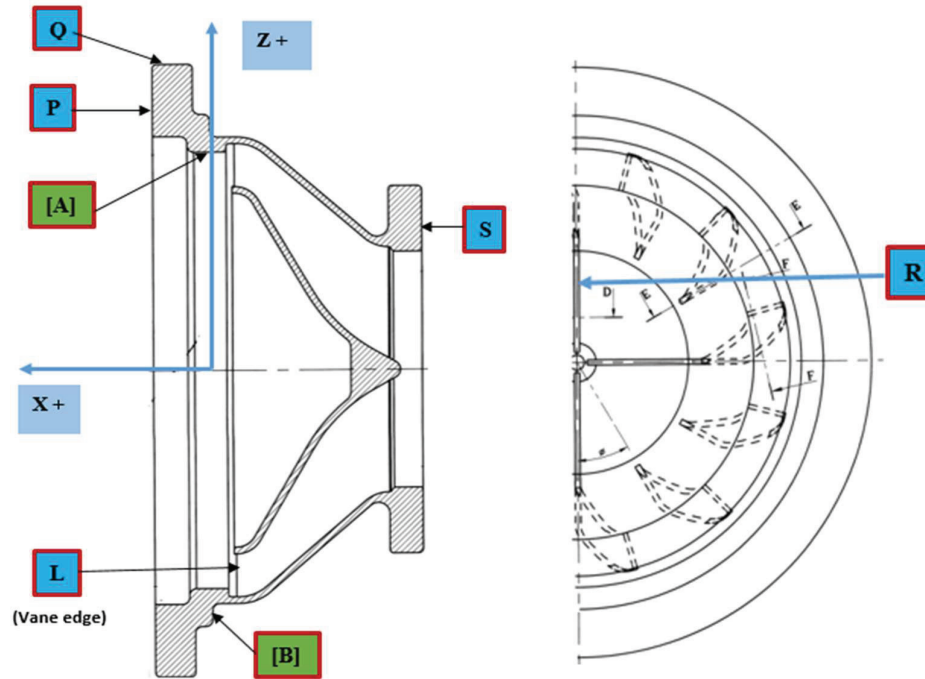


## Details of Pre-machining: -

- (a) Hold the casting on Right hand side, level datum [B] & Vane edges (L); true datum[A] max. possible extent.
- (b) In above set up turn out dia  $\text{Ø}275$  [Q] and face [P]
- (c) Additionally, skin-cut may be given on smaller flange face [S].  
(in 2<sup>nd</sup> set-up taking references of features pre-machined in 1<sup>st</sup> set-up.)



**Sketch-1**

**Note A:** During Turning on [Q] OD  $\text{Ø}275$  and facing on left as well as right end faces (ie;  $\text{Ø}275$  end face [P] and  $\text{Ø}165$  end face [S]); following 2 conditions must be considered:

- 1) Just minimum cut which is sufficient for removing the high points and establishing a reliable datum in CMM, only need to be provided.
- 2) Based on design requirements and final machining allowances, Maximum limits on the dimension while pre-machining is prescribed as below:

**OD  $\text{Ø}275$  [Q] may go up to  $\text{Ø}274$ ; 0.5mm facing on [P] face is allowed so that dims.  $(17.5+7.5) = 25$  is restricted to become 24.5mm; similarly, 0.5mm facing on [S] face to limit dim. 14.5 to 14 only**

Machining must be stopped once any of the above conditions achieved.

