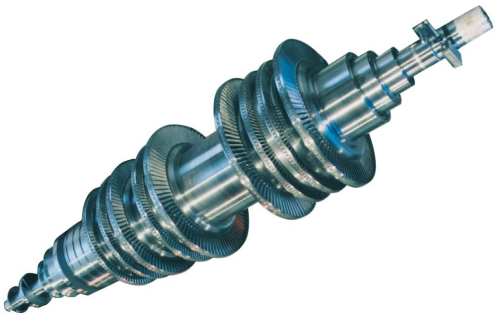
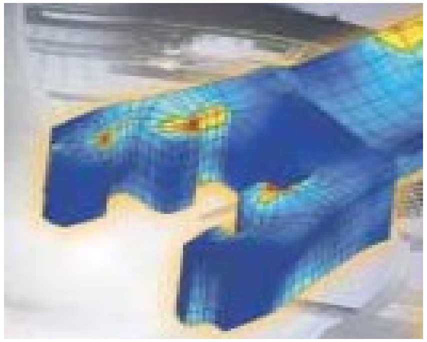




HOW TO DEFINE

INSPECTION PROCESS THROUGH SIMULATION

Background History

Background

- Straddle root blade fitted LP row 1 Komati set 8 & 9
- Straddle root fitted originally

Ingagane 1-5 Komati 4 -5 , Hendrina 1-10

Whilst Komati's blades 8-9 are not identical in length and profile

History

- Komati Unit 8

- 12/81

Row 1 TS 71blades on 303 found broken or cracked

- 07/85

Row 1 TS 18 blades found cracked or broken

History

- Komati 9
- Hendrina

- 07/77
- Row 1 TS 1 blade found cracked

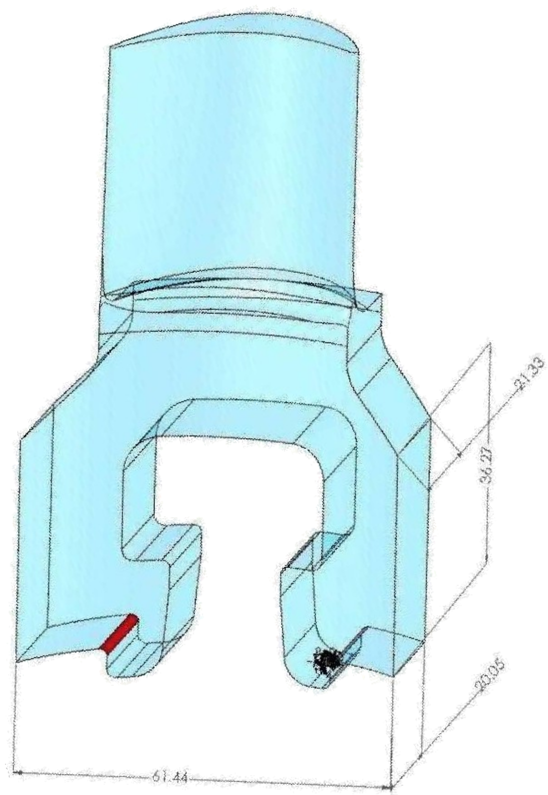
- Mid 1970's LP row 1
- Numerous blades found cracked

History

- Komati 4 ,5
- Ingagane 1 ,2

- LP row 1
- Original Design straddle root has been replaced by pinned root blades integrated to shrouds

