

Effiziente Schweißnahtbewertung anhand eines 120t-Baggerportals

CAE Simulation & Solutions Maschinenbau Ingenieurdienstleistungen GmbH

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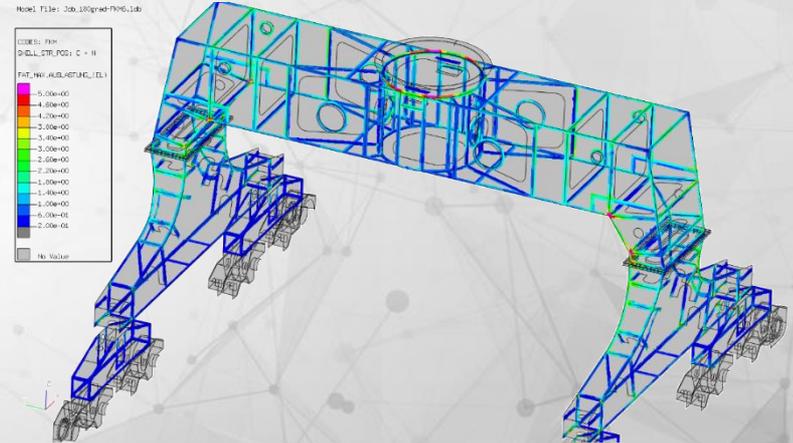
Albatros Engineering GmbH

Ströbitzer, W.

MSC Software Conference

Fachkonferenz für Simulation und Berechnung

24. – 26. Oktober 2017 in Berlin



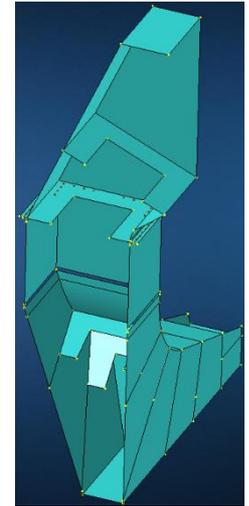
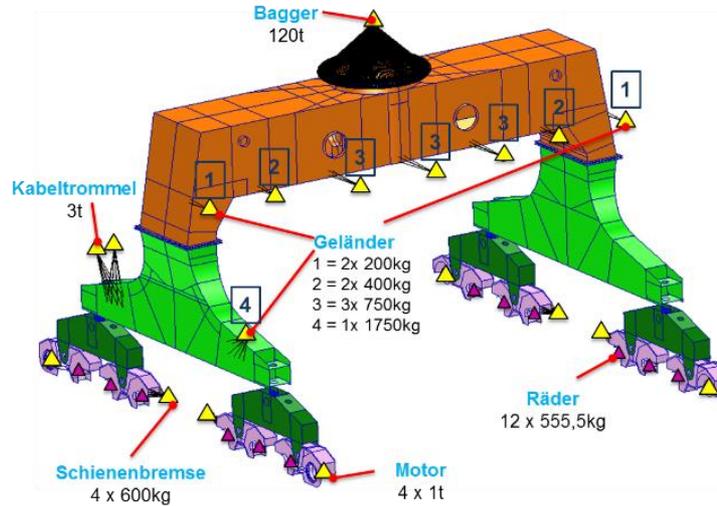
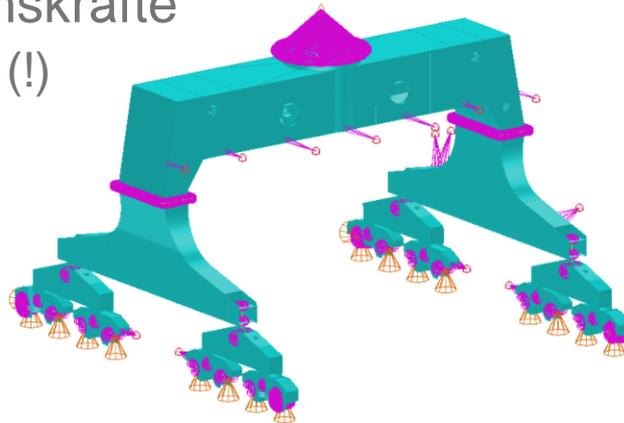
★ Aufgabenstellung

- Auslegung Baggerportal
- Schnittstelle = Vorgabe Baggerhersteller
- Bestimmung ‚Balkenquerschnitte‘
- Bestimmung Blechdicken
- Festlegung Schweißnahtart und Schweißnahtquerschnitt



Modellierung

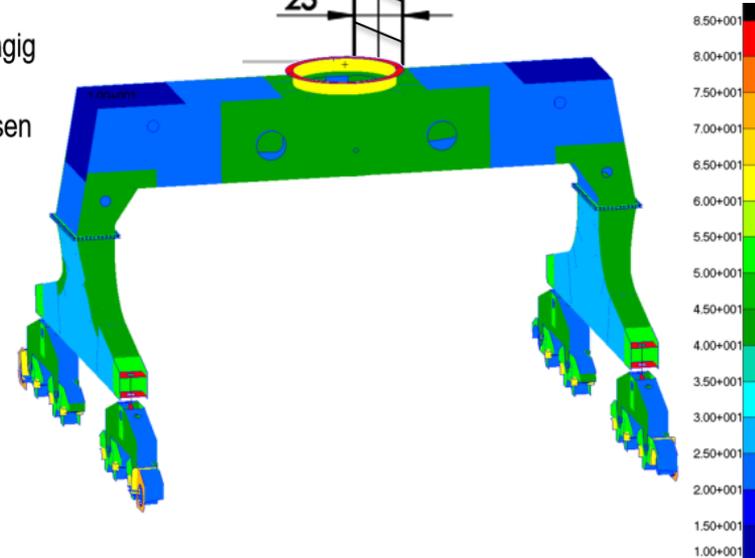
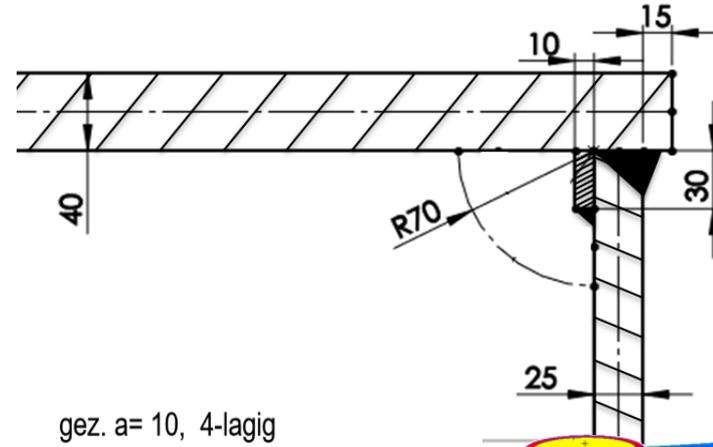
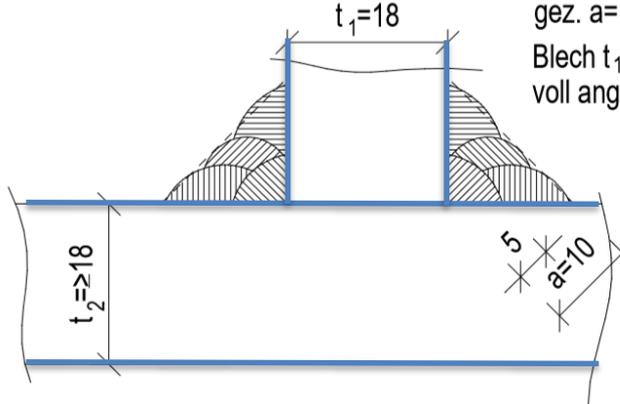
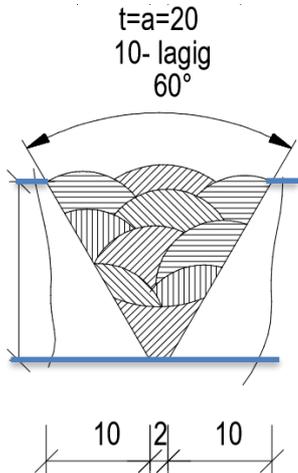
- Schalenmittelflächen
- Massenpunkte
 - Masse ca. 80t
 - Baggermasse 120t
- Reaktionskräfte
 - Kippen (!)



Modellierung

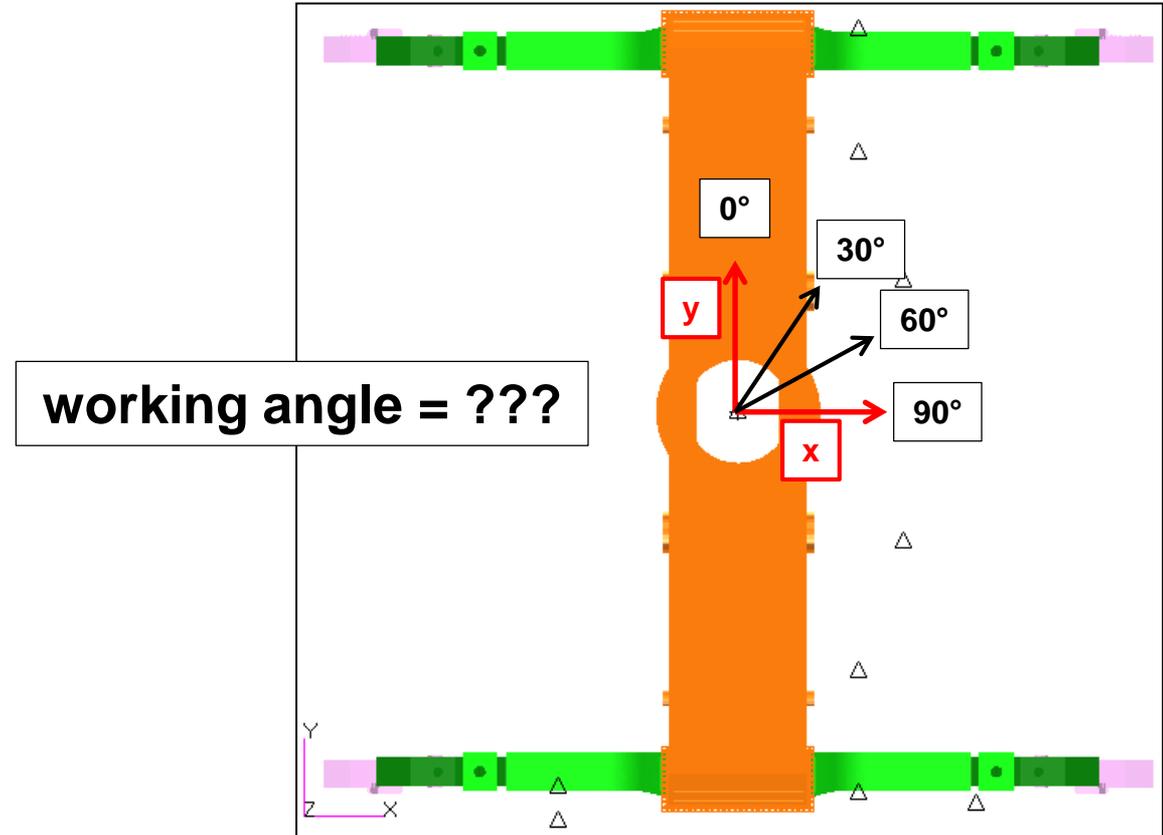
Schweißnähte

- $a = t$
- Nahtart undefiniert
- **Annahme = V-Naht (!)**
- Beispiele:



