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(RESEARCH ARTICLE)

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Study of dished end forming by hot forming Vs fully machining method

SAKTHIVEL S * and P VIJAYAKUMAR

Department of Mechanical Engineering, Prist University, Vallam, Thanjavur, Tamilnadu, India.

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Abstract

Hemispherical dished end by fully machining from hollow forging instead of conventional process like hot forming, cold forming, deep drawing, flanging and dishing. For bulk and mass production of dished ends conventional method used. But for each and every dished end with different material and different size we go for fully machining from hollow forging material. Economically, cycle time and equivalent strength to compare to conventional method.

Keywords: Dished End; Hot Forming; Fully Machining; Forging; Heat Treatment; Yield Strength

1. Introduction

Nowadays, there are hundreds of manufacturers of tanks, silos, pressure vessels, truck tanks, and metal rolls components around the world. Nearly all these companies need to produce or source dished ends of various types, sizes, and specifications to finalize their products.

However, an essential part, the dished end, is manufactured by a reduced number of suppliers and therefore dished end production has become a very profitable business and a craft that companies are carrying on and preserving generation after generation.

Several types and different sizes of dished ends needed in the industry today are produced using different methods each with a different level of complexity. These methods include hot and cold forming, deep drawing, spinning, as well as the forming of heads in crown and petal segments and also dishing and flanging.

Dished end manufactured by fully machining from the hollow forging is one of the technique. which one is fully different from conventional techniques.

Dished end manufactured from forming method requires bullet and ring for each and every size of the dished end. both hot forming and cold forming. If the requirement of dished ends are huge numbers in same size, we go for conventional methods.

* Corresponding author: SAKTHIVEL S

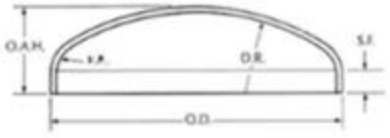
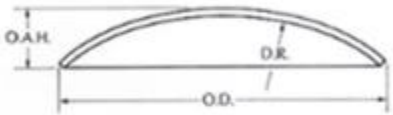
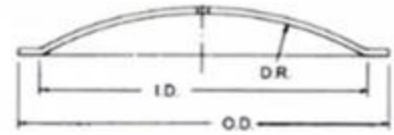
	A. S. M. E. Code Stainless Steel & Carbon Steel Heads
	Standard Flanged and Dished
	Shallow Flanged and Dished
	Flathead Stainless Steel & Carbon Steel Heads
	Dished Only Heads Available down to 10"
	Dished & Flared Heads