**Note B:** After pre-machining, CMM inspection has to be done using pre-machined datum instead of the drg. Datum. Following points to be considered while inspection:

- 1) Additional information [like- concentricity, perpendicularity, parallelism etc.] between new datum (pre-machined) and the drg. datum is to be reported.
- 2) If some un-cleaned patches after pre-machining are observed (because machining limits are fixed for each castings), details of these patches like depth, length and breadth shall be mentioned in the report in “Visual Remarks” column.
- 3) Whenever any diameter (IDs/ODs) of a casting is to be inspected using CMM, in addition to diameter, other associated data like circularity and off-set/concentricity with respect to axis are to be reported in tabular form, putting additional cells in “Observed Dimensions” column.
- 4) If observed values of typical features (like Ribs, vanes, slots, holes etc.) go out of tolerance provided, Report locations and numbers for deviated features.
- 5) Open tolerance on angle is  $\pm 30'$ , though it is not mentioned in the drawings. It is recommended to amend the Drawings.
- 6) If any depression/ gouge marks observed out of tolerance provided, report locations with respect to datum/reference surface, observed thickness and size of deviations.
- 7) The basic equipment / instruments are only mentioned in the inspection plan but any advanced equipment also can be used at any place.

**Details for CMM Datum-1 set-up for pre-machined component (refer sketch-1 above):**

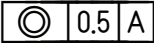
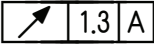
1. Level datum [P] (machined end face)
2. Align plane [R] (ie; one side plane of the bigger vane) in Y-axis as secondary datum.
3. Set origin (0,0), at the intersection point between Cylinder [Q] & datum [B].

**Details for CMM Datum-2 set-up for Vane Inner profile measurement (refer figure-1 in Annexure 1):**

1. Level vane edges (L)
2. Align plane [R] (ie; one side plane of the bigger vane).
3. Set origin (0, 0), on inner cup OD ( $\varnothing 165$ )

**Dimensional inspection plan:****DRG. SHEET: 1/1**

<b>PART NAME</b>		<b>LH2 TURBINE EXHAUST CASING CASTING</b>		
<b>DRAWING NO</b>		<b>CE20-1200-121C (R1)</b>		
<b>SL. NO</b>	<b>SPECIFIED</b>			<b>INSTRUMENTS USED / METHODS</b>
	<b>DIMENSION</b>	<b>TOLERANCE</b>	<b>DRG. ZONE</b>	<b>Note : Resolution needed for various instrument / equipments / machines are given as an annexure-A</b>
I	// of "P" pre - machined w.r.t drg. Datum B	--	--	CMM
II	◎ of "Q" pre machined w.r.t drg. Datum A	--	--	CMM
III	// of "S" w.r.t drg. Datum B	--	--	CMM
<b><u>SECTION- MM</u></b>				
1	82	±0.55	G-14	CMM/Height gauge
2	R3 (Three places)	±0.5	G-14	Radius gauge
3	R2 (outer corner two places)	±0.5	G-15	Radius gauge
4	R1 (two places)	±0.5	H-14	Radius gauge
5	49°	±30'	H-14	CMM
6	R5	±0.5	H-14	Radius gauge
7	71(TH)		I-13	Set dimension for R16. Refer SL.No: 8
8	R16	±0.5	H-13	CMM, radius point method (after set Z=71 & X=77.5; measure at 3 locations & report Min/Max.)
9	R4	±0.5	I-13	Radius gauge
10	Ø106	±0.55	I-13	CMM (measure 2 circle; report '○' & co-ordinates also)
11	◎ 0.5 A		H-13	CMM
12	Ø165	±0.8	I-13	CMM (measure 2 circle; report '○' & co-ordinates also)