Komati 's Design



Cracks Mechanism

Visual examinations

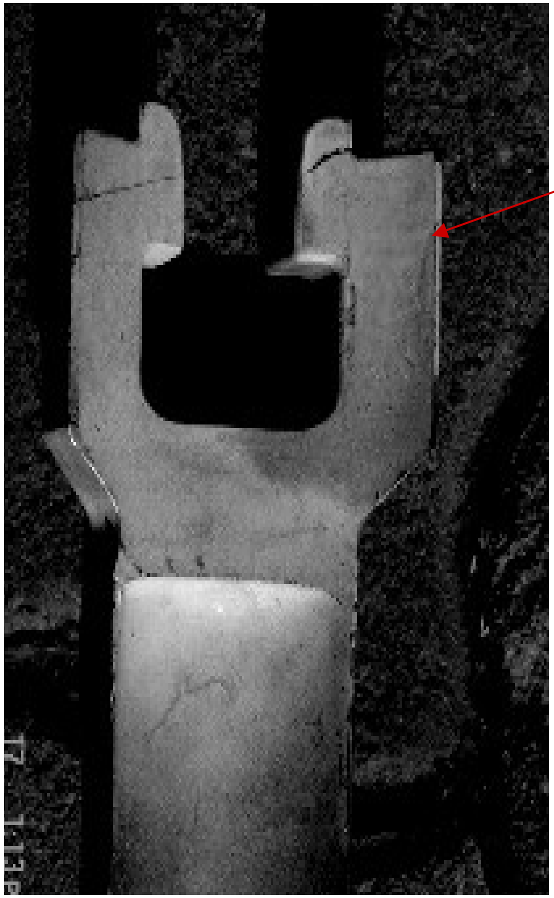
- Magnetic particle examination of blades removed revealed crack location and extent
- Cracks are predominantly located in the fillet between the tenon and arm of straddle

Cracks Mechanism

Physical examinations

- Physical examinations testify that cracks are initiated at the edge of clamp
- Cracks propagate by fatigue action
- Propagation starts Inter-granular propagation becomes trans-granular propagation

Cracks Mechanism



- Cracks detected by MPI
- Starts from fillet growing horizontally +/- 20 °

Cracks Mechanism

Crack causes

- Thermodynamic conditions: saturated steam
- Chemical conditions : polluted steam
- Operating conditions : cyclical load

Stress Corrosion Cracking

Modifications

- Komati 8 -9
- Some modifications of working conditions to improve steam quality
- Changes of design
- Close fittings was reduced from 55 mm to 16 mm leaving clearance +/- 0.3 mm for the remaining part
- On some new blades increasing of height of tenon

Modifications

- Hendrina

Pinned root blades and integral shroud

- Komati 4-5 Ingagane 1-2

Pinned root blades and integral shroud

In-service Results

Komati 8	02/88 Row 1 TS 9 blades broken or cracked
Komati 4 -5 Ingagane 1 -2	Disc cracking problems around pin