Figure 1 Types of dished ends

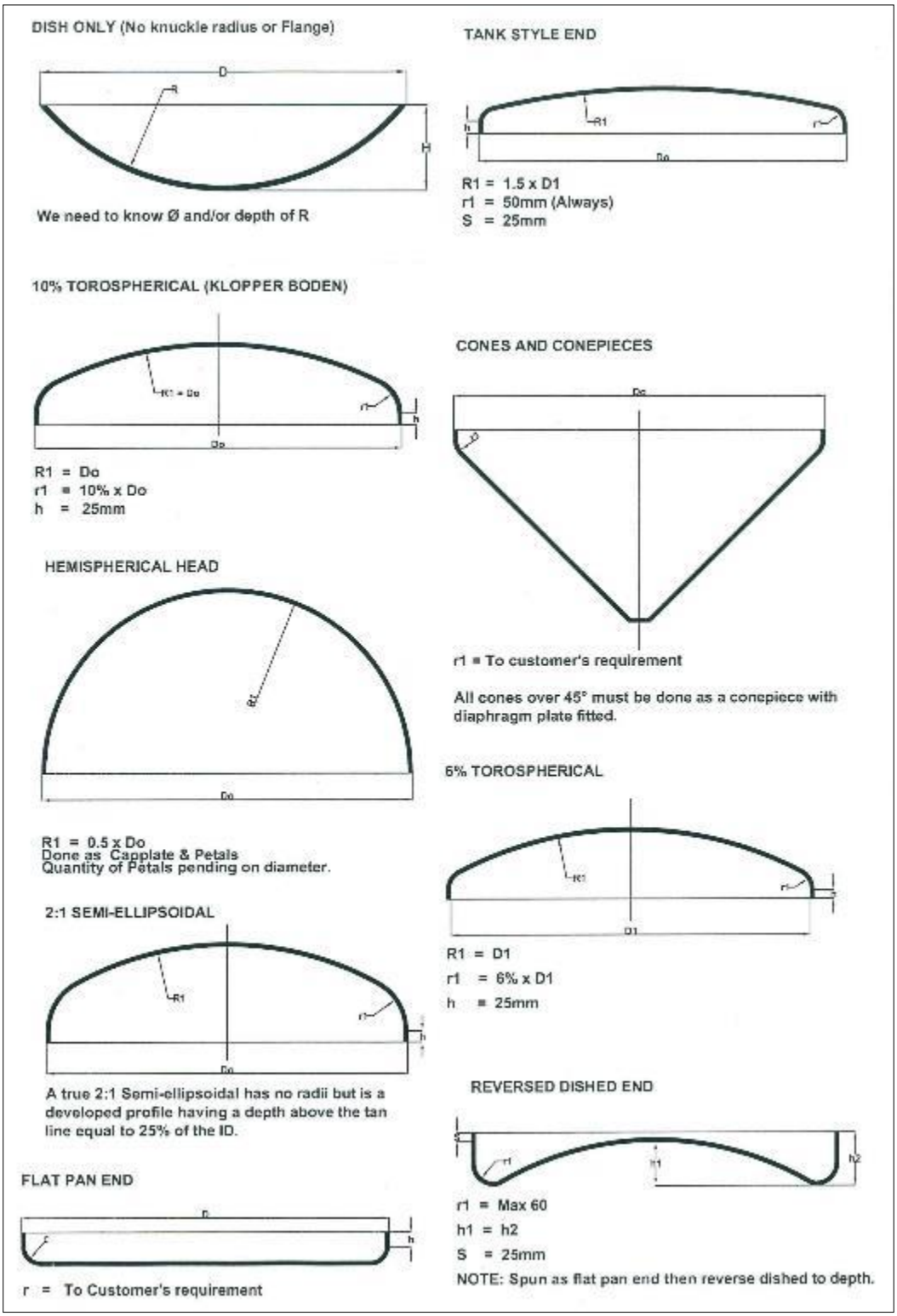


Figure 2 Types of dished ends

2. Literature Review

- 1998, BłachutJ. "Pressure Vessel Components: Some Recent Developments in Strength and Buckling
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3. Problem Identification

Manufacturing dished ends from different size and different material very costly in existing manufacturing methods.

Here we take with hot forming method. In this method consist of raw material preparation, heating cycle for pressing, bullet and ring for inner profile and outer profile control, heat treatment cycle, shot blasting operation and finally edge preparation for welding.

Huge amount of costs for each and every activity .it also high capital cost for bullet and outer ring while pressing hot forming method for this problem we go for alternative method of manufacturing. Dished end manufacturing in different sizes with different materials (SA105, F22, F91) we go for manufacturing dished ends by machining from hollow forging.

4. Methodology & Flow chart

4.1. Flow chart for hot forming method dished end manufacturing

Figure3 Flow chart for hot forming process

4.2. FLOW CHART FOR MANUFACTURING OF FULLY MACHINING METHOD

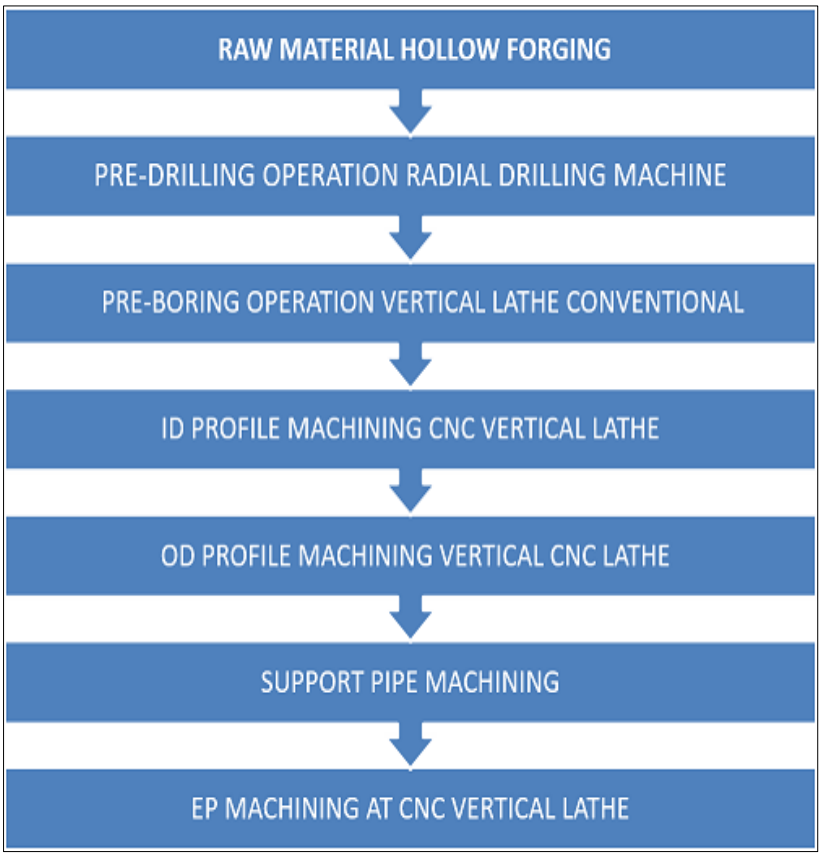


Figure 4 Flow chart for fully machining

5. Design criteria / Material Details

5.1. Raw material Test certificate for SA515 GR70

Table 1 Raw material details for SA515 GR 70

JINDAL STEEL & POWER LIMITED

Works:Chhendipada Road,SH- 63, At/Po : Jindal Nagar, Dist : Angul (ODISHA)-759111 INDIA
Email:qclab.pm@angul.jspl.com
Registered Office:Post box No. 6 ,O P Jindal Marg ,Hisar (Haryana)
Corporate Office :Jindal Center,12 Bhikaji Cama Palace, New Delhi -110066 INDIA
Phone No.:-(06761) 254191-95; Fax :-06761 -254141-44

