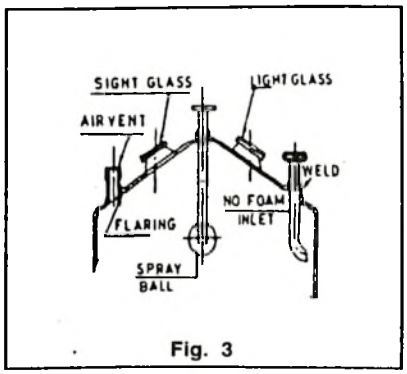


Fig. 3

The inside finish should be 3B or dull finish which is around 200-300 abrasive grain, ground and polished. The outer surfaces can be finished to customers' requirements ranging from dull to bright ground, Millfinish or MS painted.

The basic concept to be adopted while designing an equipment is to give lot of importance to aesthetic looks and high uniform finish in addition to Hygienic construction of the vessel.

The bottom dishes are with flat taper bottom, conical bottom, Hemispherical and Torispherical bottoms. The lip radii should be at least 25 mm or above.

FABRICATION

Sheet layout

For fabrication of Cylindrical vessels the layout is marked in a single sheet or in combination by using additional sheets. Additional sheets are tack welded and the entire layout is either cut with a Nibbler for sheets 1mm to 3mm thick or by plasma arc. After cutting the layout, the joints are removed for thickness beyond 2.5mm and bevelling of 60 Deg. is provided. (Ref : Fig.4).

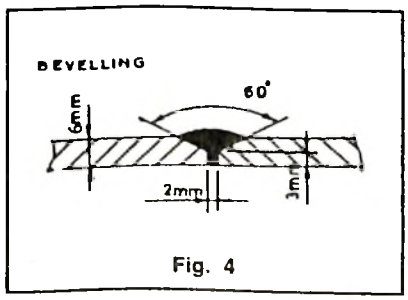


Fig. 4

For less thickness, a minimum gap of 1.6mm is given. For shells the joints can be avoided by using coils. While manufacturing cylindrical vessels it is better to use SS coils as it avoids rolling operation. Simply the two edges are tack welded and if required prebending is done. Most of the cylindrical tanks are fitted with flat bottom having a knuckle radius of minimum 25mm. Due to non-standard sizes of vessels and quantities being less, these flat dishes are formed. A layout is shown progressively (Ref : Fig.5). Some of the cylindrical tanks are with conical ends having a cone angle of 15 deg. These cones can be formed in a simple manner as shown (Ref : Fig.6). In rectangular vessels, the bottom dishes have slopes and shell is preferably marked on a single piece. Folding is done by pressbrake operation wherever required. A typical rectangular layout is shown (Ref : Fig.7). The weld area is clearly defined to avoid distortion.

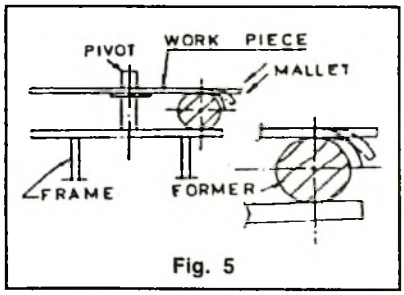


Fig. 5

WELDING

This is a very important operation in Dairy Equipment Fabrication. Normally TIG (Tungsten Inert Gas) welding is preferred. All precautions must be used in welding and procedures very strictly adhered to, otherwise distortion is bound to occur.

The following points should be remembered while welding SS sheets.