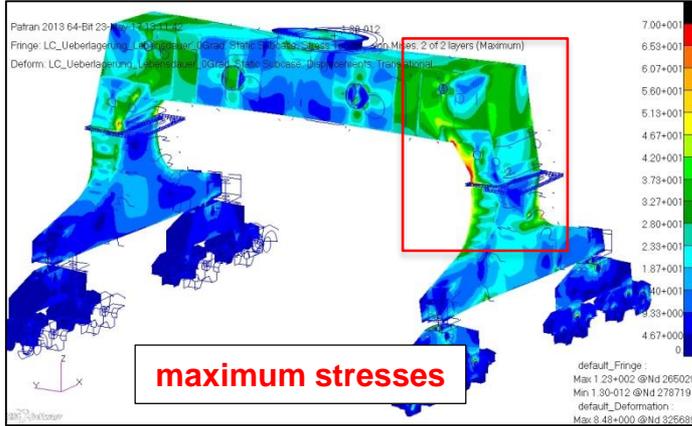
★ Fatigue Load - Lebensdauer

- Überlagerung_Leben – 0°
 - Fx_175kN
 - » x = 0 kN
 - » y = 175 kN
 - » $\Sigma = 175$ kN
 - My_4043 kNm
 - » x = 0 kNm
 - » y = 4.043 kNm
 - » $\Sigma = 4.043$ kNm
 - Mz_420 kNm
 - » z = 420 kNm
 - » $\Sigma = 420$ kNm

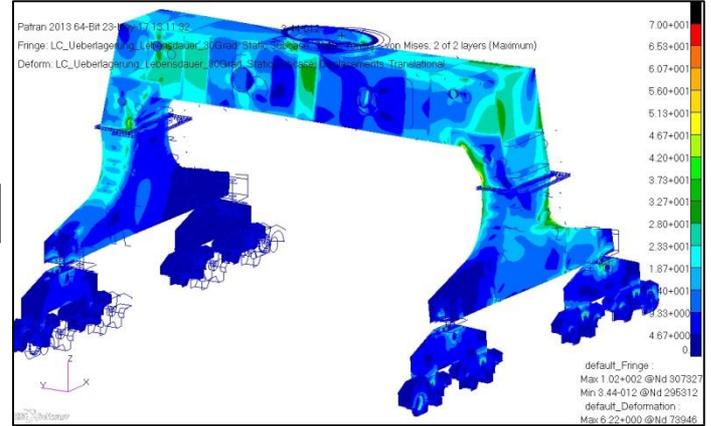


★ Fatigue loading – Lebensdauer – Back view (70MPa, D-Scale 100)

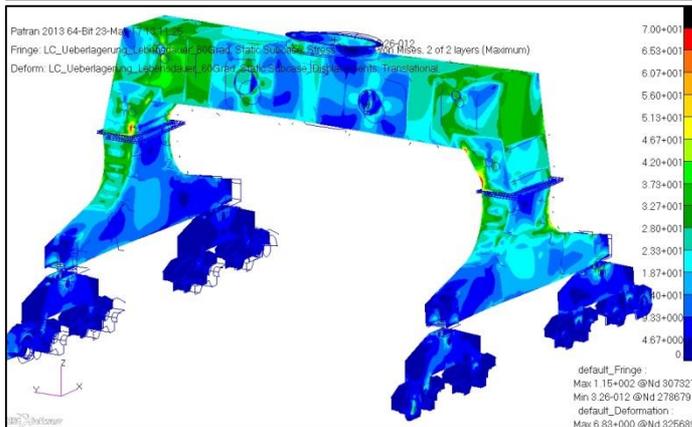
0°



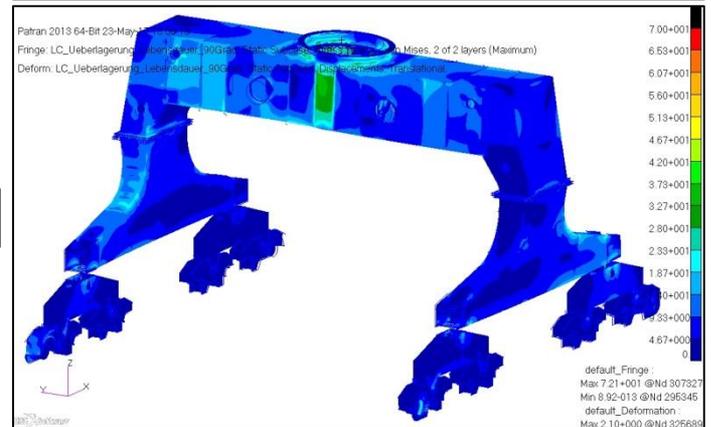
30°



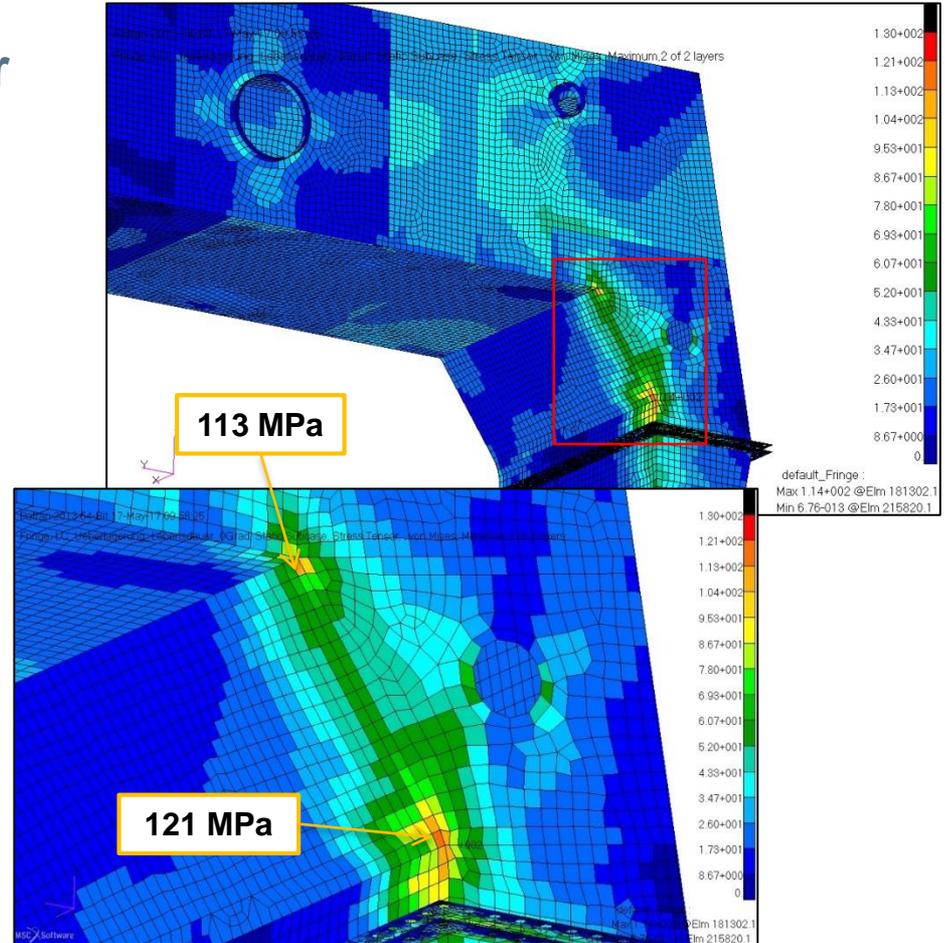
60°



90°



- ✦ Fatigue loading – Lebensdauer
- ✦ **10 Jahre haltbar ???**
- ✦ Spannungsschwingbreiten?
- ✦ Normbewertung nach EC3
- ✦ FKM-Richtlinie
- ✦ ...