13			G-13	CMM
14	∅230	±1.2	I-13	CMM (measure 1 circle; report 'O' & co-ordinates also )
15	12.5	±0.22	J-13	Vernier caliper (Mini/Max)
16	72(TH)		J-13	Set dimension for R73. Refer SL.No:18
17	30.2(TH)		K-13	Set dimension for R73. Refer SL.No: 18
18	R73	±0.5	J-13	CMM (after setting the origin co-ordinates ;radius point method measure at 3 locations ; report Min/Max)
19			K-13	CMM
20	R2	±0.5	J-13	Radius gauge
21	14.5	±0.22	K-13	Vernier caliper (Mini/Max)
22	R1.5	±0.5	K-14	Radius gauge
23	3	± 1	K-14	Thickness mapping on both inner & outer walls of the casting shall be carried out using <b>UT thickness gauge</b> . More no. of points are to be taken on Outer Wall (at least 4 points on each of 12 sectors between vanes).
24	70.5(TH)		J-15	Set dimension for R12. Refer SL. No: 26
25	10.5(TH)		J-15	Set dimension for R12. Refer SL. No: 26
26	R12	±0.5	K-14	CMM (after setting the origin co-ordinates ;radius point method measure at 3 locations ; report Min/Max)
27	83.75(TH)		J-15	Set dimension for R18. Refer SL.No: 29
28	11.5(TH)		K-15	Set dimension for R18. Refer SL.No: 29
29	R18	±0.5	K-14	CMM (after setting the origin co-ordinates ;radius point method measure at 3 locations ; report Min/Max)

30			K-14	CMM (report flatness also)
31	7.5	±0.18	K-14	CMM/depth Vernier (Mini/Max)
32	77.5	±0.45	L-14	CMM /Height gauge (report Min/Max)
33	17.5	±0.22	K-15	Vernier caliper (Min/Max)
34			K-15	CMM
35	∅275	±1.3	I-16	CMM/ Vernier caliper (Mini/Max)
36	∅210 (ID)	±1.2	I-16	CMM (measure 2 circle; report 'O' & co-ordinates also)
37	∅209.5 (OD)	± 1.2	I-16	CMM (measure 2 circle; report 'O' & co-ordinates also)
38	∅203.5	± 0.8	I-16	CMM (measure 1 circle; report 'O' & co-ordinates also)
39	∅196	±1.2	I-15	CMM (report 'O' & Co-ordinates also )
40			K-15	CMM
41	∅165	± 0.5	I-15	CMM (Lip portion to be considered), (report 'O' & Co-ordinates also)
42			H-15	CMM
43	10	±0.18	J-15	CMM (Mini/Max)
44	9.5	±0.18	J-14	CMM (Mini/Max)
45	3	± 1	J-14	Refer Sl. No. 23
46	7	±0.18	J-14	Vernier caliper (calculated value) (Mini/Max)
47	60.9	±0.55	J-14	CMM/ Height gauge
48	60°	±30'	I-14	CMM
49	30°	±30'	I-14	CMM
50	R5	±0.5	J-14	Radius gauge
51	1	±0.15	I-14	CMM (distance b/w cup face ribs edges)
52	L			Cut casting dimension; Profile errors of vanes surface
53	θ			using by CMM CAD base inspection. Refer Note-1

54	68	± 0.3	I-14	CMM (distance b/w inner cup edge to bigger vane edge)
55	R3 (Two places)	±0.5	H-15	Radius gauge
<b><u>DETAIL-K</u></b>				
56	0.5	±0.15	F-12	Instead of these dimension R 25 <sup>±1</sup> has to be measured using template/Radius gauge.
57	2	±0.15	E-12	
58	Ø110	+0.10/0	F-11	CMM ( measure at 78mm from Datum-B)
<b><u>SECTION-FF</u></b>				
59	50°	±30'	F-11	CMM/ Bevel Protector, only at lip portion to be measure. (report Min/Max)
<b><u>SECTION-DD</u></b>				
60	2.5	0/-0.3	F-9	Cut casting measurement; (first piece should be cut open and measure using Dial thickness caliper /UT gauge; separately report for 4 bigger vanes & other curved ribs with mapping) <i>For remaining casting accessible portion has to be measured &amp; report separately</i>
<b><u>SECTION-EE</u></b>				
61	Ø110	±0.55	E-4	CMM (report Min/Max)
62	30°	±30'	F-2	CMM (report Min/Max)

**Note- 1: - Vane Inner profile inspection (Tolerance= ± 1)**

*Vane qualification:*

Instead of L, Ø & Φ, inner vane profile variation has to be measured after cutting the casting. One from a batch of 50 castings may be cut and 50% of vanes have to be inspected using CMM with Cad model. (refer Datum-2). If anyone among the following conditions such as i) change of vendor ii) change of alloy / material iii) change in processing route – from investment casting to additive manufacturing route or forging route happens, cut casting evaluation should be repeated.