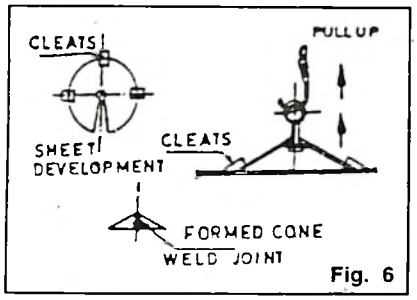


Fig. 6

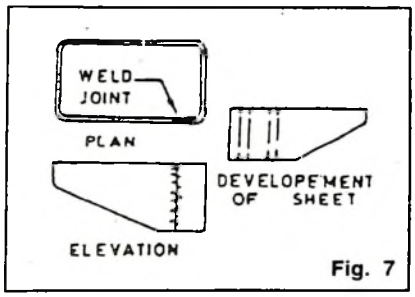


Fig. 7

1. Sheet layout must be done very perfectly.
2. Wherever possible selve edge to be used.
3. Upto 2 mm thickness, a minimum of 1 to 1.6 mm gap to be provided.
4. Beyond 2 mm upto 8 mm one side bevelling of 60 Deg. to be given.
5. Purging the bottom side with either Argon or Nitrogen gas. This protects back of the weld from injurious effects of air and gives a weld surface which is resistant to acids and the like. (Ref : Fig.8)
6. Wherever nozzles, outlet cups, inlets, etc. are welded, follow the joints shown in the Fig.3.
7. For thickness upto 2 mm pulsing can be adopted to avoid distortion and to get a good weld joint.

As TIG welding is very important in SS fabrication of thin sheets some salient features of TIG welding are enumerated to take not of during welding :

- Current required/mm of plate thickness 30-40 Amps.
- The angle of torch and filler material to the work piece when downhand welding a butt joint are shown in Fig. 8.
- As a rule the inner diameter of the gas cowl is about 4 times the electrode diameter. (Ref : Fig.9).
- Recommended TIP angle for Tungsten electrode. (Ref : Fig.9)
- Tungsten rod projection (Ref : Fig.9)
- Selecting the size of the electrode. (Ref : Chart)
- Gas flow rate and its pressure (Ref : Chart)
- Welding current and position (Ref : Chart)

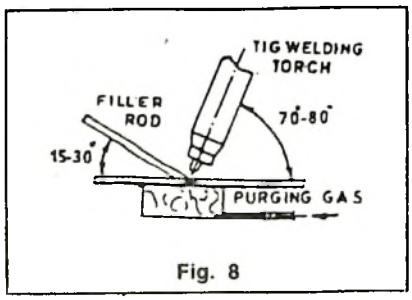


Fig. 8

GRINDING & POLISHING

No sooner the sheet joints are butt welded, before rolling in case of plain sheets, and after cylinders are rolled and joined with bottom dish or cone, the weldment is peened (Ref

Recommeded Tip Angles For Tungsten Electodes

WELDING CURRENT (A)	ELECTRODE TIP ANGLEA
20	20-100°
20-100	60-90°
>200	120°

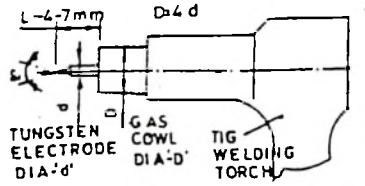


Fig. 9

: Fig.10) causing a slight plastic flow of the surface metal to a depth of few thousands of an inch. Having the surface in compression greatly offsets fatigue which results from tension stresses. This peening operation must be performed on weld joints as it strengthens the weldment area and also makes the surface convenient for grinding and polishing operations. After the weldment is peened, the weldment is ground flush by using initially 5" wheel or by sandering with 60 or 80 grit discs. Next the surface is finished with 80 grit Resin bonded mops. After this operation the weldment is tested for pinholes or porosity by applying DP (Dye penetrant) test. The DP test must be performed in a systematic manner,

