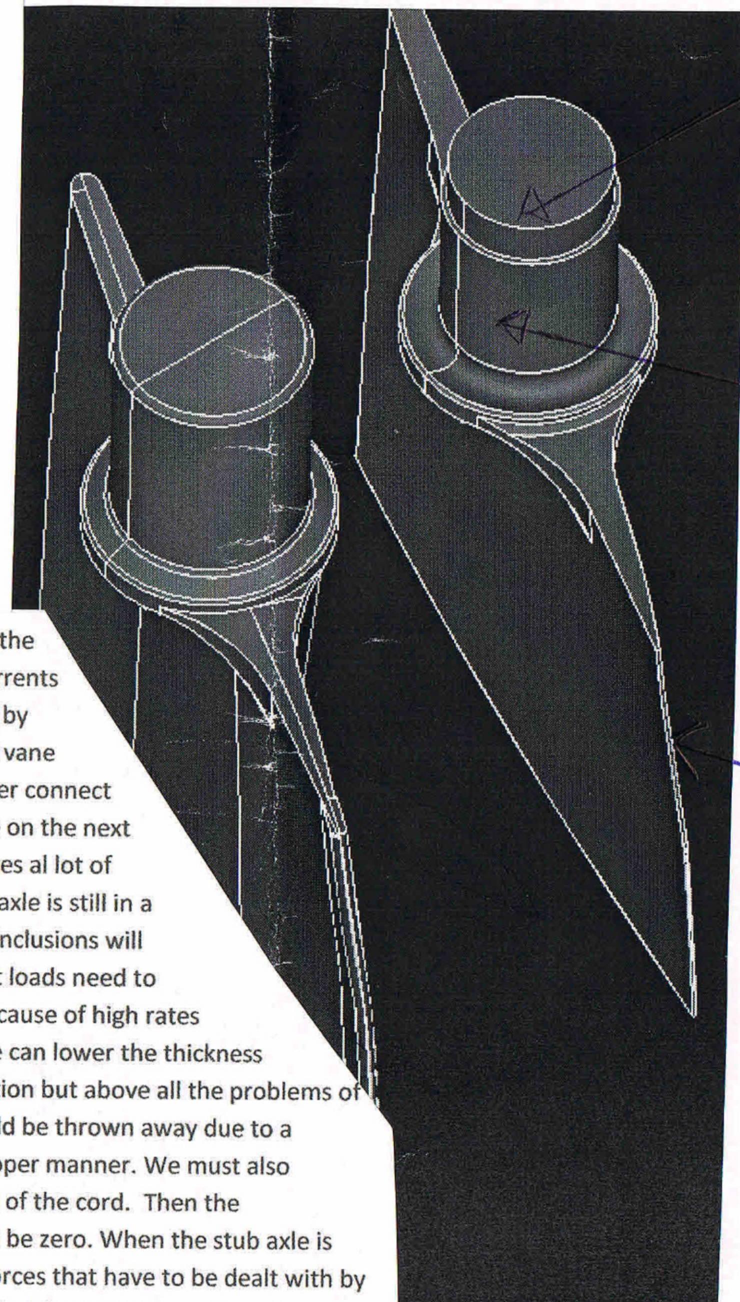
Design errors in the cooling vanes of a generator