Decision to set In-service examination

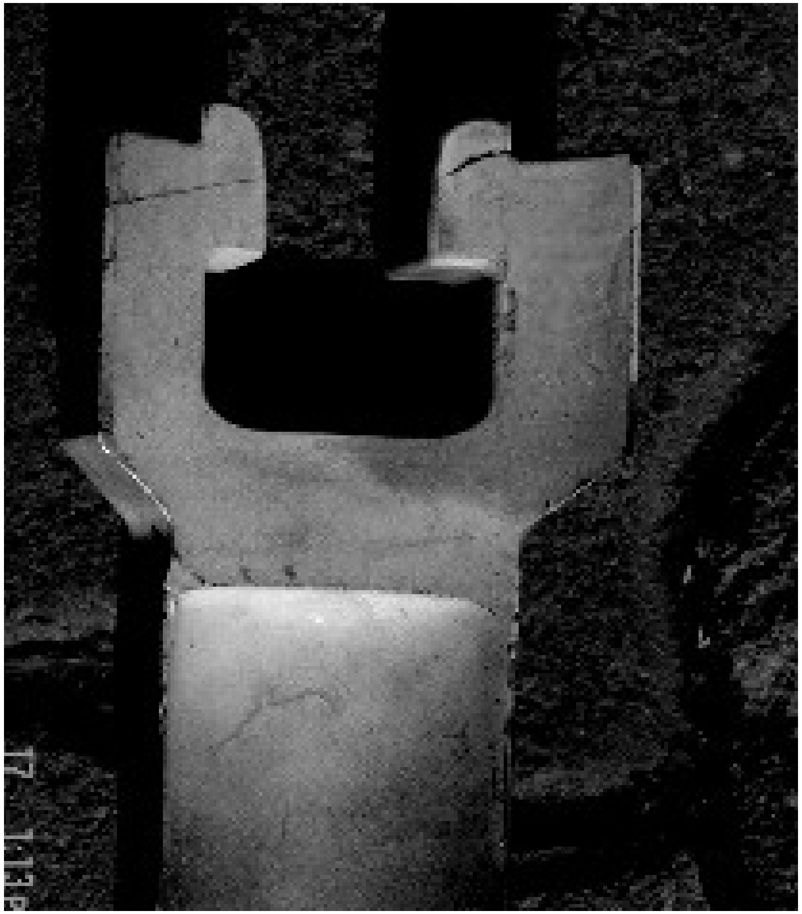
Method

- Method must be able to achieve volumetric examination
- Method must be performed from outer surface of blades
- Method must provide records for further processing through in shortest possible time
- UT seems most efficient and powerful test method

UT examination Hypothesis

General Hypothesis

- Detection and sizing / sizing of changes
- Examinations done in situ
- Geometrical /Mechanical conditions don’t permit usual trials with conventional equipment



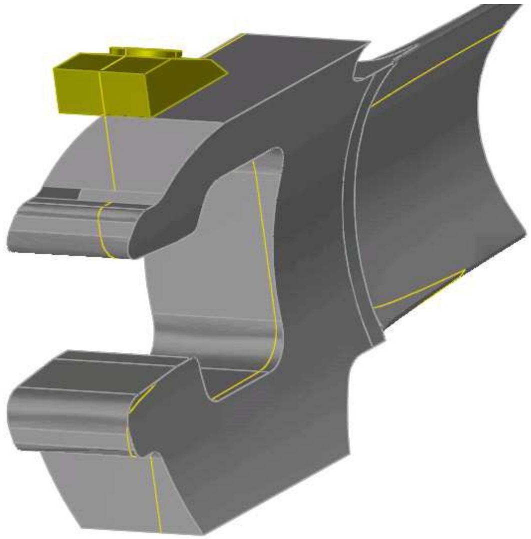
UT examination Hypothesis

Specific Hypothesis

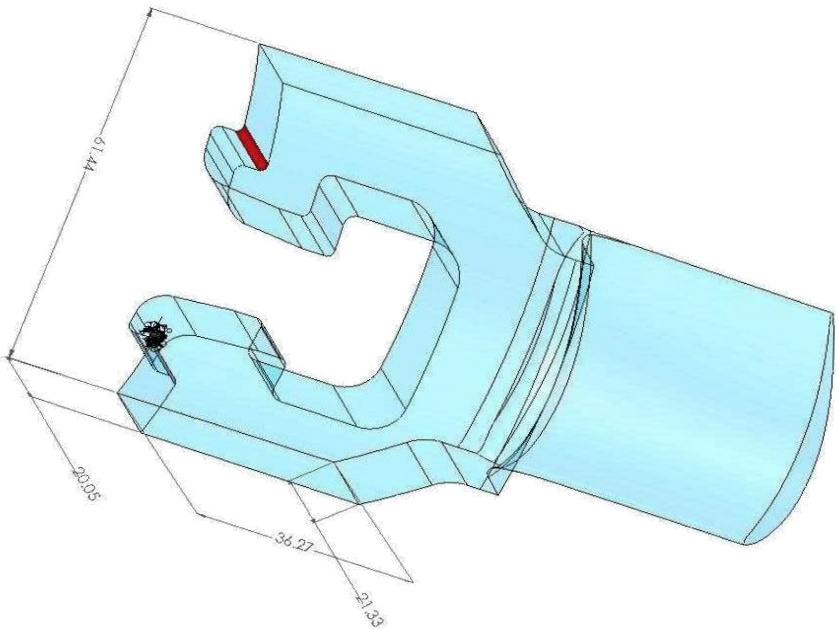
- Cracks initiated in fillet and arm of straddle
- Propagating horizontally +/- 20 °
- Only top surface available 36x20 mm
- Complex shapes