IS 2041
CM/L 0005719579

MILL TEST CERTIFICATE OF STEEL PLATES FOR PRESSURE VESSELS USED AT MODERATE AND LOW TEMEPERATURE

Test Certificate No. 0000010614 — Date : 06.09.2021

Page 1 of 4

To, M/s BHEL,HPVP, VISAKHAPATNAM
FORMERLY BHARAT HEAVY PLATE & VESSELS LT (A GOVT.OF INDIA UNDERTAKING.),NATHYAYAPALEM,,VISAKHAPATNAM,PIN-530012Andhra Pradesh

It is certified that the material described below fully conforms to IS 2041:2009. Chemical composition and mechanical properties of the product as tested in accordance with the Scheme of Testing and Inspection contained in the BIS certification marks license No. CM/L0005719579 are as indicated below against each plate number. (Please refer to IS 2041:2009 for specification requirements).Dimensional tolerance conforms to IS/ISO 7452.

TEST RESULTS

Process of Manufacture : EAF->LRF->VD->CCM->RHF->Hot rolling — Supply Condition:FURNACE NORMALIZED — Deoxidation : Fully Killed

Material Grade : IS2041 R260/ASME SA516 GR70 Plate Dimension -Thickness x Width x Length : 85.00MMX2900MMX10800MM

Heat No	Plate No	No.of. Pcs	Wt. (MT)	Analysis L/P	Chemical Analysis %C	%Mn	%S	%P	%Si	%Cr	%Ni	%Cu	%Ti	%V	%Nb	%Mo	%Al	N (PPm)	%Ca	%B	Nb+V+Ti	Cr+Cu+Mo	Al/N	CE **
B17031/04A0	1	20.848	L	0.184	1.43	0.003	0.017	0.25	0.011	0.190	0.004	0.010	0.002	0.017	0.0950	0.036	52	0.0009	0.0005	0.029	0.11	6.9231	0.45
B17031/04A0			P	0.181	1.42	0.002	0.015	0.27	0.010	0.193	0.004	0.009	0.002	0.015	0.0920	0.038	54	0.0011	0.0004	0.026	0.106	7.037	0.45
B17031/05A0	1	20.848	L	0.184	1.43	0.003	0.017	0.25	0.011	0.190	0.004	0.010	0.002	0.017	0.0950	0.036	52	0.0009	0.0005	0.029	0.11	6.9231	0.45
B17031/05A0			P	0.182	1.44	0.002	0.015	0.25	0.010	0.192	0.004	0.009	0.002	0.015	0.0920	0.038	54	0.0012	0.0004	0.026	0.106	7.037	0.45
Sub Total		2	41.696																				

Mechanical properties:

Heat No	Plate No	No.of Pcs	Wt. MT	Tensile test Orientation : Tr. .Tested at ambient temp. YS (MPa)	UTS (MPa)	%EL *	Bend Test Mand. Rad	Charpy V-notch impact test @ °C (Joules) Orientation : 1	2	3	Avg	Elevated Temp Tensile Test @ °C YS (MPa)	Ultrasonic Test As per ASME SA-578 L-B	Hardness Unit
B17031/04A0	1	20.848		377	568	32	OK(1.5T)						Satisfactory	
B17031/04A0				348	542	34	OK(1.5T)						Satisfactory	
B17031/05A0	1	20.848		368	570	32	OK(1.5T)						Satisfactory	

The above material supplied conforms to the specified dimensions and tolerances as per specifications and as per mutually agreed Technical Delivery Conditions

Purchase Order No. & Date: GEMC-511687701656239 08.07.2021
Despatch Advice No:
Truck/Wagon No.

Prepared by SRIDHAR.BEHERA
Preparation Date :06.09.2021 17:06:20
Printing Date 06.09.2021 & Time 17:06:41