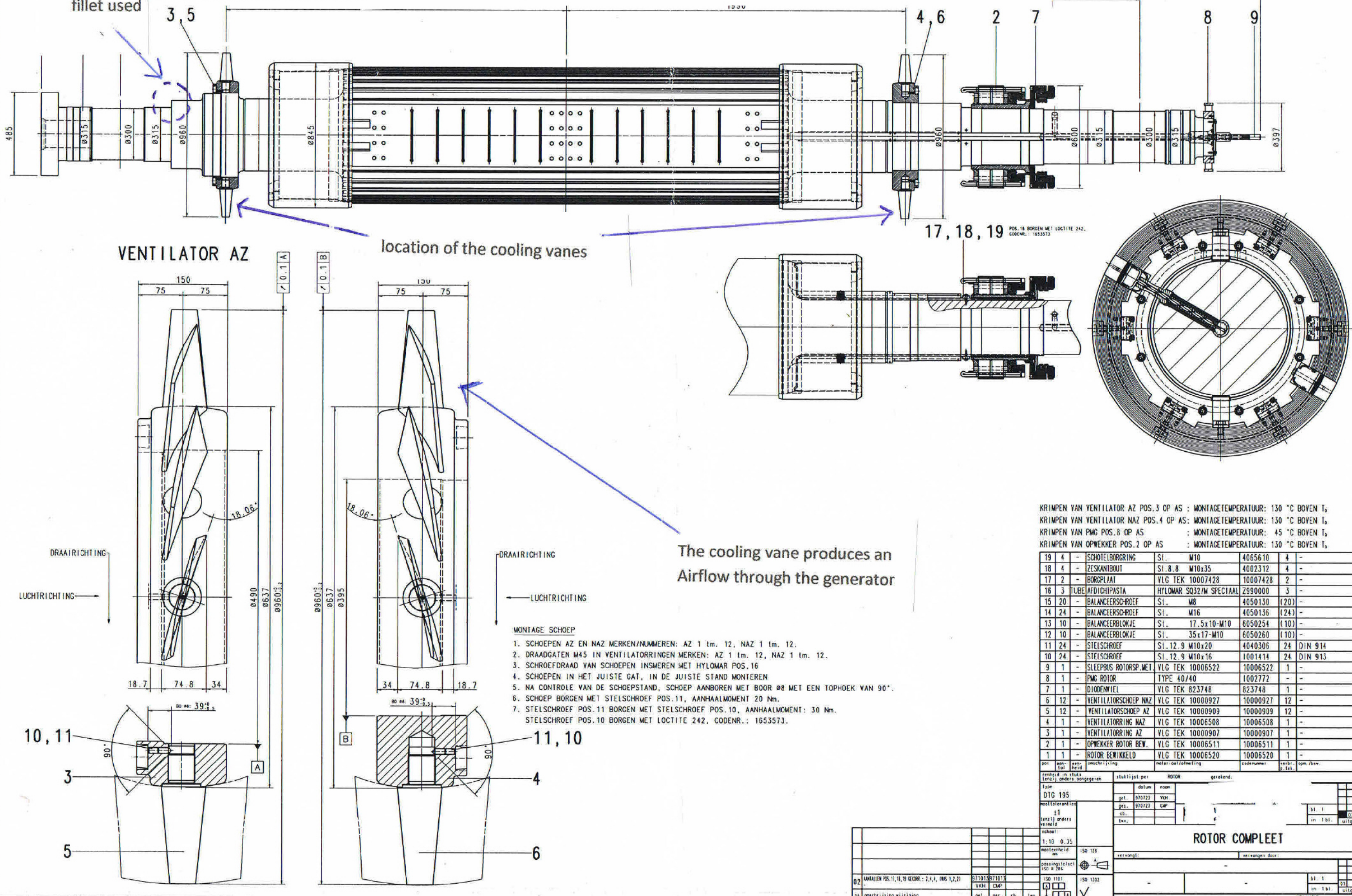
(vanes are fitted on the spinning rotor axis)