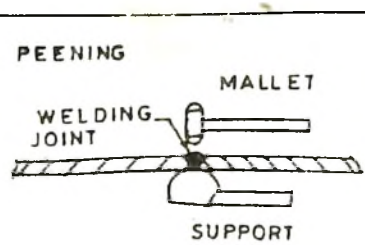


Fig. 10

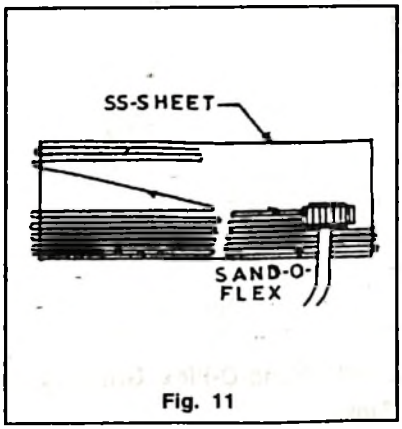
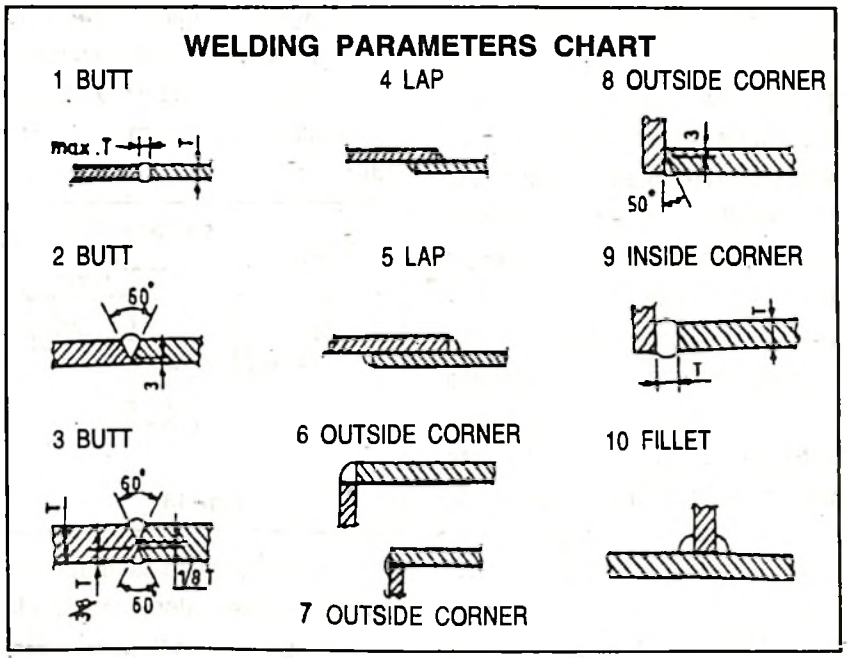


Fig. 11

otherwise very minute pinholes cannot be traced. These pinholes, if found, must be ground with coarse emery and TIG welded and again the DP test is performed, till the surface is free of defects. After this operation sand-o-flex grinding is used for obtaining finished surface. The grinding could be done stagewise by using 150 grit followed by 220 grit for normal finish. If very high finish is required then 300 grit to 400 grit emery is used in sand-o-flex. Grinding using sand-o-flex is described in a detailed manner as this is a very important finishing operation.

Sand-O-Flex Grinding

Sand-o-flex grinding is the most widely used method for obtaining a finished surface. The number of steps/operations depend on the quality of the surface to be finished. The methods used depend on the requirement for the specific jobs. However, the most important aspect to be kept in mind is that the grinding lines in all operation follow the same direction.



WORK THK. MM	WELD Type	Number	Tungsten electrode dia	FILLER Rod dia. mm	DC Current Amperes	Argon Gas flow pr. 1 pm	Kpa	Speed mm per min
1.6	butt	1	1.6	1.6	80-100	5	138	305
	lap	4,5	1.6	1.6	100-120	5	138	254
	corner	6,7,9	1.6	1.6	80-100	5	138	305
	fillet	10	1.6	1.6	90-100	5	138	254
2.4	butt	1	1.6	1.6 or 2.4	100-120	5	138	305
	lap	4,5	1.6	1.6 or 2.4	110-130	5	138	254
	corner	6,7,9	1.6	1.6 or 2.4	100-120	5	138	305
	fillet	10	1.6	1.6 or 2.4	110-130	5	138	254
3.2	butt	1	1.6	2.4	120-140	5	138	305
	lap	4,5	1.6	2.4	130-150	5	138	254
	corner	6,7,9	1.6	2.4	120-140	5	138	305
	fillet	10	1.6	2.4	130-150	5	138	254
4.8	butt	1	2.4	3.2	200-250	6	138	254
	lap	5	2.4 or 3.2	3.2	225-275	6	138	203
	corner	6,7,9	2.4	3.2	200-250	6	138	254
	fillet	10	2.4 or 3.2	3.2	225-275	6	138	203
5.4	butt	1,2	3.2	4.8	275-350	6	138	127
	lap	5	3.2	4.8	300-375	6	138	127
	corner	6,7,8	3.2	4.8	275-350	6	138	127
	fillet	10	3.2	4.8	300-375	6	138	127
12.7	butt	2,3	3.2 or 4.8	6.4	350-450	7	138	
	lap	5	3.2 or 4.8	6.4	375-475	7	138	
	corner	8	3.2 or 4.8	6.4	375-475	7	138	
	fillet	10	3.2 or 4.8	6.4	375-475	7	138	