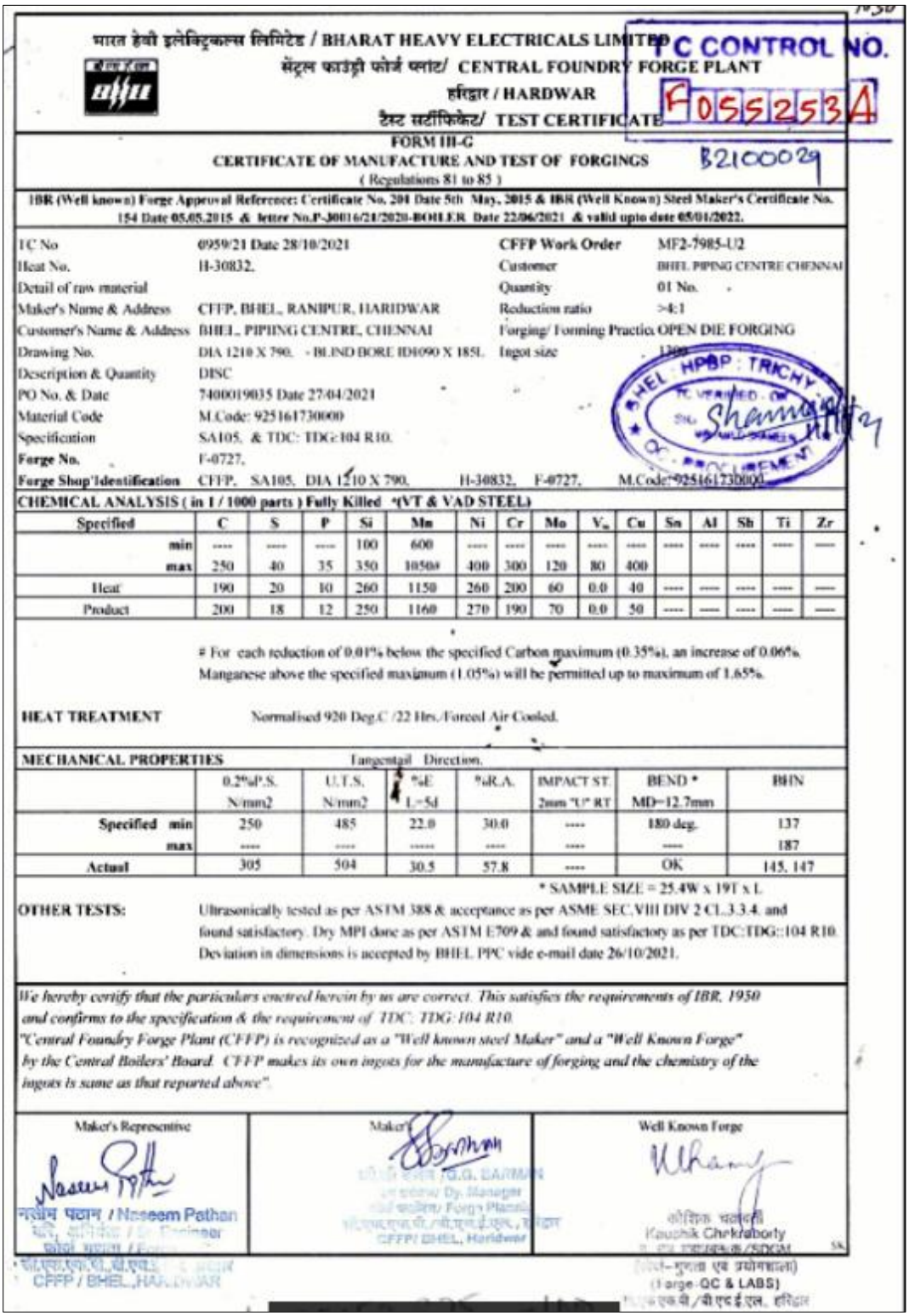
* Gauge Length: 50 MM
**CE=C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15
REC-PM-TSD-14-37,Rev 01,Eff date : 07.10.2020

Deepak Prasad
Authorised Signatory
TSD PlateMill- ANGUL
For, JINDAL STEEL & POWER LIMITED

Legends: YS:Yield Strength,UTS:Ultimate Tensile Strength,%EL:% Elongation,B:Bale,P:Product,MPa:Mega Pascal,SO: Original Cross section area,Temp.:Temperature, Wt.:Weight,Pcs.:Pieces,TDC: Technical Delivery Condition,Doc:

5.2. Raw material Test certificate for SA105

Table 2 Raw material details for SA105



भारत हेवी इलेक्ट्रिकल्स लिमिटेड / BHARAT HEAVY ELECTRICALS LIMITED
सेंट्रल फाउंड्री फोर्ज प्लांट/ CENTRAL FOUNDRY FORGE PLANT
हरिद्वार / HARDWAR
टैस्ट सर्टीफिकेट/ TEST CERTIFICATE

PC CONTROL NO. F055253A

FORM III-G
CERTIFICATE OF MANUFACTURE AND TEST OF FORGINGS
(Regulations 81 to 85)

IBR (Well known) Forge Approval Reference: Certificate No. 204 Date 5th May, 2015 & IBR (Well Known) Steel Maker's Certificate No. 154 Date 05.05.2015 & letter No.P-30016/24/2020-BOILER Date 22/06/2021 & valid upto date 05/01/2022.

TC No	0959/21 Date 28/10/2021	CFFP Work Order	MF2-7985-U2
Heat No.	H-30832.	Customer	BHEL PIPING CENTRE CHENNAI
Detail of raw material		Quantity	01 No.
Maker's Name & Address	CFFP, BHEL, RANIPUR, HARIDWAR	Reduction ratio	>4:1
Customer's Name & Address	BHEL, PIPING CENTRE, CHENNAI	Forging/ Forming Practice	OPEN DIE FORGING
Drawing No.	DIA 1210 X 790. - BLIND BORE ID1090 X 185L	Ingot size	1300
Description & Quantity	DISC		
PO No. & Date	7400019035 Date 27/04/2021		
Material Code	M.Code: 925161730000		
Specification	SA105. & TDC: TDG:104 R10.		
Forge No.	F-0727.		
Forge Shop Identification	CFFP. SA105. DIA 1210 X 790. H-30832. F-0727. M.Code:925161730000		

BHEL HPBP : TRICHY TC VERIFIED

CHEMICAL ANALYSIS (in 1 / 1000 parts) Fully Killed *(VT & VAD STEEL)

Specified	C	S	P	Si	Mn	Ni	Cr	Mo	V	Cu	Sn	Al	Sb	Ti	Zr
min	----	----	----	100	600	----	----	----	----	----	----	----	----	----	----
max	250	40	35	350	1050#	400	300	120	80	400					
Heat	190	20	10	260	1150	260	200	60	0.0	40	----	----	----	----	----
Product	200	18	12	250	1160	270	190	70	0.0	50	----	----	----	----	----

For each reduction of 0.01% below the specified Carbon maximum (0.35%), an increase of 0.06% Manganese above the specified maximum (1.05%) will be permitted up to maximum of 1.65%.