Some errors were made in the design of the cooling vanes that are fitted on the rotor axis for cooling het generator. Cooling is necessary because of high currents flowing through the copper wiring of the generator. Cooling vanes are made by pouring liquid aluminum in a die. The cooling vane consists of a wing shaped vane connected with a stub axle. Thread is put on the stub axle to be able to proper connect the vane on the rotor axis of the generator. The whole rotor axis you can see on the next page. The change in material thickness of the vane towards the stub axle gives al lot of problems. The thin wing shaped blade is solid already when the thicker stub axle is still in a liquid stadium. Due to the fact that metals shrink when they cool down gas inclusions will arise at the transition of vane to stub axle. Exactly at this position the highest loads need to be transferred. Also the molding shop has problems due to this transition because of high rates of rejected products. By placing an insert in the stub axle (change the die) we can lower the thickness difference in this product. As a consequence the molding shop has less rejection but above all the problems of gas inclusions can be overcome. A generator costing more than € 1 milj. could be thrown away due to a broken vane. This did not need to happen if the vanes were designed in a proper manner. We must also change the position of the stub axle from the middle of the cord towards 1/3 of the cord. Then the contribution of the torsion forces at the transition from vane to stub axle will be zero. When the stub axle is placed at the middle of the length of the vane torsion will raise the total of forces that have to be dealt with by this product (see last page of this PDF). At this page you also see the effect of adding a notch on the rotor axis. This notch will lower the forces in the critical part of the rotor axis. The critical part is where the diameter reduction is positioned. Also sharp fillets should not be used in fatigue situations.

Drawing of a rotor axis

(turning part of generator)



KRIMPEN VAN VENTILATOR AZ POS.3 OP AS : MONTAGETEMPERATUUR: 130 °C BOVEN T_0

KRIMPEN VAN VENTILATOR NAZ POS.4 OP AS: MONTAGETEMPERATUUR: 130 °C BOVEN T_0

KRIMPEN VAN PMG POS.8 OP AS : MONTAGETEMPERATUUR: 45 °C BOVEN T_0

KRIMPEN VAN OPWEKKER POS.2 OP AS : MONTAGETEMPERATUUR: 130 °C BOVEN T_0

MONTAGE SCHOEP

1. SCHOEPEN AZ EN NAZ MERKEN/NUMMEREN: AZ 1 tm. 12, NAZ 1 tm. 12.
2. DRAADGATEN M45 IN VENTILATORRINGEN MERKEN: AZ 1 tm. 12, NAZ 1 tm. 12.
3. SCHROEFDRAAD VAN SCHOEPEN INSMEREN MET HYLOMAR POS.16
4. SCHOEPEN IN HET JUISTE GAT, IN DE JUISTE STAND MONTEREN
5. NA CONTROLE VAN DE SCHOEPSTAND, SCHOEP AANBOREN MET BOOR ø8 MET EEN TOPHOEK VAN 90°.
6. SCHOEP BORGEN MET STELSCHROEF POS.11, AANHAALMOMENT 20 Nm.
7. STELSCHROEF POS.11 BORGEN MET STELSCHROEF POS.10, AANHAALMOMENT: 30 Nm.
   STELSCHROEF POS.10 BORGEN MET LOCTITE 242, CODENR.: 1653573.

pos.	aantal	eenheid	omschrijving	materiaal/afmeting	codenummer	verbr. p.tek.	opm./bew.
19	4	-	SCHOTELBORGRING	St. M10	4065610	4	-
18	4	-	ZESKANTBOUT	St.8.8 M10x35	4002312	4	-
17	2	-	BORGPLAAT	VLG TEK 10007428	10007428	2	-
16	3	TUBE	AFDICHTPASTA	HYLOMAR SQ32/M SPECIAAL	Z990000	3	-
15	20	-	BALANCEERSCHROEF	St. M8	4050130	(20)	-
14	24	-	BALANCEERSCHROEF	St. M16	4050136	(24)	-
13	10	-	BALANCEERBLOKJE	St. 17.5x10-M10	6050254	(10)	-
12	10	-	BALANCEERBLOKJE	St. 35x17-M10	6050260	(10)	-
11	24	-	STELSCHROEF	St.12.9 M10x20	4040306	24	DIN 914
10	24	-	STELSCHROEF	St.12.9 M10x16	1001414	24	DIN 913
9	1	-	SLEEPBUS ROTORSP.MET.	VLG TEK 10006522	10006522	1	-
8	1	-	PMG ROTOR	TYPE 40/40	1002772	-	-
7	1	-	DIODENWIEL	VLG TEK 823748	823748	1	-
6	12	-	VENTILATORSCHOEP NAZ	VLG TEK 10000927	10000927	12	-
5	12	-	VENTILATORSCHOEP AZ	VLG TEK 10000909	10000909	12	-
4	1	-	VENTILATORRING NAZ	VLG TEK 10006508	10006508	1	-
3	1	-	VENTILATORRING AZ	VLG TEK 10000907	10000907	1	-
2	1	-	OPWEKKER ROTOR BEW.	VLG TEK 10006511	10006511	1	-
1	1	-	ROTOR BEWIKKELD	VLG TEK 10006520	10006520	1	-