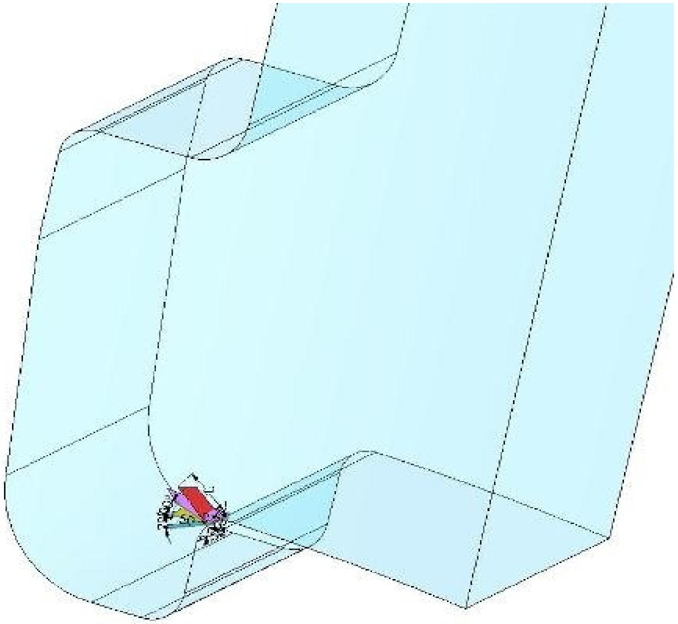
- UT effects : corner trap, specular reflection, diffraction

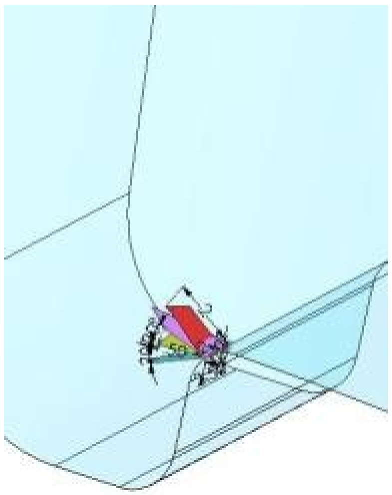
- UT scenario



UT examination
Hypothesis







Studies and Design of processing of examination

due to mechanical conditions , necessity of reliability

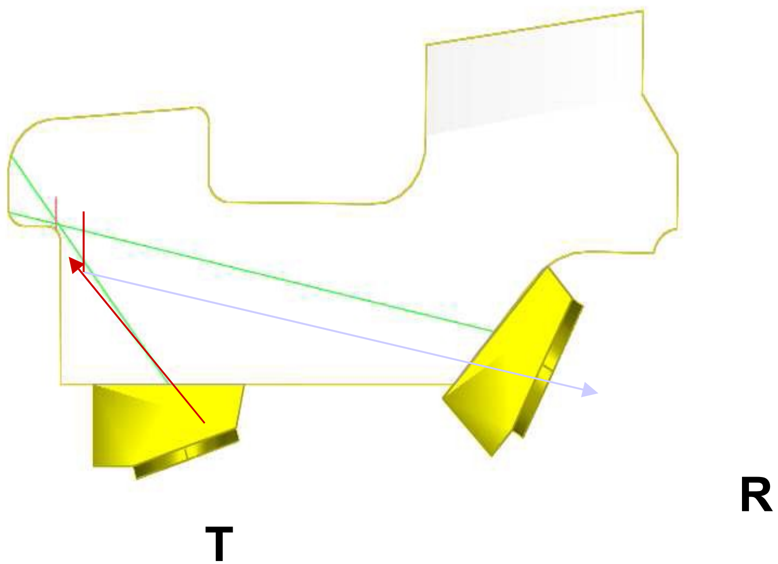
- Simulation will be the basic tool for studies
- Results will be basic lines for Design