HEAT TREATMENT Normalised 920 Deg.C /22 Hrs./Forced Air Cooled.

MECHANICAL PROPERTIES Tangential Direction.

	0.2%P.S. N/mm2	U.T.S. N/mm2	%E L=5d	%R.A.	IMPACT ST. 2mm 'U' RT	BEND * MD=12.7mm	BHN
Specified min	250	485	22.0	30.0	----	180 deg.	137
max	----	----	----	----	----	----	187
Actual	305	504	30.5	57.8	----	OK	145, 147

* SAMPLE SIZE = 25.4W x 19T x L

OTHER TESTS: Ultrasonically tested as per ASTM 388 & acceptance as per ASME SEC.VIII DIV 2 CL.3.3.4. and found satisfactory. Dry MPI done as per ASTM E709 & and found satisfactory as per TDC:TDG:104 R10. Deviation in dimensions is accepted by BHEL PPC vide e-mail date 26/10/2021.

We hereby certify that the particulars enetred herein by us are correct. This satisfies the requirements of IBR, 1950 and confirms to the specification & the requirement of TDC: TDG:104 R10.
"Central Foundry Forge Plant (CFFP) is recognized as a "Well known steel Maker" and a "Well Known Forge" by the Central Boilers' Board. CFFP makes its own ingots for the manufacture of forging and the chemistry of the ingots is same as that reported above".

Maker's Representive — Naseem Pathan / नसीम पठान / Sr. Engineer
Maker — CFFP / BHEL, HARDWAR
Well Known Forge — Kaushik Chakraborty (Large QC & LABS)

5.3. Raw material shape for both SA105and SA515GR70

Materials used for dished end manufacturing are Aluminium, carbon steel, stainless steel, mild steel, alloy steel and nickel alloys.

Carbon steel:SA105 GRC, SA516GR70, SA299, SA515GR70

ALLOY STEEL : SA183F12, SA183F22, SA183F91

Both manufacturing methods Hot forming and fully machining materials used are not same.

5.3.1. Difference in raw material

Hot forming method: Plate prepared for dished end manufacturing

Fully machining process: hollow forging material used.