★ Fatigue evaluation – LIMIT Load case Overview

Loads				
Name	Load Group	FE Result	Factor/Channel	
LOAD_IC_Ueberlagerung_Lebensdauer_0Grad	Default	LC_Ueberlagerung_Lebensdauer_0Grad	1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_120Grad	Default	LC_Ueberlagerung_Lebensdauer_0Grad	-0.5	
		LC_Ueberlagerung_Lebensdauer_90Grad	0.866	
LOAD_IC_Ueberlagerung_Lebensdauer_150Grad	Default	LC_Ueberlagerung_Lebensdauer_0Grad	-0.866	
		LC_Ueberlagerung_Lebensdauer_90Grad	0.5	
LOAD_IC_Ueberlagerung_Lebensdauer_300Grad	Default	LC_Ueberlagerung_Lebensdauer_0Grad	0.5	
		LC_Ueberlagerung_Lebensdauer_90Grad	-0.866	
LOAD_IC_Ueberlagerung_Lebensdauer_330Grad	Default	LC_Ueberlagerung_Lebensdauer_0Grad	0.866	
		LC_Ueberlagerung_Lebensdauer_90Grad	-0.5	
LOAD_IC_Ueberlagerung_Lebensdauer_null	Default	LC_Ueberlagerung_Lebensdauer_0Grad	0.0	
LOAD_IC_Ueberlagerung_Lebensdauer_180Grad	Default	LC_Ueberlagerung_Lebensdauer_0Grad	-1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_30Grad	Default	LC_Ueberlagerung_Lebensdauer_30Grad	1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_210Grad	Default	LC_Ueberlagerung_Lebensdauer_30Grad	-1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_60Grad	Default	LC_Ueberlagerung_Lebensdauer_60Grad	1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_240Grad	Default	LC_Ueberlagerung_Lebensdauer_60Grad	-1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_90Grad	Default	LC_Ueberlagerung_Lebensdauer_90Grad	1.0	
LOAD_IC_Ueberlagerung_Lebensdauer_270Grad	Default	LC_Ueberlagerung_Lebensdauer_90Grad	-1.0	

Lastfall-
kombinationen

Selected:

LOAD_IC_Ueberlagerung_Lebensdauer_0Grad
LOAD_IC_Ueberlagerung_Lebensdauer_120Grad
LOAD_IC_Ueberlagerung_Lebensdauer_150Grad
LOAD_IC_Ueberlagerung_Lebensdauer_180Grad
LOAD_IC_Ueberlagerung_Lebensdauer_210Grad
LOAD_IC_Ueberlagerung_Lebensdauer_240Grad
LOAD_IC_Ueberlagerung_Lebensdauer_270Grad
LOAD_IC_Ueberlagerung_Lebensdauer_300Grad
LOAD_IC_Ueberlagerung_Lebensdauer_30Grad
LOAD_IC_Ueberlagerung_Lebensdauer_330Grad
LOAD_IC_Ueberlagerung_Lebensdauer_60Grad
LOAD_IC_Ueberlagerung_Lebensdauer_90Grad
LOAD_IC_Ueberlagerung_Lebensdauer_null

← 360 Grad

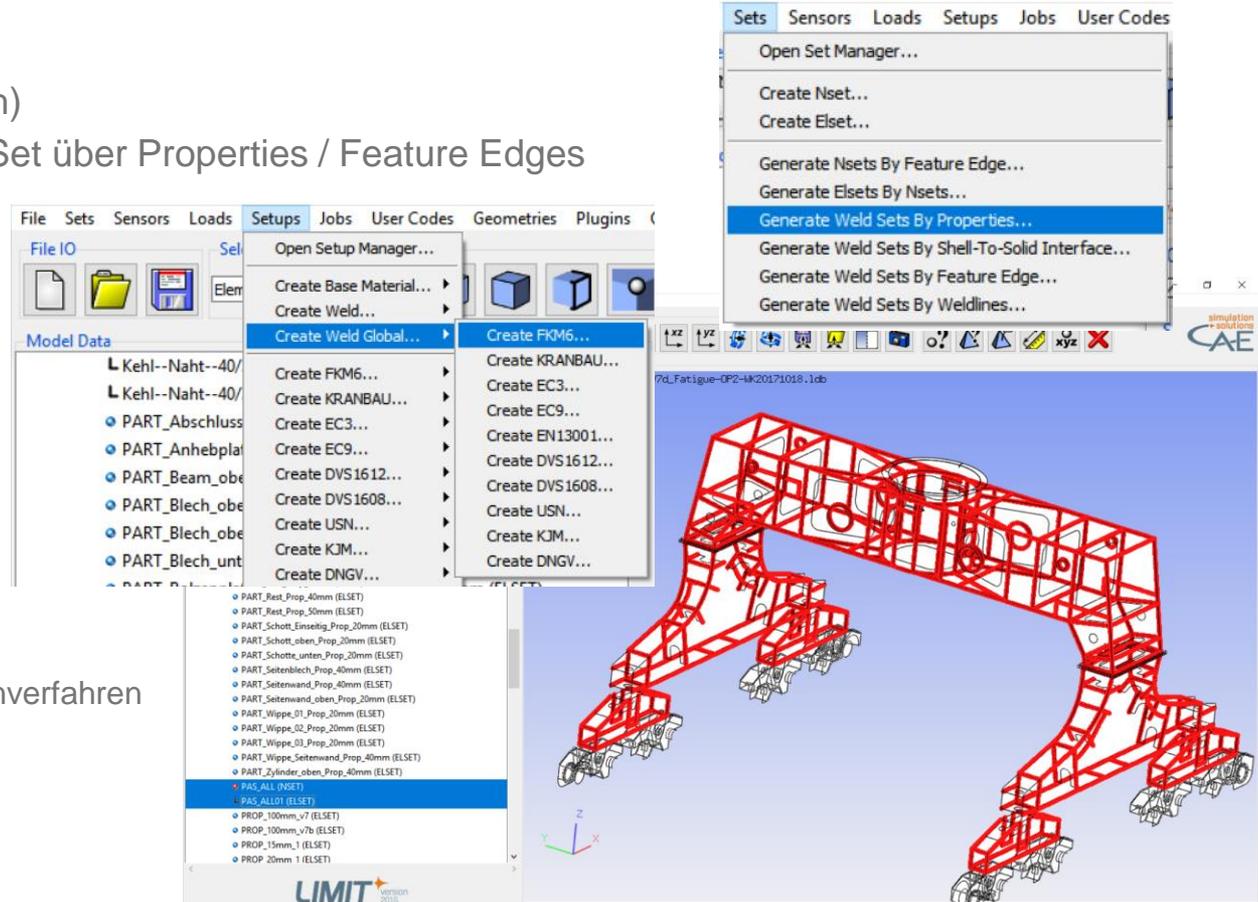
180 Grad →

Selected:

LOAD_IC_Ueberlagerung_Lebensdauer_0Grad
LOAD_IC_Ueberlagerung_Lebensdauer_120Grad
LOAD_IC_Ueberlagerung_Lebensdauer_150Grad
LOAD_IC_Ueberlagerung_Lebensdauer_180Grad
LOAD_IC_Ueberlagerung_Lebensdauer_30Grad
LOAD_IC_Ueberlagerung_Lebensdauer_60Grad
LOAD_IC_Ueberlagerung_Lebensdauer_90Grad
LOAD_IC_Ueberlagerung_Lebensdauer_null

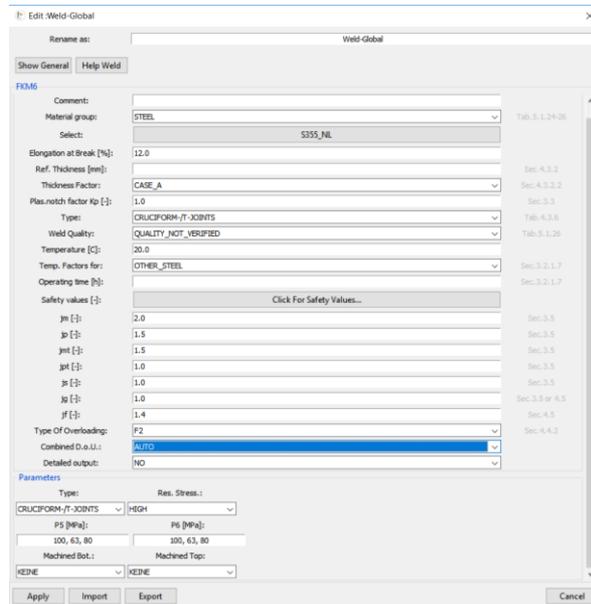
★ LIMIT

- Method: Weld global (1h)
 - Element Set / Knoten Set über Properties / Feature Edges
 - » PAS_ALL
 - Create Weld Global
 - » Normenauswahl FKM6
 - Vorteile
 - » Sehr schnell
 - » Globaler Überblick
 - Nachteile
 - » $a=t$
 - » Längs / Quer / Schub
 - » kritisches Schmittebenenverfahren
crit. Planes

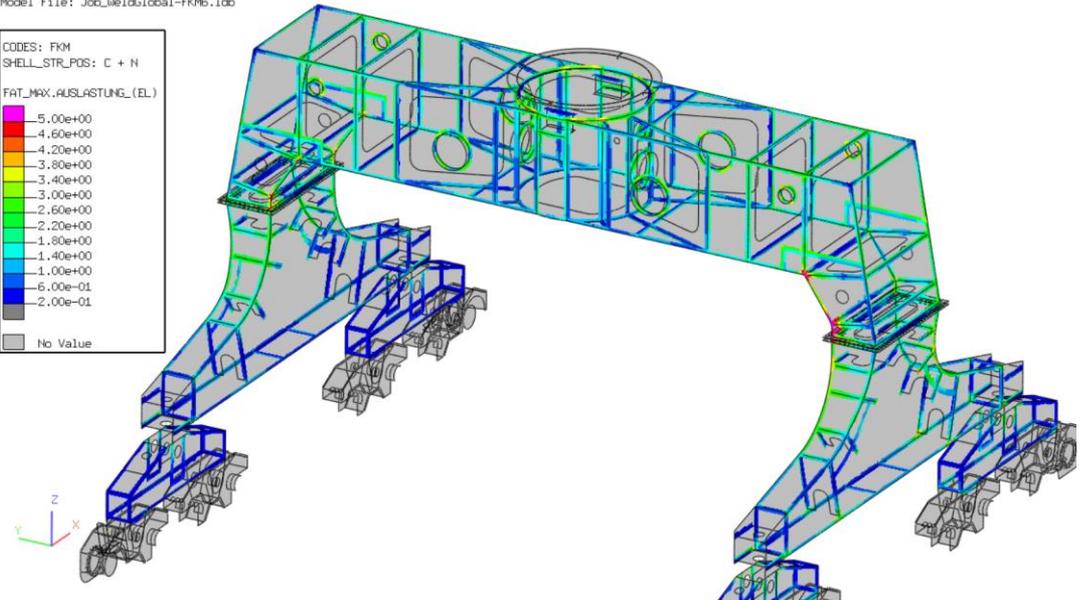
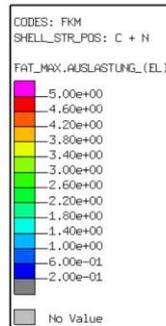


LIMIT

- Method: Weld global (1h)
 - » critical Plane – kritisches Schnittebenenverfahren
 - » Daher SEHR konservativ, weil Schnittebenenverfahren höchste Spannung in Richtung der geringsten zulässigen Spannung legt!
 - » Längs / quer / Schub trotzdem sinnvoll (Interaktion)



Model File: Job_WeldGlobal-FKM6.1db



LIMIT

Method: Multiedit (3h)

– Bestimmung der relevanten Schweißnähte

– Normenauswahl

» Nahttypen teilen

» $a = 0.8 \cdot t$

» Längs / Quer / Schub

» 2 Durchläufe wegen einseitiger Kehlnähte

– Vorteile

» schnell

» Guter Überblick

» Berücksichtigung der Nahtrichtung!