- Simulation will be carried out through CIVA's Software facilities

Simulation Hypothesis

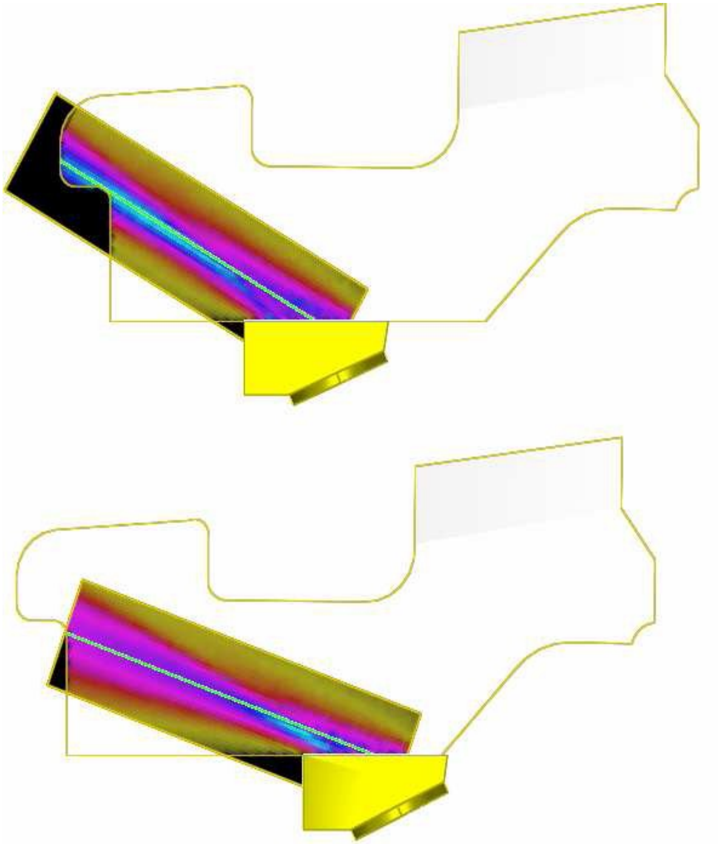
- Simulated configurations
- TOFD backward 1 & 2
- Twin crystal probes
- Phase array probes
- Crystal properties : 6 -7.5 MHz
- Diameter according to more current location of indication
- Reference indication planar 2x2.5 mm
- LW

TOFD backward 1

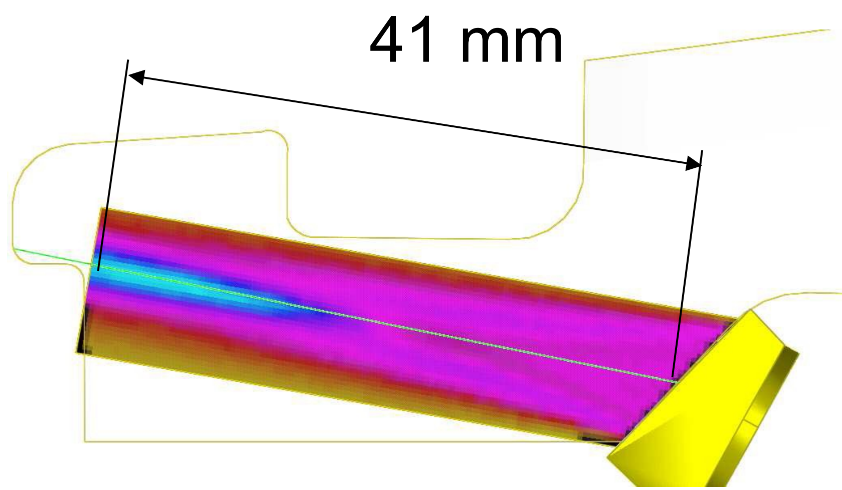


- T moves R fixed
- Ø T 10 mm best average insulation for all positions of probe
- Refracted angle is adjusted as probe location
- Ø R 11,5 mm N0 =41 mm
- Refracted angle 35°