eenheid in stuks tenzij anders aangegeven — stuklijst per ROTOR

type DTG 195

	datum	naam
get.	970723	VKH
gec.	970723	CMP

maattoleranties ±1

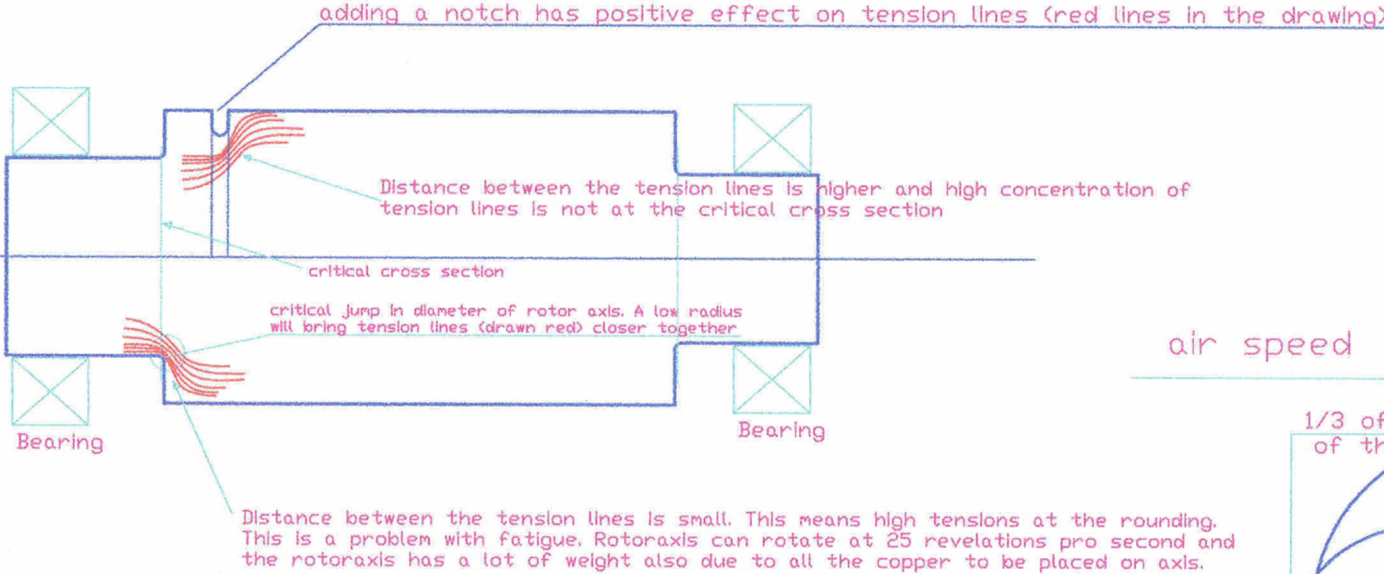
schaal 1:10 0.35

ROTOR COMPLEET

A1

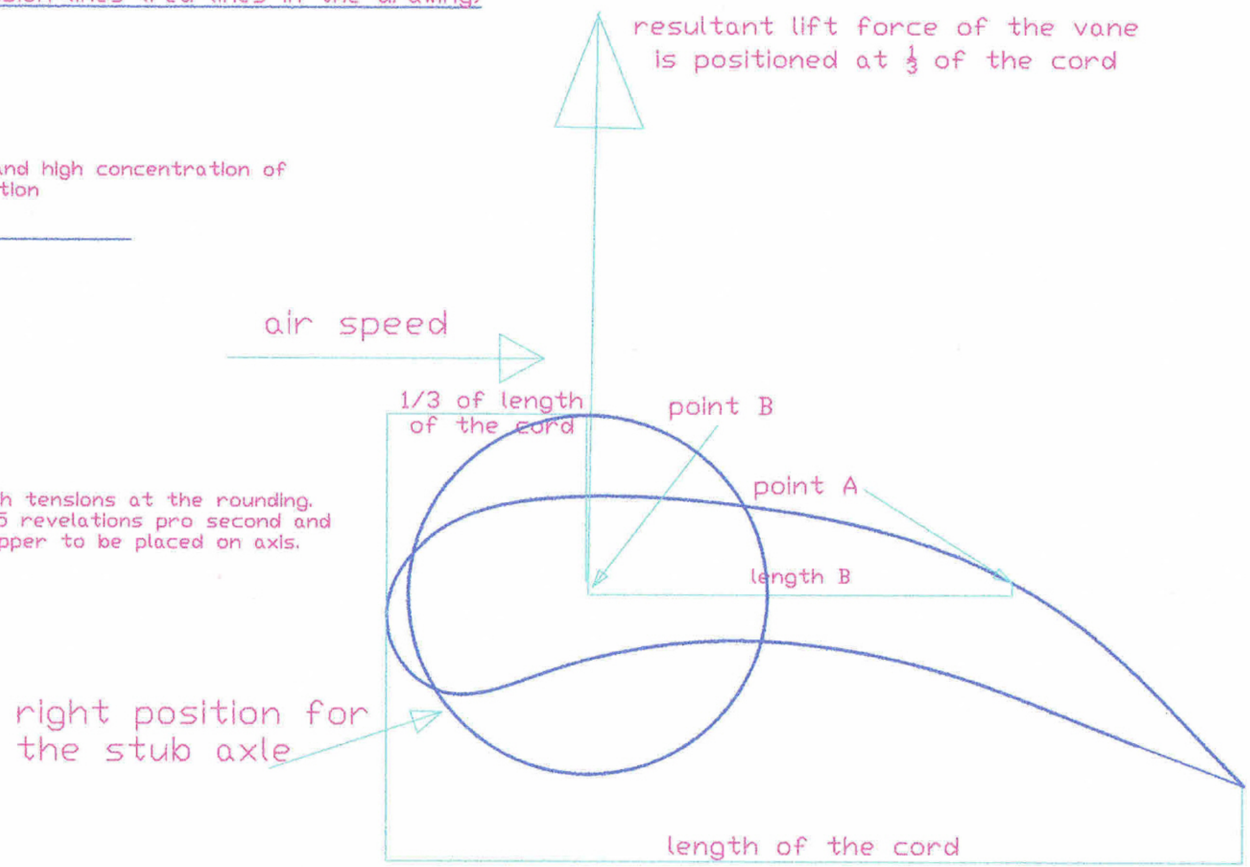
Simplified image of a rotor axis

By making a notch in the axis with higher diameter a better tension situation will occur at the transition form higher to lower diameter of the rotor axis. Due to the notch the higher tensions are transferred more towards the middle of the axis. There the axis is stronger because at the surface of the axis the material has no support because there is no material. Due to this redesign the rotor axis is stronger and cheaper. The material from which the axis is made is very expensive. Due to the notch less weight is delivered.



By milling an extra notch at the higher diameter of the rotor axis you push the high concentration of tension lines away from the edges of the axis. The edges are the weak point because the material has no support from surrounding material. Air will not help supporting the axis. The notch will lower the high tensions in the critical diameter. As a consequenz the tensions will rise a little in the not critical part of the axis. The total product is now made much stronger.

the right position for the stub axle



Holding the wing shaped vane at point A gives extra torsion tensions in the transition from vane to stub axle. This torsion equals Flift x length B. When stub axle is placed at point B (1/3 of cordlength) no torsion tensions will occur in the transition from vane tot stub axle. So placing the stubshaft in point B will lower the tensions in the critical part of this product.