– Nachteile

» Nahtgruppenbewertung

The screenshot displays the SetupManager application window. At the top, there are options for 'Highlighting', 'Sort by Name', 'Sort by Groups', 'Status Color', and 'Show Symbol'. Below this is a table of welds with columns for Name, Groups, Node Set, Assignment, Code, and Status. A context menu is open over the table, showing options like 'Create', 'Edit', 'Separate', 'Split', 'Copy', and 'Delete'. A secondary dialog box is open, titled 'Edit D_Kehl-Naht-40/20-01', showing settings for a specific weld, including 'Effective weld length', 'Material group', and 'Weld quality'. A small 3D visualization of the weld is shown in the bottom right corner of the dialog.

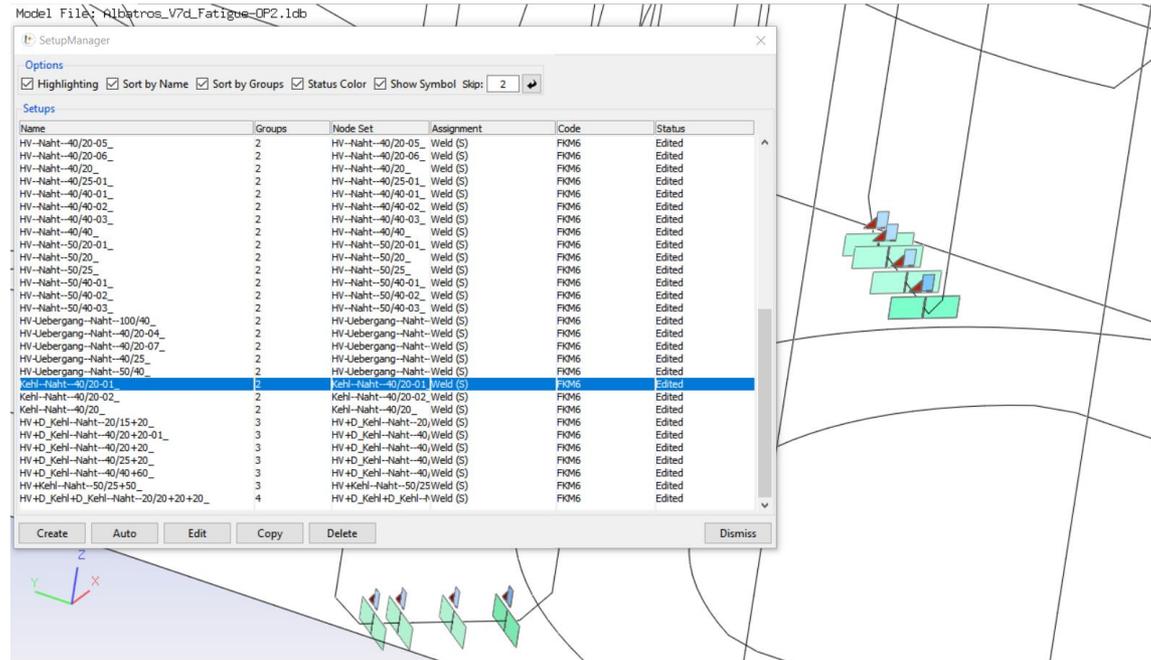
★ LIMIT

- Method: Schweißnahtdefinitionen (3 Tage)

– Bewertung der relevanten Schweißnähte

– Normenauswahl

- » $a = 0.8 \cdot t$
- » Längs / Quer / Schub
- » Bilder Nähte
- » Kehlnaht
- » V-Naht
- » 100% Prüfung



★ LIMIT - Weld line evaluation – Lebensdauer

- Weld line assessment using LIMIT
- FKM 6th edition
- STATIC assessment
- Fatigue assessment

General

Use Sensor:

Assignment: Weld

Code: FKM6

Assessment: STATIC_STRENGTH+FATIGUE_STRENGTH

Status: Edited

Sets: Selected: Existing:

PAS000201 PAS0001

- static safety factor

Static Safety Factor: jp, jm, jpt, jmt (Tab. 3.5.1)

	HIGH Consequ. Of Failure	MEAN Consequ. Of Failure	MODERATE Consequ. Of Failure
HIGH Prob. Of Stress Comb. Occur.	jm=2.0 jp=1.5 jmt=1.5 jpt=1.0	jm=1.85 jp=1.4 jmt=1.4 jpt=1.0	jm=1.75 jp=1.3 jmt=1.3 jpt=1.0
LOW Prob. Of Stress Comb. Occur.	jm=1.8 jp=1.35 jmt=1.35 jpt=1.0	jm=1.7 jp=1.25 jmt=1.25 jpt=1.0	jm=1.6 jp=1.2 jmt=1.2 jpt=1.0

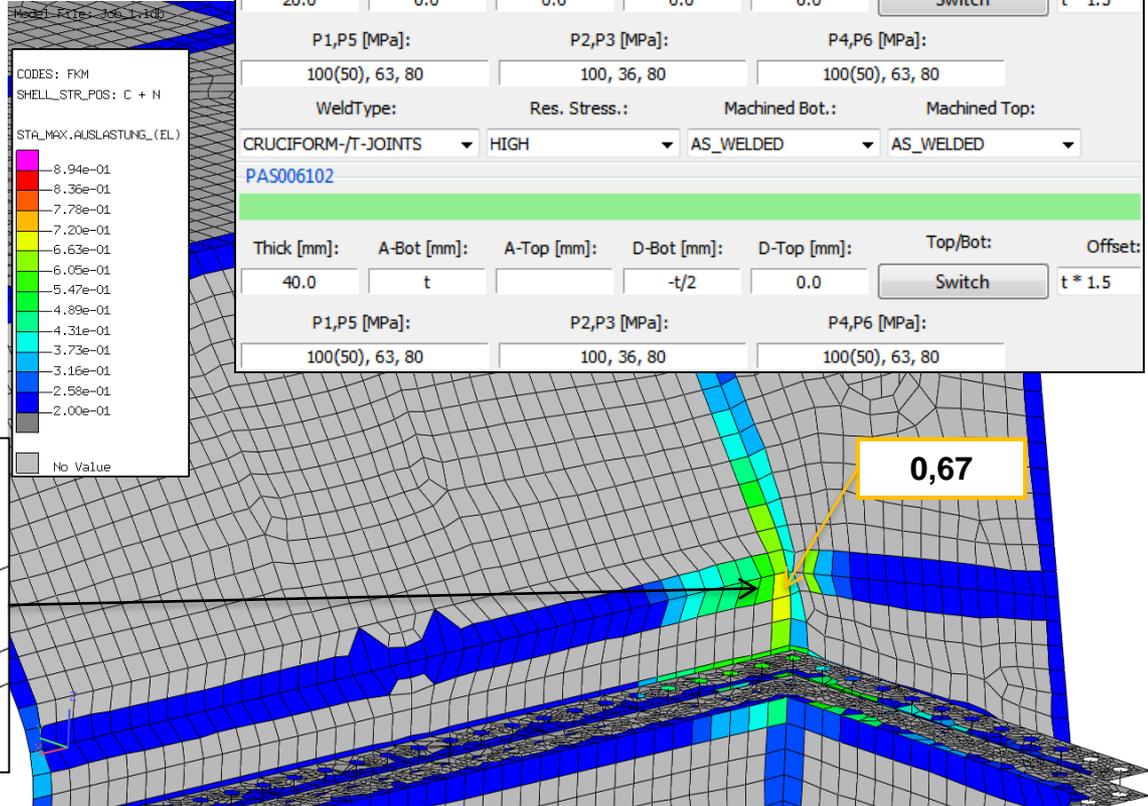
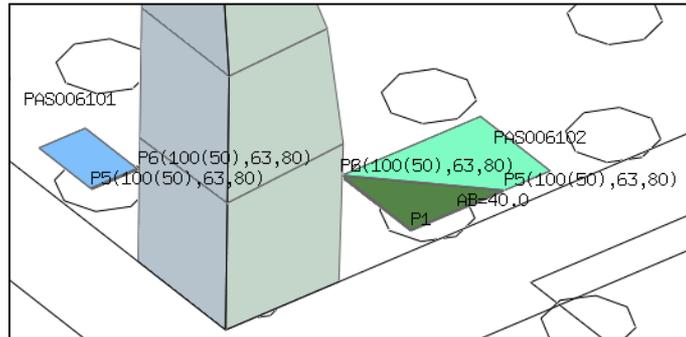
- Material safety factor Fatigue assessment

Material Safety Factors For Welded Components: jf (Tab 4.5.3)

	HIGH Consequ. Of Failure	MEAN Consequ. Of Failure	MODERATE Consequ. Of Failure
NO Regular Inspection	jf=1.4	jf=1.25	jf=1.15
YES Regular Inspection	jf=1.2	jf=1.1	jf=1.0

★ LIMIT static results – statisch

- Weld line assessment using LIMIT



HV weld, transition in thickness

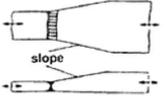
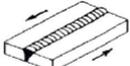
No.	Structural detail	Description	FAT Steel	FAT Al
300	Longitudinally loaded welds			
313		Longitudinally loaded butt weld, without stop/start positions, NDT, with stop/start positions.	100 90	40 36
200	Butt welds, transversely loaded			
222		Transversely loaded butt weld made in shop, welded in flat position, weld profile controlled, NDT, with transition in thickness and width, Δ^1 slope 1:5 slope 1:3 slope 1:2 Some misalignment is already allowed for by the fatigue class.	90 80 72	32 28 25
215		Transversely loaded butt weld on permanent backing bar, root crack. Δ^2	71	25

Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher 13/*

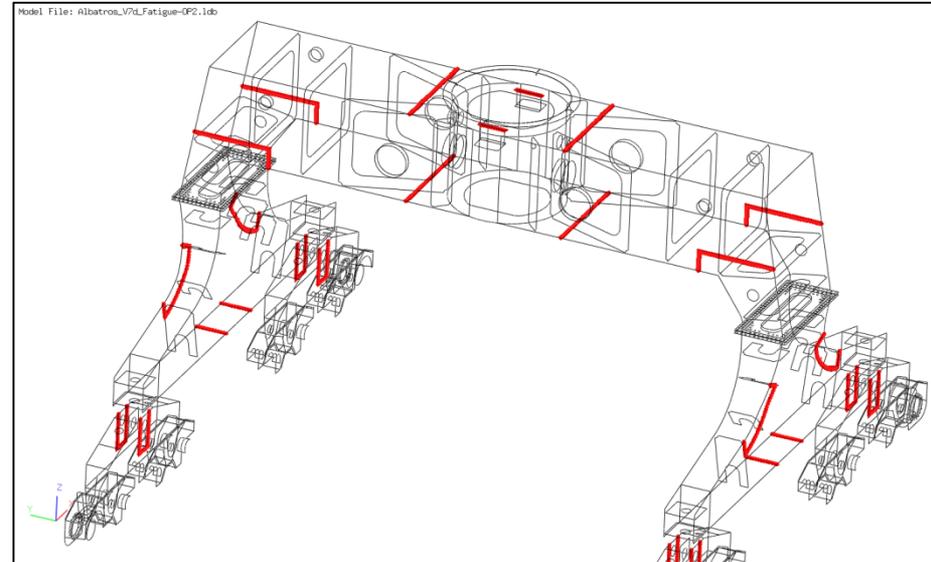
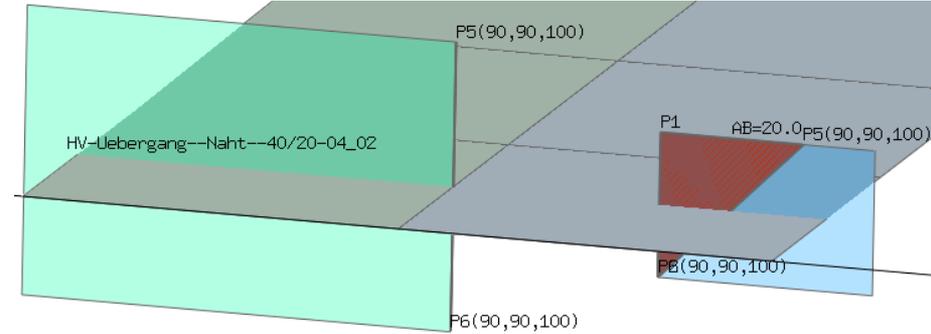
No.	Structural detail	Description	FAT Steel	FAT Al
1		Full penetration butt welds.	100	36

P1 – P6

P1, P5, P4, P6

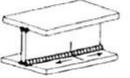
P3

P1 – P6



Thick [mm]:	A-Bot [mm]:	A-Top [mm]:	D-Bot [mm]:	D-Top [mm]:	Top/Bot:	Offset:	Endings:
20.0	t	0.0	-1/2	0.0	Switch	t* 1.5	t* 1.5
P1,P5 [MPa]:		P2,P3 [MPa]:		P4,P6 [MPa]:			
90,90,100		90,71,100		90,90,100			
WeldType:		Res. Stress.:		Machined Bot.:		Machined Top:	
CRUCIFORM-T-JOINTS		HIGH		AS_WELDED		AS_WELDED	
HV-Uebergang--Naht--40/20-04_02							
Thick [mm]:	A-Bot [mm]:	A-Top [mm]:	D-Bot [mm]:	D-Top [mm]:	Top/Bot:	Offset:	Endings:
40.0	0.0	0.0	0.0	0.0	Switch	t* 1.5	t* 1.5
P1,P5 [MPa]:		P2,P3 [MPa]:		P4,P6 [MPa]:			
90,90,100		90,71,100		90,90,100			

double fillet weld

No.	Structural detail	Description	FAT Steel	FAT Al
300 Longitudinally loaded welds				
323		Continuous manual longitudinal fillet or butt weld (based on stress range in flange).	90	36
500 Non-load carrying attachments				
521		Longitudinal fillet welded gusset at length l L ≤ 50 mm 50 mm < L ≤ 150 mm 150 mm < L ≤ 300 mm 300 mm < L gusset near edge: see 525 "flat side gusset".	80 71 63 50	28 25 20 18

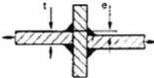
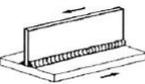
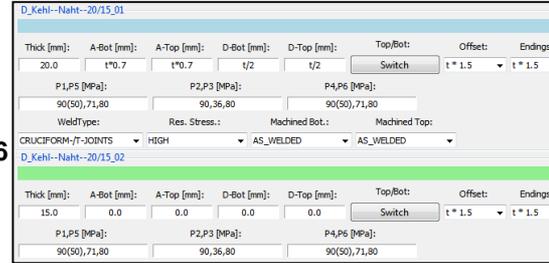
400 Cruciform joints and/or T-joints				
413		Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds, no lamellar tearing, toe crack. Misalignment $e < 0.15 \cdot t$, No misalignment.	63 71	22 25
414		Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds including toe ground joints, root crack. Analysis based on stress in weld $\sigma = F / (\Sigma(a \cdot l))$ length of the weld joint for $a/t \leq 1/3$ t sheet metal thickness	36 40	12 14

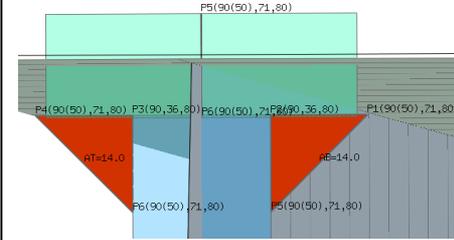
Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher/13/*

No.	Structural detail	Description	FAT Steel	FAT Al
2		Fillet welds, partial penetration butt welds.	80	28



P1 – P6

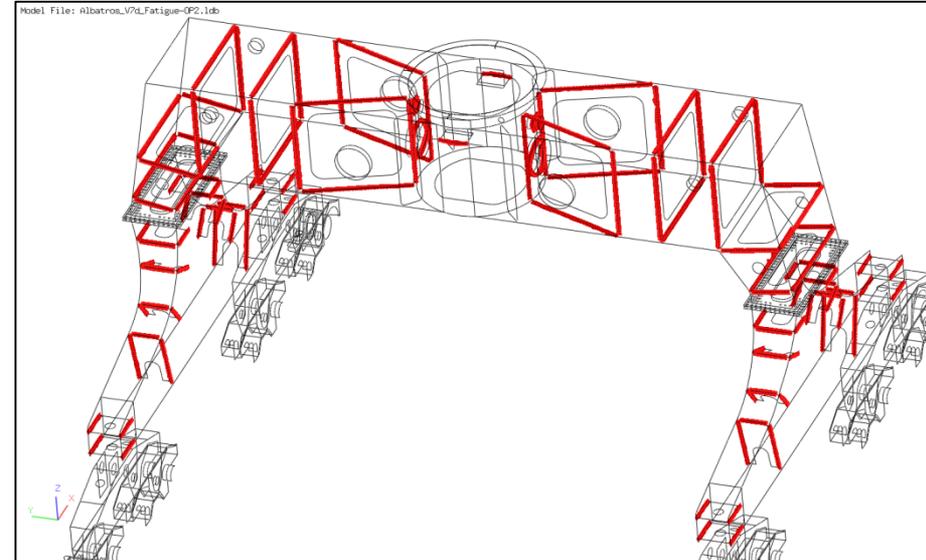
(P1 – P6)



P1, P5, P4, P6

P3

P1 – P6



HV + double fillet weld + double fillet weld

No.	Structural detail	Description	FAT Steel	FAT Al
300	Longitudinally loaded welds			
323		Continuous manual longitudinal fillet or butt weld (based on stress range in flange).	90	36
500	Non-load carrying attachments			
521		Longitudinal fillet welded gusset at length l L ≤ 50 mm 50 mm < L ≤ 150 mm 150 mm < L ≤ 300 mm 300 mm < L gusset near edge: see 525 "flat side gusset".	80 71 63 50	28 25 20 18
400	Cruciform joints and/or T-joints			
413		Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds, no lamellar tearing, toe crack. Misalignment $e < 0.15 \cdot t$, No misalignment.	63 71	22 25
414		Cruciform joint or T-joint, fillet welds or partial penetration K-butt welds including toe ground joints, root crack. Analysis based on stress in weld $\sigma = F/\Sigma(a \cdot l)$ l length of the weld joint for $a/t \leq 1/3$ t sheet metal thickness	36 40	12 14

Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher /13/*

No.	Structural detail	Description	FAT Steel	FAT Al
2		Fillet welds, partial penetration butt welds.	80	28

double fillet weld definition → worst case

HV-D_KeHl=D_KeHl--Naht--20/20+20+20_01

Thick [mm]:	A-Bot [mm]:	A-Top [mm]:	D-Bot [mm]:	D-Top [mm]:	Top/Bot:	Offset:	Endings:
20.0	t*0.7	t*0.7	1/2	1/2	Switch	t*1.5	t*1.5

P1,P5 [MPa]: 90(50),71,80 P2,P3 [MPa]: 90,36,80 P4,P6 [MPa]: 90(50),71,80

WeldType: Res. Stress.: Machined Bot.: Machined Top:

CRUCIFORM-/T-JOINTS HIGH AS_WELDED AS_WELDED

HV-D_KeHl=D_KeHl--Naht--20/20+20+20_02

Thick [mm]:	A-Bot [mm]:	A-Top [mm]:	D-Bot [mm]:	D-Top [mm]:	Top/Bot:	Offset:	Endings:
20.0	t*0.7	t*0.7	1/2	1/2	Switch	t*1.5	t*1.5

P1,P5 [MPa]: 90(50),71,80 P2,P3 [MPa]: 90,36,80 P4,P6 [MPa]: 90(50),71,80

WeldType: Res. Stress.: Machined Bot.: Machined Top:

CRUCIFORM-/T-JOINTS HIGH AS_WELDED AS_WELDED

HV-D_KeHl=D_KeHl--Naht--20/20+20+20_03

Thick [mm]:	A-Bot [mm]:	A-Top [mm]:	D-Bot [mm]:	D-Top [mm]:	Top/Bot:	Offset:	Endings:
20.0	t	0.0	-1/2	-1/2	Switch	t*1.5	t*1.5

P1,P5 [MPa]: 90(50),71,80 P2,P3 [MPa]: 90,36,80 P4,P6 [MPa]: 90(50),71,80

WeldType: Res. Stress.: Machined Bot.: Machined Top:

CRUCIFORM-/T-JOINTS HIGH AS_WELDED AS_WELDED

HV-D_KeHl=D_KeHl--Naht--20/20+20+20_04

Thick [mm]:	A-Bot [mm]:	A-Top [mm]:	D-Bot [mm]:	D-Top [mm]:	Top/Bot:	Offset:	Endings:
20.0	0.0	0.0	0.0	0.0	Switch	t*1.5	t*1.5

P1,P5 [MPa]: 90(50),71,80 P2,P3 [MPa]: 90,36,80 P4,P6 [MPa]: 90(50),71,80

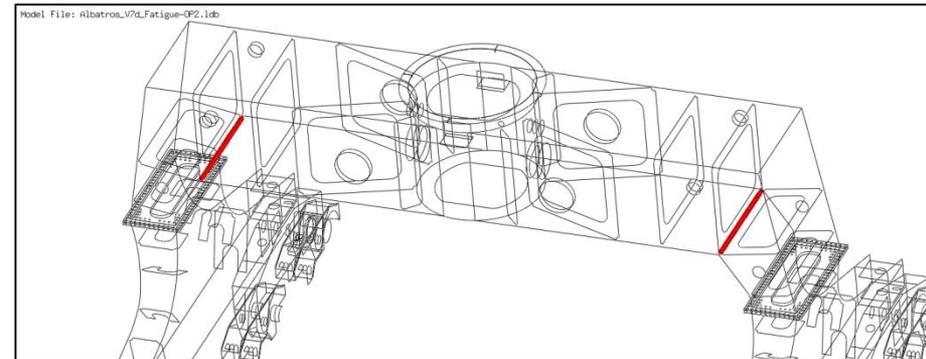
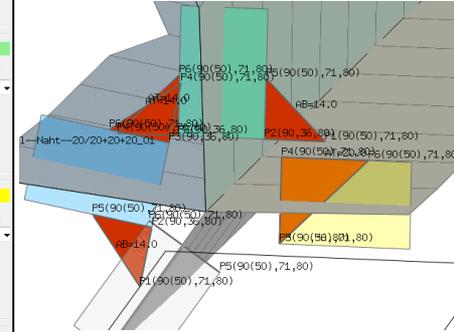
P1 – P6

(P1 – P6)

P1, P5, P4, P6

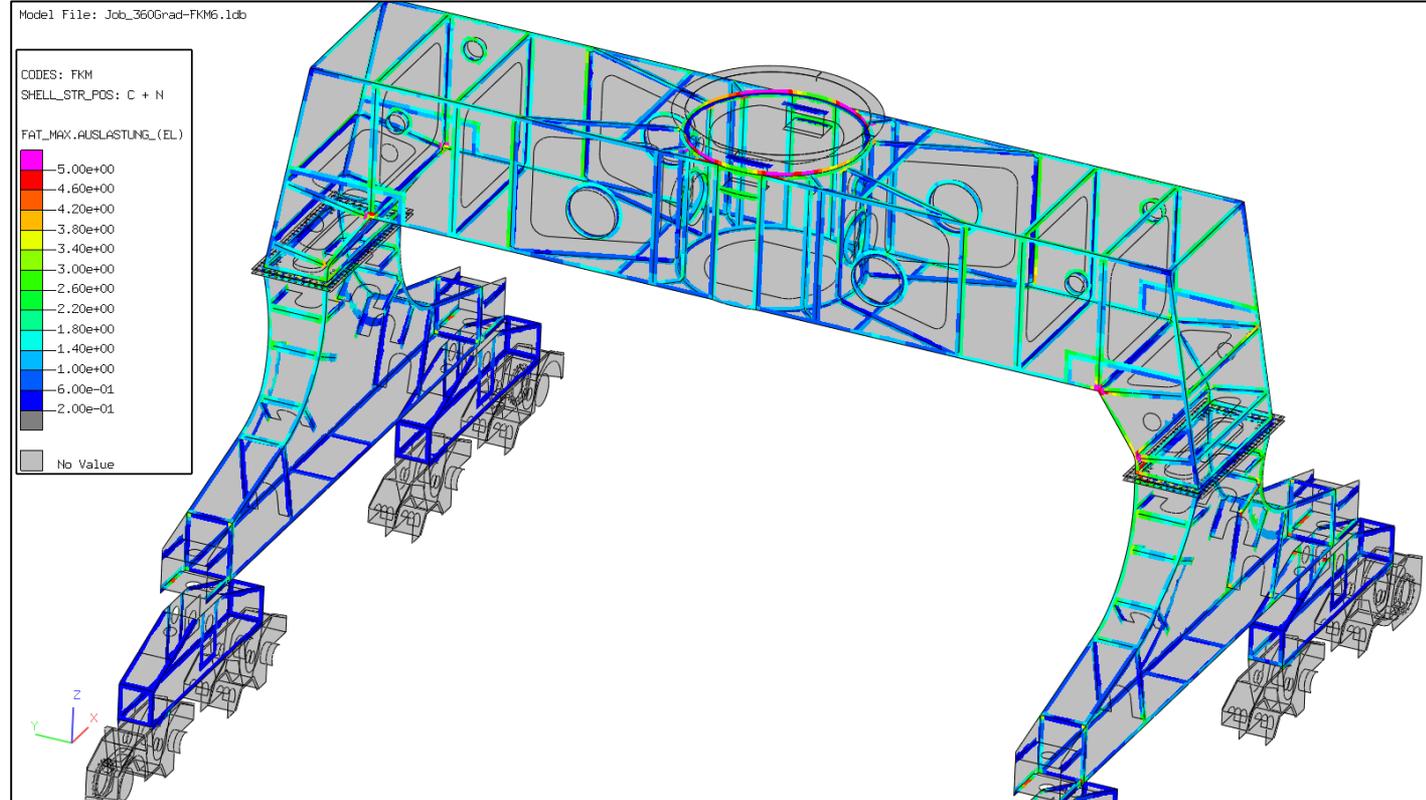
P3

P1 – P6



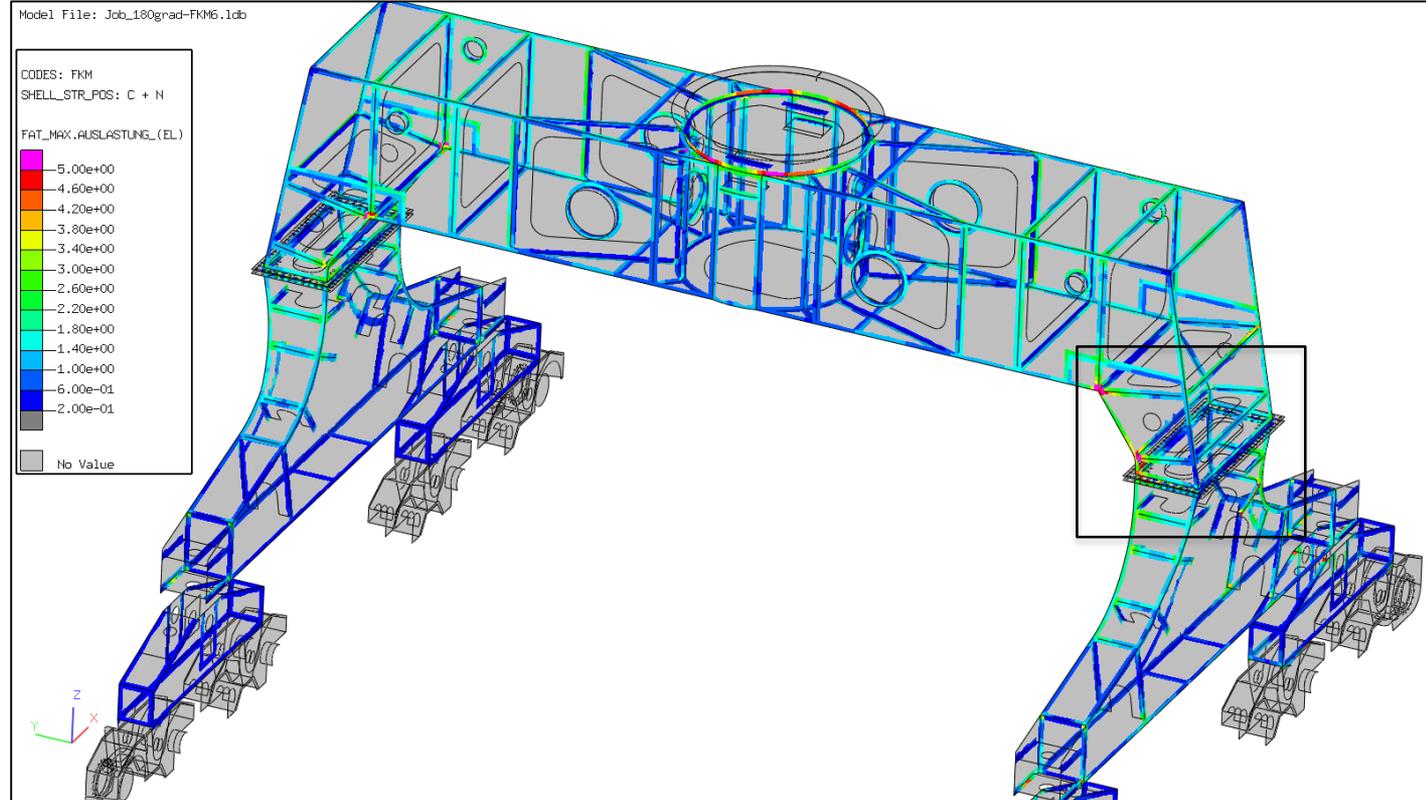
✦ Fatigue evaluation – Lebensdauer – 360 Grad – LIMIT