TOFD backward 1



Transmitter acoustic field

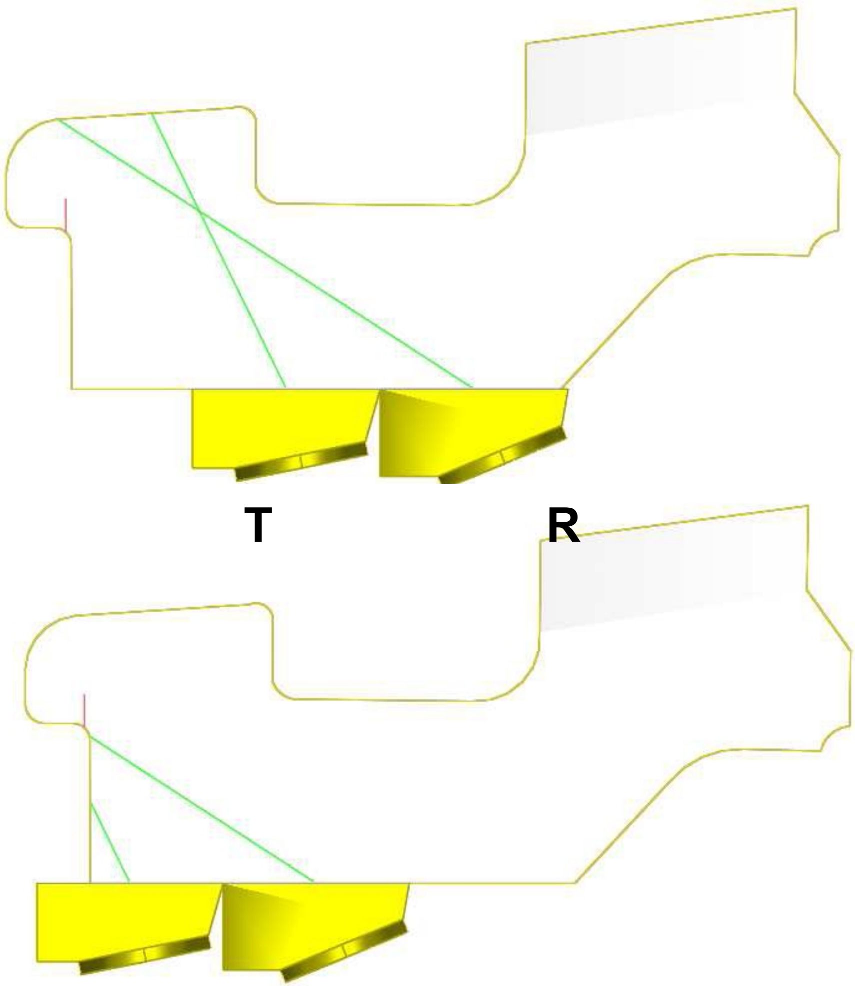


Receiver acoustic field

TOFD backward 1

Transmitter location x mm	Transmitter refracted angle (°)	Maximum amplitude % screen	Effect
5	25 15 10	8 7 4	Diffraction
10	45 40 35	16 17 12	
15	55 50 45	22 24 13	
20	62 59 55	26 29 18	
25	67 64 62	26 28 25	