Pregrinding with Sand-O-Flex

The technique is described for grinding of a rectangular sheet. This operation is started with long sweeps with preferably new brushes with approximately 100 mm long emery cloth protruding out. It is important that the Sand-o-flex head is kept as straight as possible (Ref : Fig.11). Then the same operation is repeated in the perpendicular direction with preferably slightly worn out brushes with 50-100mm long emery cloth protruding out. (Ref : Fig.12).

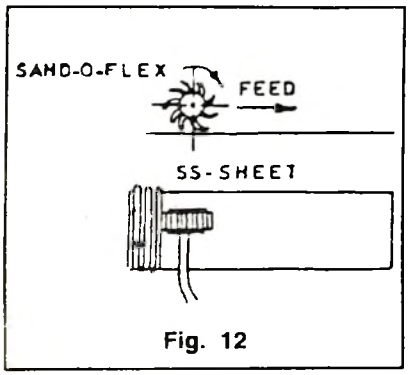


Fig. 12

Final Grinding with Sand-O-Flex

The surface is smeared with liquid paraffin or Linseed oil or equivalent. The operation is then started from the left end by shoving and drawing the sand-o-flex head straight across the sheet, moving right by 10mm at every passage. Worn out brushes with 20-30 mm long emery cloth protruding out are preferable.

Working Example : Outer Shell for Tanks

The tank is placed on rotators. The sand-o-flex motor is suspended from a trolley which is running on a rail along the side of the tank, supported by two adjustable rotators (Ref : Fig. 13). The pregrinding is carried out by first working the sand-o-flex head in an up and down motion (Ref : Fig. 13).

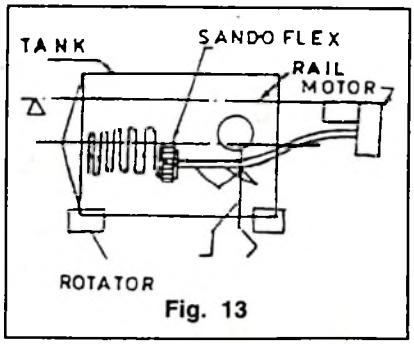


Fig. 13

After that the head is moved in straight strokes along the whole length of the tank, with the operator walking forward and backward along the length of the tank. (Ref : Fig.11). After pregrinding the portion, the tank is rolled upwards by another 2 feet or so until the pregrinding operation is completed followed by final grinding.

Sand-O-Flex Grinding of Tank Dishes

The pregrinding is done on the floor prior to setting the dishes on the tank. The final grinding is done with the dishes on the tank. The process is started at the bottom edge and worked upwards until the center of the tank is reached. Then the tank is rolled round and the rest of the tank is finished. The bottom edge can be rolled a little to one side to make the start more comfortable. At places which are difficult to access eg. manway, sight/light glass, etc. the emery cloth on the sand-o-flex can be lengthened. (Ref: Fig. 14)