**scale to 5.0 (max)
→ welds overloaded
according to FKM 6th
under current
load assumptions**

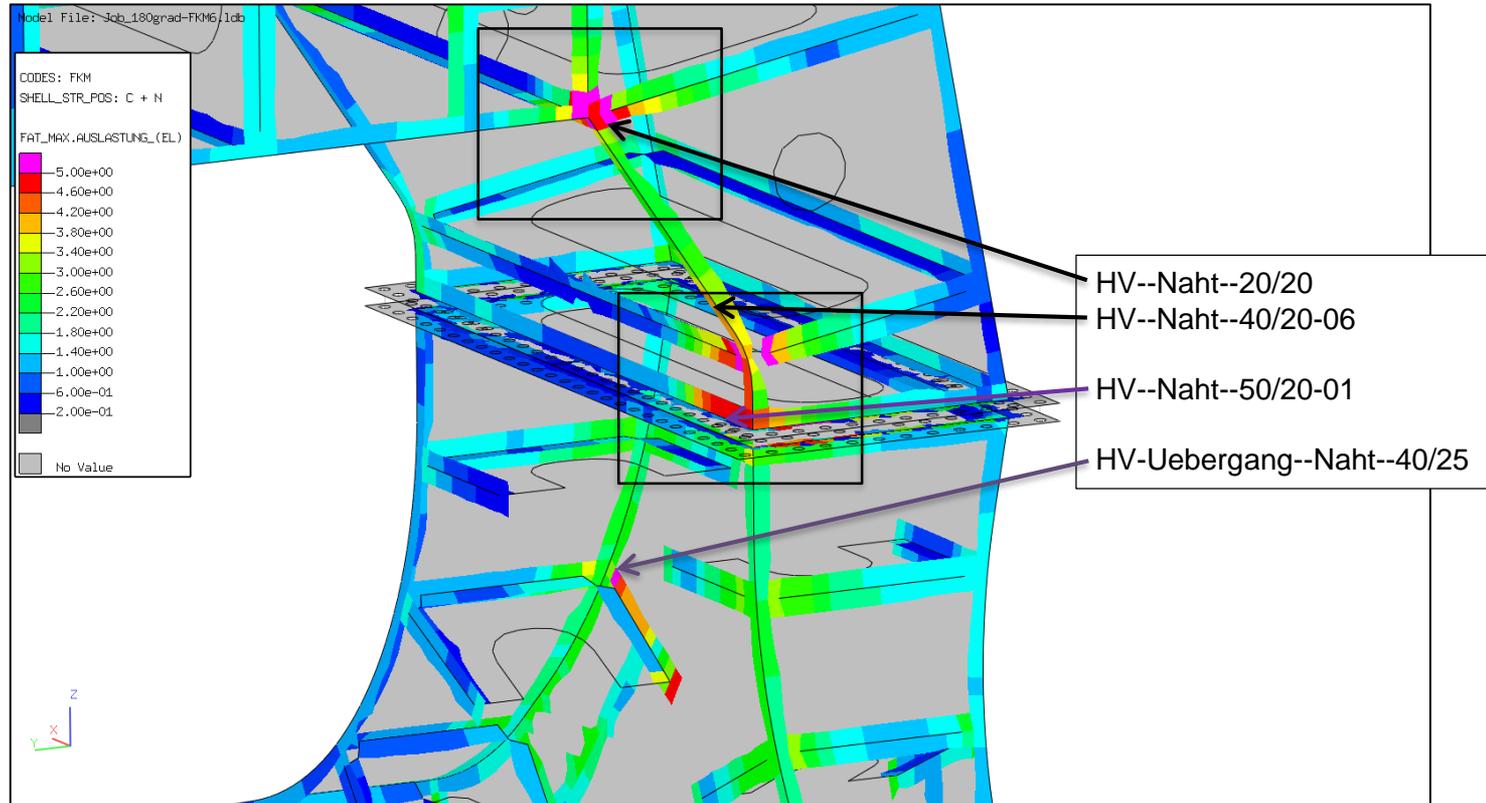


★ Fatigue evaluation – Lebensdauer – 180 Grad – LIMIT

**scale to 5.0 (max)
→ welds overloaded
according to FKM 6th
under current
load assumptions**



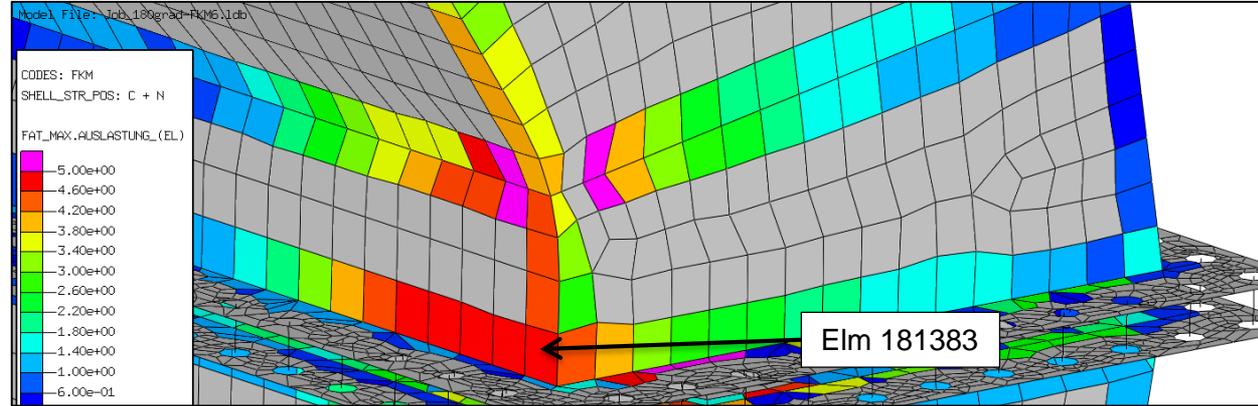
✦ Fatigue evaluation – Lebensdauer – 180 Grad – LIMIT



✦ Fatigue evaluation – 180 Grad – LIMIT

✦ Query function

Node + Max.Auslastung
weld set name
between these Loadcases
which Point and FAT-number



Element Id: 181383; Elset(s): HV--Naht--40/20-06_01, HV--Naht--50/20-01_01, _A_20.0__D_-10.0__ESN, _T_20.0__ESN_A_20.0__D_-10.0

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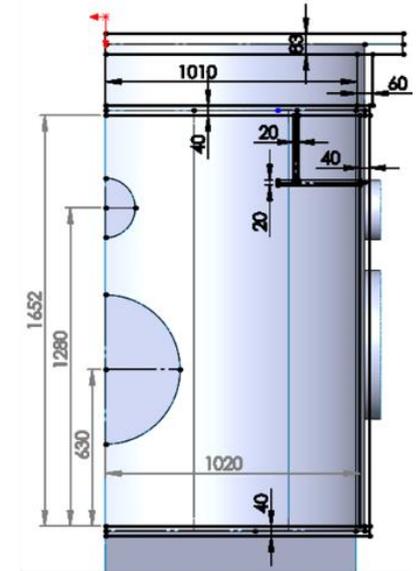
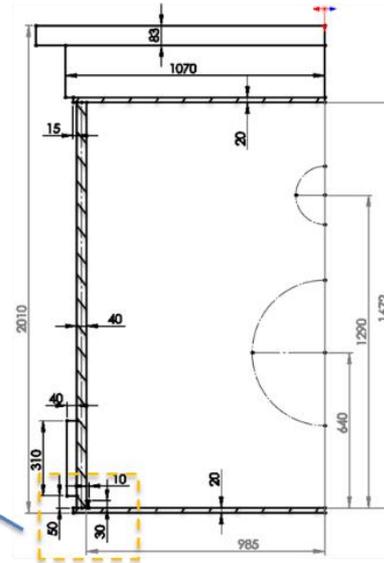
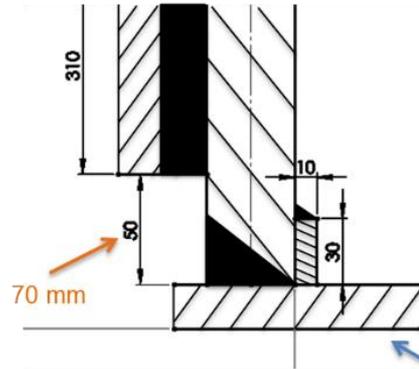
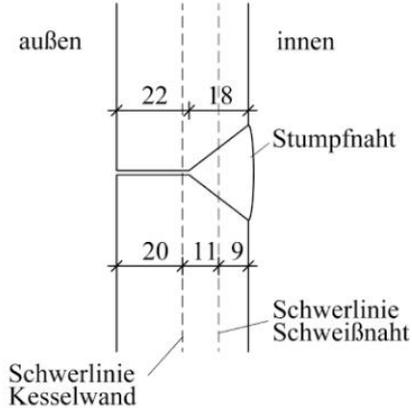
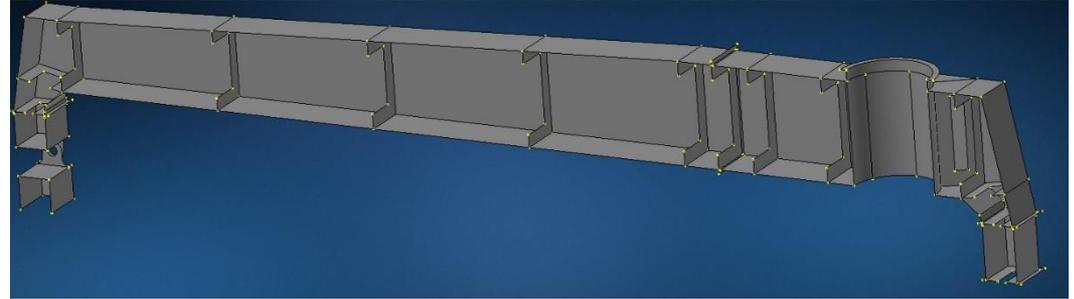
Node 259344: 3.6115 -> Set: HV--Naht--50/20-01_01_
LCs:(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_0GRAD)<->(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_180GRAD)
P1__1(FAT90/FAT80/FAT80)__2(FAT90/FAT71/FAT80)__5(FAT90/FAT80/FAT80)

Node 272523: 0.2 -> Set: not_analyzed

Node 269223: 3.9334 -> Set: HV--Naht--40/20-06_01_
Node 259328: 4.7475 -> Set: HV--Naht--50/20-01_01_
LCs:(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_0GRAD)<->(LOAD_LC_UEBERLAGERUNG_LEBENSDAUER_180GRAD)
P1__1(FAT90/FAT80/FAT80)__2(FAT90/FAT71/FAT80)__5(FAT90/FAT80/FAT80)

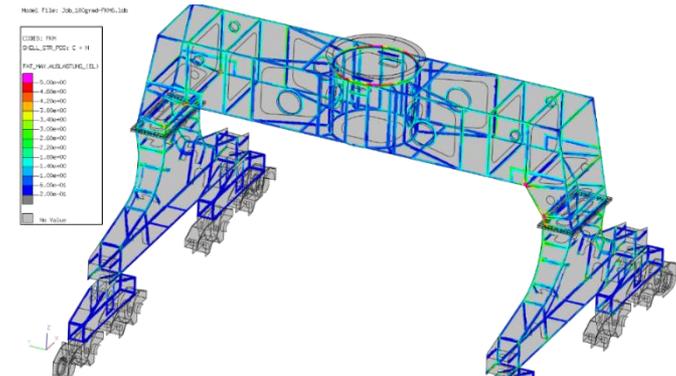
Ergebnis

- Konstruktion
- Blechstärken
- Schweißnahtfestlegung
- Inspektionsplan
 - Wo kontrollieren?