## Annexure-A

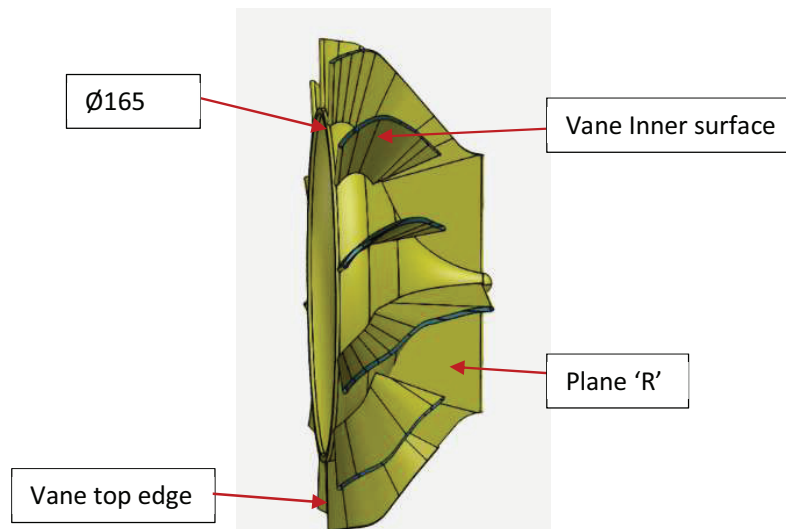
**I. Resolution & Accuracy needed for various Instruments, Equipments and machines used for inspection of the casting products are given below:**

Sl. No.	Instrument/ Equipments	Min. Range	Min. Accuracy	Min. Resolution	Remark
1	3D CMM	500x400x300mm	0.005mm	0.001mm	
2	Micrometer [ID/OD]	0-100mm	0.01mm	0.01mm	
3	Height Gauge	300mm	0.04mm	0.01mm	
4	Profile Projector	250x200mm	0.04mm	0.01mm	
5	UT gauges	0-15mm	0.04mm	0.01mm	
6	Vernier Caliper	0-300mm	0.02mm	0.01mm	
7	Depth Vernier	0-150mm	0.02mm	0.01mm	
8	Thickness Caliper	0-15mm	0.05mm	0.02mm	
9	Radius gauge	0.5-30mm	0.05mm	0.1mm step	
10	Bevel Protector	0-90°	5'	1'	
11	Sine Table	300mm (X & Y)	1'	1'	
12	Rotary Table	300mm (Ø)	1'	30"	
13	Depth Mic.	0-100mm	0.01mm	0.01mm	

**Note:**

**(1) Surface finish for overall area of castings shall be reported against vv or vvv (as applicable) mentioned in the drawings.**

**II. Figure for Vane Profile measurement: -**



**FIGURE-1 (Cut open casting)**

<b>Process Critical Dimensions (PCD)</b>					
<b>PCD No.</b>	<b>Drg. No.</b>	<b>Component</b>		<b>Sub System</b>	
1.3	CE20-1200-121C	LH2 Turbine Exhaust Casing Casting		CE20 LH2 Turbopump Assembly	
Sl. No.	Dimensions		Zone		
	Specification	Measured			
1	Φ203.5		1		
2	Φ165±0.5		2		
3	9.5		3		
4	3±1		4		
5	3±1		5		
6	R73		6		
7	R16		7		
8	Φ 110 <sup>+0.1</sup>		8		
9	Visual inspection				
<b>QC Inspector</b>		<b>RE-QC</b>	<b>Id. No.</b>	<b>Material</b>	<b>QCM</b>