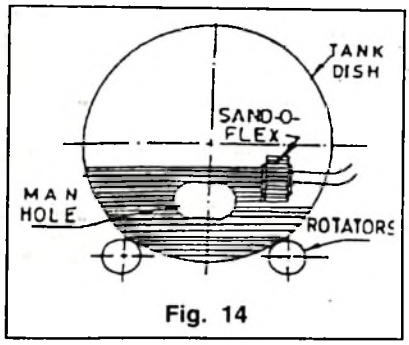


Fig. 14

Inside Sand-O-Flex Grinding of Tanks

Normally the inside of the tanks is only bandpolished at the weld joints. The other surfaces are left undisturbed being protected by plastic sheets. In case the entire inner surface is to be polished, the operator has to get down on one knee with the sand-o-flex motor behind him and the flexible shaft along the tank. He now starts from side to side covering an area which is confortable for him (approx. 1m x 1m). This is followed by working the sand-o-flex head back and forth over the same area from left to right. After completing each section the tank is rolled over. As the polishing is done in sections it is necessary to have the overlap as even as possible; to obtain an uniform finish. (Ref: Fig. 15). The final grinding is done in the

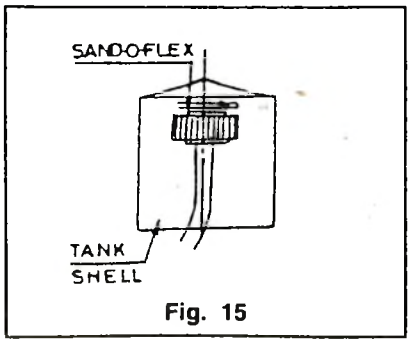


Fig. 15

same way as pregrinding, liquid paraffin or oil being avoided on the inside of the tanks. This complete operation is carried out before the last dish is placed on the tank.

Possibilities for automation

The dust generated and the weight of the sand-o-flex head with shaft can be very uncomfortable for the operator and hence the operation calls for an automation. This grinding device can be used inside of tank bodies before any dishes are placed on the body and even many other types of jobs. (Ref : Fig. 16)

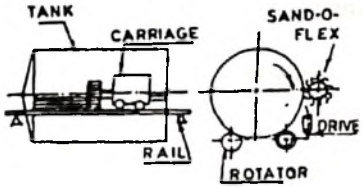


Fig. 16

Mirror Polishing

After the surface is ground with 220 grit emery Green Soap is smeared on the polishing mop (preferably made of Sisal fibre) preferably of size 8" or 10" dia. (as surface speed increases with the diameter, Recommended surface speed 35 to 45 M/Hr.). Subsequently Black soap is smeared on the cloth mop of diameter 8" or 10" and the surface is polished to attain a mirror finish.

Circle Polishing

This is a special effect given to the surface by grinding a surface using emery sheet of 150 grits in the particular fashion as shown (Ref : Fig.17). **Note** : Never use a grinding wheel or emery mop which has been used on MS or Stainless steel surface.

PASSIVATION

Passivation of SS is a surface cleaning operation to remove contamination of iron and contaminated grinding and polishing materials. The removal of these residues from SS surfaces promotes the complete formation of the invisible oxide film that gives these alloys their corrosion resistant properties. For chrome-Nickel steels, Nitric acid passivating solutions usually contain 20% to 40% Nitric Acid (by volume). Passivating temperature ranges from room temperature upto 60Deg.C for periods of 30 to 60 minutes. This must be followed by thorough washing in clean hot water.

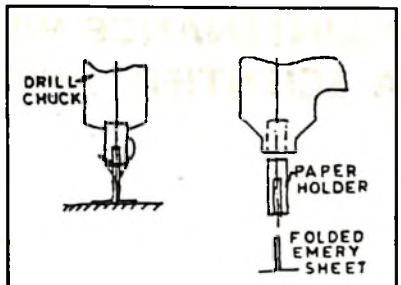


Fig. 17

TESTING

- All Dairy Equipments are normally tested for water tightness for non-pressure vessels.
- 100% DP test is performed on all weldments.
- No sharp corners or crevices are allowed in an equipment where the product comes in contact.
- For pressure vessels the required test pressure is applied and held preferably for 8-10 hours.
- Sand blasted level markings or Etched level markings inside the tanks are allowed.
- Asbestos packing is a must between the inner vessel and the MS stiffener ring. ☒

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