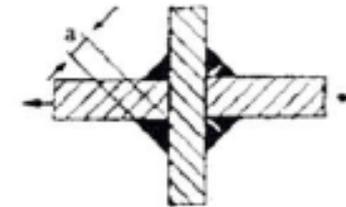
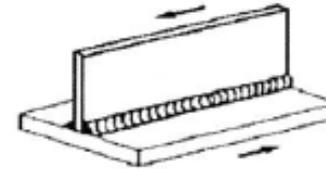
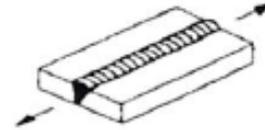
★ Zusammenfassung

- FE Modellierung
 - Schalenmodell
- Lasten
 - Von Baggerlieferanten
 - 360° Rotation vs. 180° Rotation
- Lebensdauerbewertung in 3 Schritten
 - Weld Global = kritisches Schnittebenenverfahren
 - Multiedit von Nahtgruppen (Kehlnaht, V-Naht, ...)
 - Einzelnahtbewertung (z.B. Röntgenprüfung)
- Schweißnahtfestlegung
 - Normbewertung (FKM) wegen Sicherheit
 - Kostenreduktion soweit möglich (Schweißzeiten)
 - Bewusstsein für Schweißnähte schaffen (!)



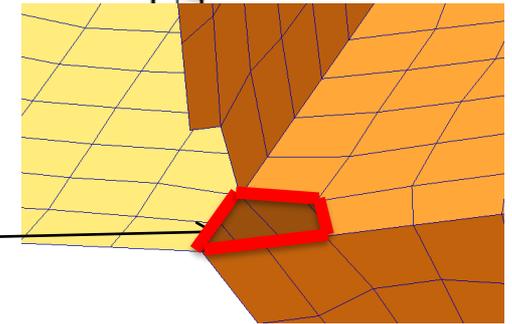
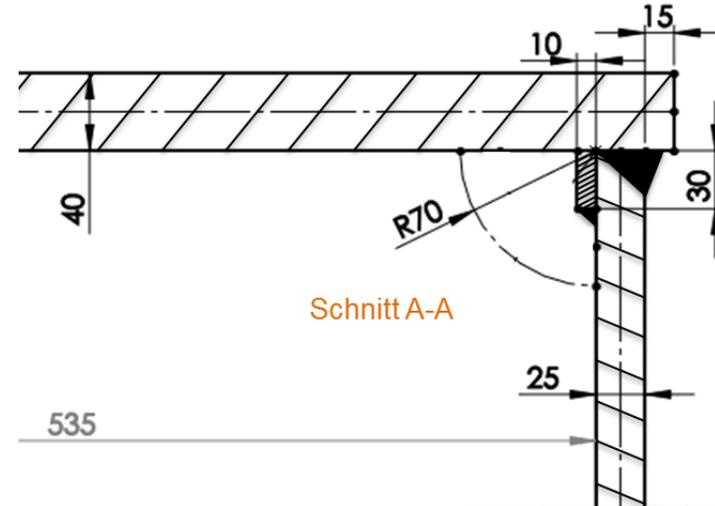
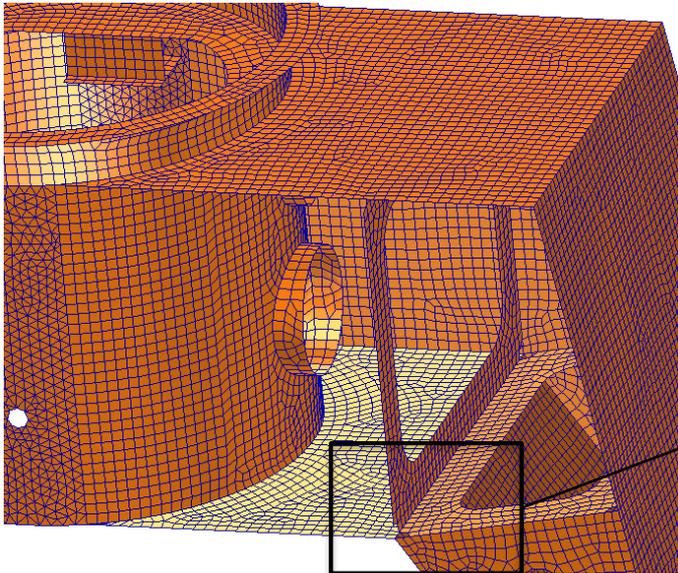
★ LIMIT

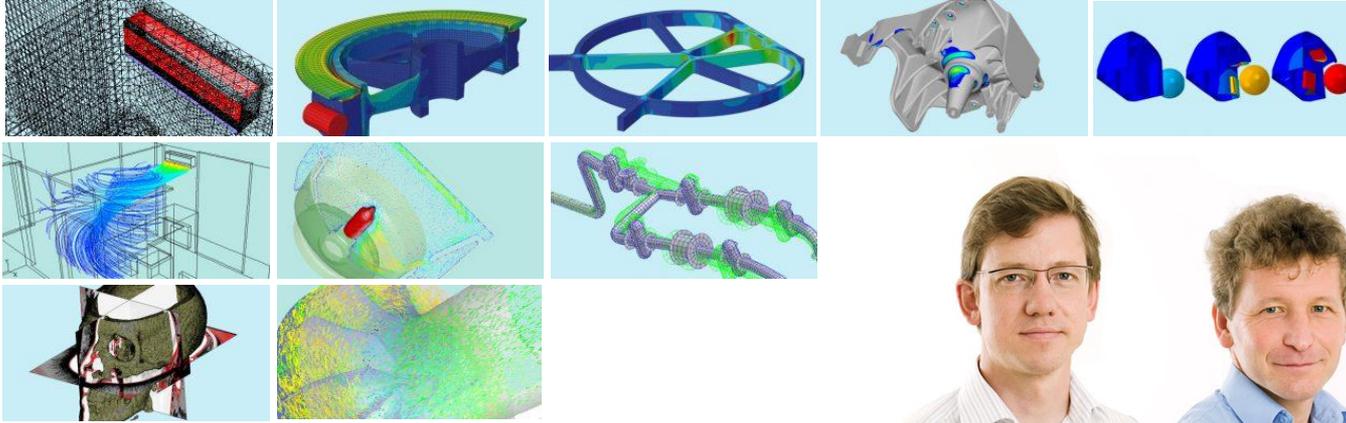
- Method: Ausblick **Smart** Multiedit (3h)
 - Bestimmung der relevanten Schweißnähte
 - Automatisierte Erkennung der Nahttypen
 - » Stumpfnah
 - » T-Stoß (Kehlnaht, V-Naht)
 - » Kreuzstoß
 - Normenauswahl
 - » $a = 0.8 \cdot t$
 - » Längs / Quer / Schub



★ NCSP V7d

- Ecken ausschweißen ?!
- Diskussion





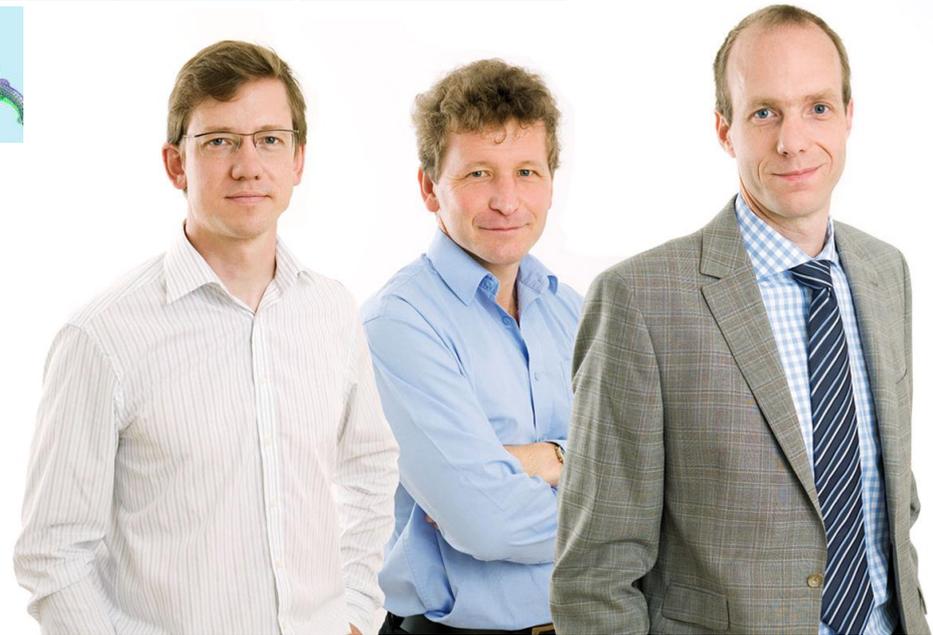
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