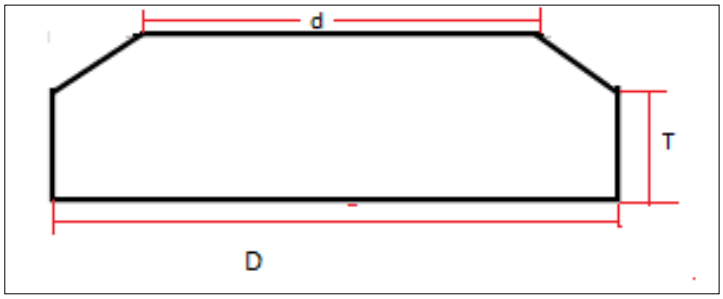


Figure 5 Raw material preparation for hot forming

5.4. Raw material for hot forming method

D-diameter of the blank for outer diameter of the dished end

d-diameter of the inner profile

T-thickness of the dished end to be formed

5.4.1. Raw material for fully machining method

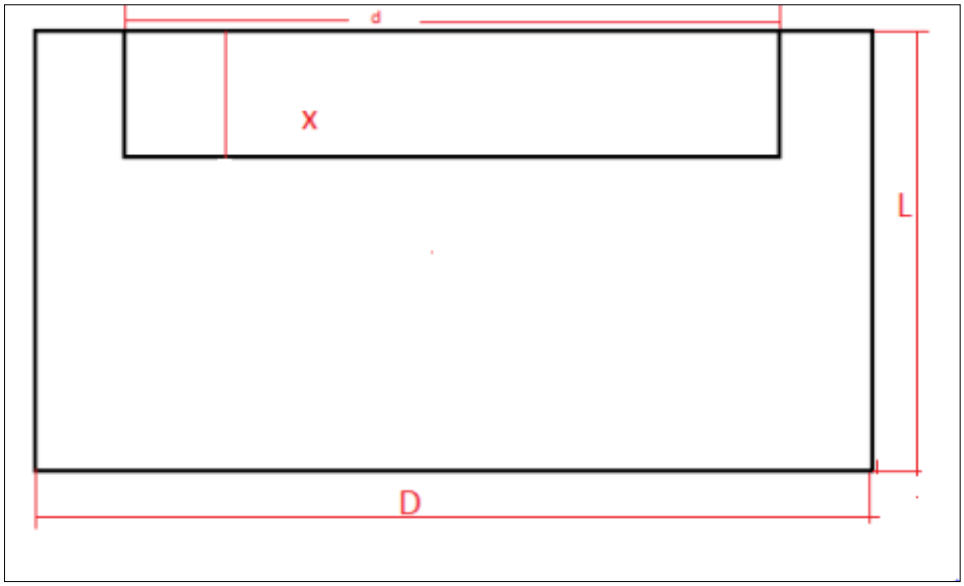


Figure 6 Raw material preparation diagram for hollow forging

D-diameter of the outer profile of dished end with stock

D-diameter of the inner profile of the dished end with stock

L-total length of the dished end with stock

5.5. Cost for forming process

Table3 Cost calculation for hot forming method

Material cost for hot forming from raw material to final product	Cost in rupees
Raw material cost from vendor	600000
Bullet and ring for pressing raw material	150000
Bullet and ring machining cost	50000
Raw material preparation cost (from rectangular plate to round size plate)	15000
Heating of plate at LPG furnace cost	150000
Pressing at 2000ton press cost	20000
Heat treatment cost at 150 ton press (normalizing)	150000
Shot blasting for de-scaling the slag during normalizing cost	20000
Total cost	1155000

5.6. Cost for machining method

Table 4 Cost calculation for fully machining

Material cost for fully machining method from hollow forging	Cost in rupees
Raw material cost	From scrap Haridwar forged unit
Pre-drill cost	10000
Pre-boring cost	5000
Rough boring operation for id profile cost	50000
Final id profile on CNC vertical lathe cost	50000
Od final profile on CNC vertical lathe cost	10000
Support pipe machining cost	1500
Ep preparation at CNC vertical lathe cost	20000
	146500

5.7. Cycle time for hot forming method

Table 5 Time calculation for hot forming method

Hot forming method	Hours
Raw material prpeparation (gas cutting,machining)	16
Bullet preparation	56
Ring preparation	56
Heating cycle at at 50 ton lpg furnace 890 dergee celcius	8
Bullet and ring setting at2000 ton press	8
Pressing at 2000 ton press	8
Heat treatment normalizing at 150 ton furnace	16
Shot blasting operation id and od	8
Raw material inspection	8

Id profile machining(job setting,programming,machining)	48
Od profile machining(job setting,programming,machining)	16
Support pipe machining	8
Edge preparation machining	8
Total cycle time	264

5.8. Cycle time for fully machining method

Table 6 Time calculation for fully machining

Fully machining method cycle time	**Hours**
Pre-drilling at radial drilling machine (HSS drill bit) DIA 63mm	16
Pre-boring at radial drilling machine (HSS drill bit)DIA 101mm	16
Pre-boring operation at vertical conventional lathewith carbide tip	56
Id profile machining at CNC vertical lathe	32
Od profile machining at CNC verticla lathe	16
Support pipe machining	8
Edge preparation at CNC vertical lathe	8
Total hours	152

6. Experimental Details

Table 7 Comparison various strength hot forming vs fully machining

Comparison of hot forming vs machining of dished ends	**Hot forming**	**Machining**
Raw material stage	Normalized fully killed	Normalized fully killed
Ultimate tensile strength	540n/mm square	504n/mm square
% of elongation	32	30
Manufacturing method	Rolled	Forging open die
Ultimate tensile strength	Test piece under lab test since after forming normalizing done 540 n/mm square	504n/mm square since after machining no heat treatment required

7. Hemispherical Dished End cover

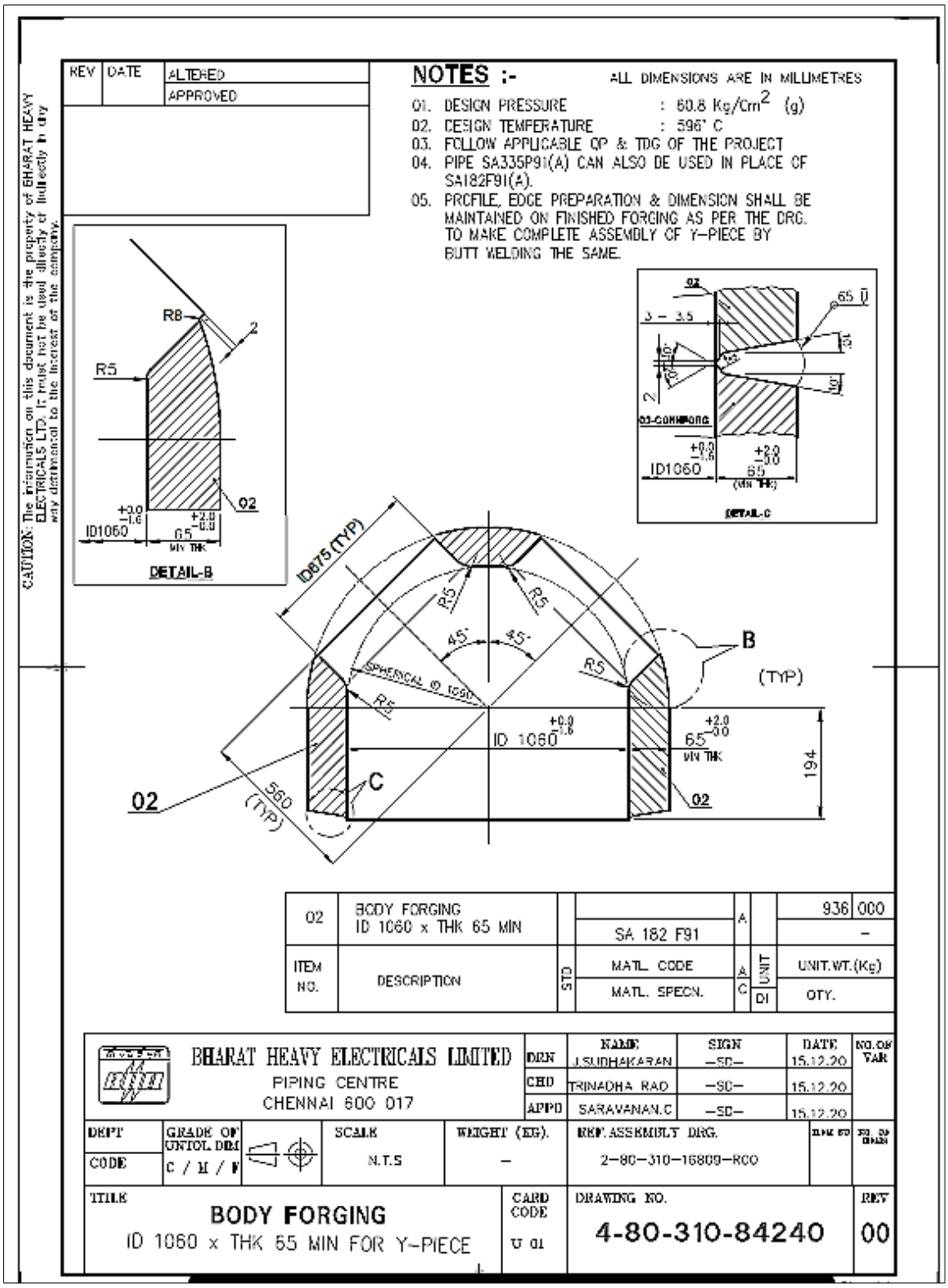


Figure 7 Drawing for dished end

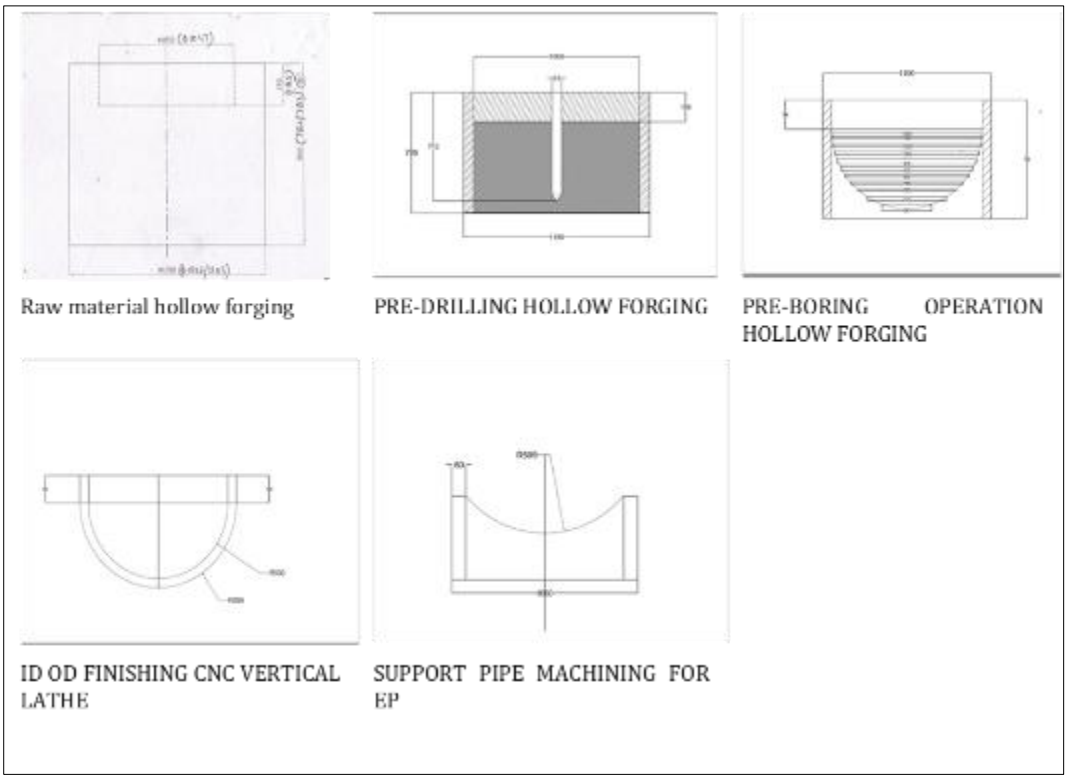


Figure 8 Hollow forging machining Sequences

Figure 9 Photos for machining hollow forging

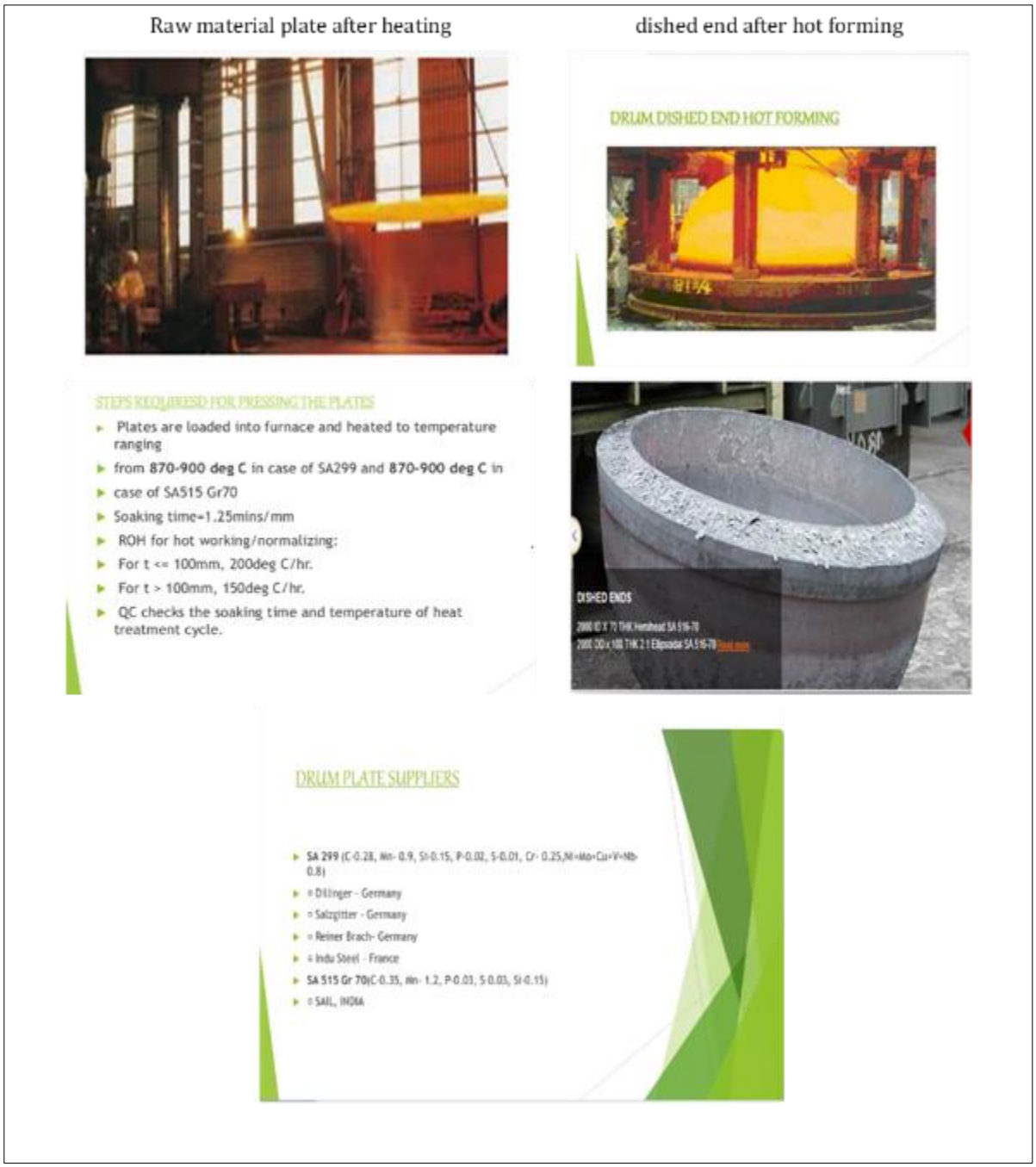


Figure 10 Photos for hot forming Process

8. Conclusion

Comparison of hot forming and machining method of dished end forming we conclude that machining for dished end of various sizes can be better than hot forming process, since comparison of cycle time for manufacturing and also cost comparison shows the difference for individual dimension of dished end forming. For strength wise there is no big different.

Future scope

Future scope for individual dished end manufacturing would be better in fully machined process.

Compliance with ethical standards

Acknowledgments

I wish to express my deep sense of gratitude to our Hon'ble Chancellor PRIST DEEMED TO BE University Thanjavur, for given me an opportunity to do and provide essential facilities.

I sincere and grateful thanks to our Hon'ble Vice Chancellor PRIST DEEMED TO BE University Thanjavur for permitting me to undertake this research work

I extend my hearty thanks to our beloved Dean for motivate our project and arranged to utilize all facilities provided in laboratories.

I take this opportunity to convey my sincere thanks to the Head of the Department for the cooperation and support given during the course of the Dissertation.

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I express to my deepest heartfelt and thanks to Teaching and non-teaching staff members for encourage our efforts and give a motivation to every stages of project.

Disclosure of conflict of interest

The authors certify that they have no conflict of interest in the subject matter or materials discussed in this manuscript.

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[3] Design and Modelling of Hemispherical and Flat Dish End Pressure Vessel Akshaya T. Poojary1, Rahul S. Sharma2, Meet H. Patel3, Dharmik U. Sheth4, Chandra Kant R. Kini1 and Rajesh Nayak.