TOFD backward 2



Transmitter and receiver moves together

Ø T & R 10 mm

T 30 º R 60 º

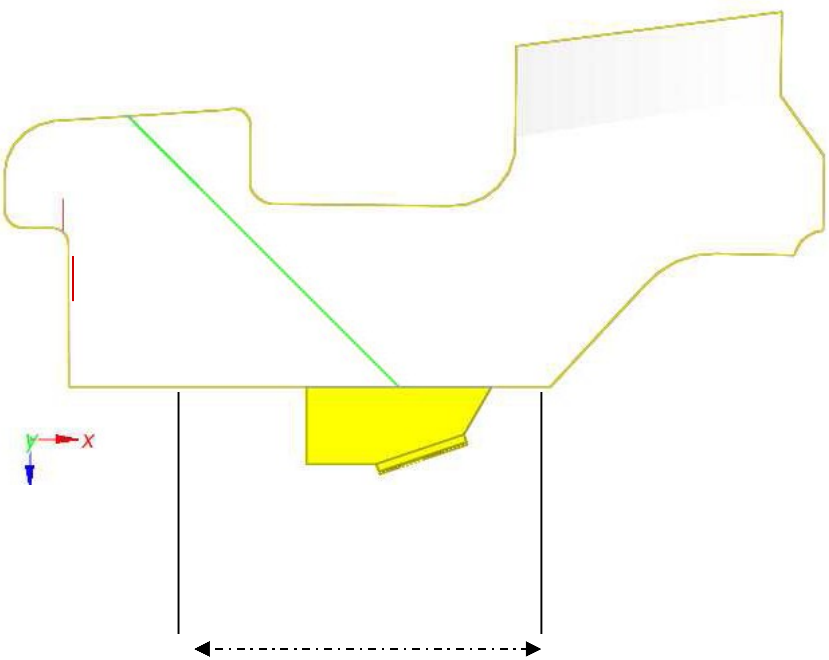
PCS 14 mm

TOFD backward 2

Echo type	Amplitude (% of screen)
Diffraction	8
Specular	weak
Wedge	3.5

For the best position of Probes set

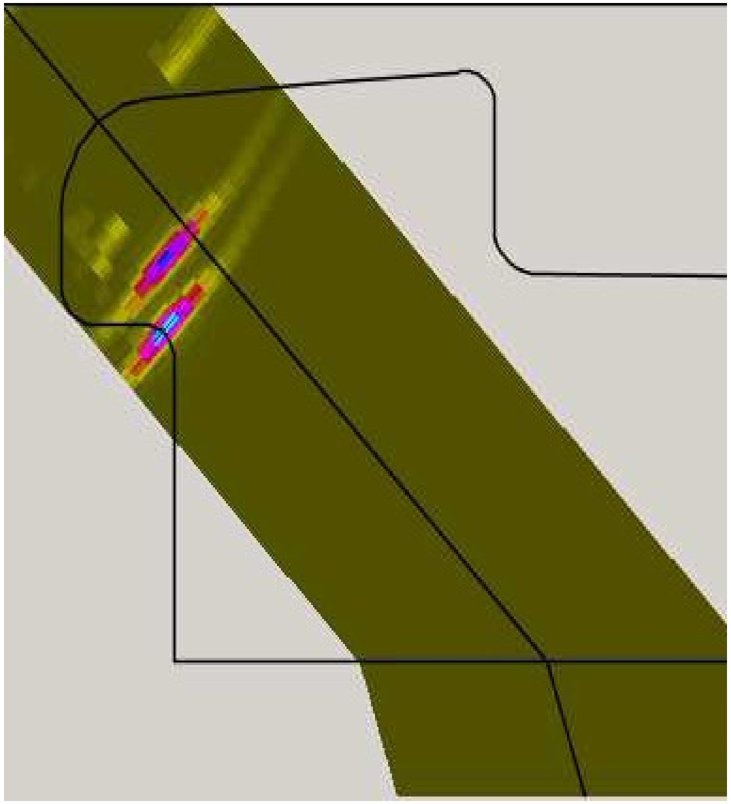
Twin Crystal probes



8 mm to 25 mm

- Twin crystal probes moves on top surface
- Crystal 7x 14 mm
- Focal point 15 mm
- Refracted angle 45 °

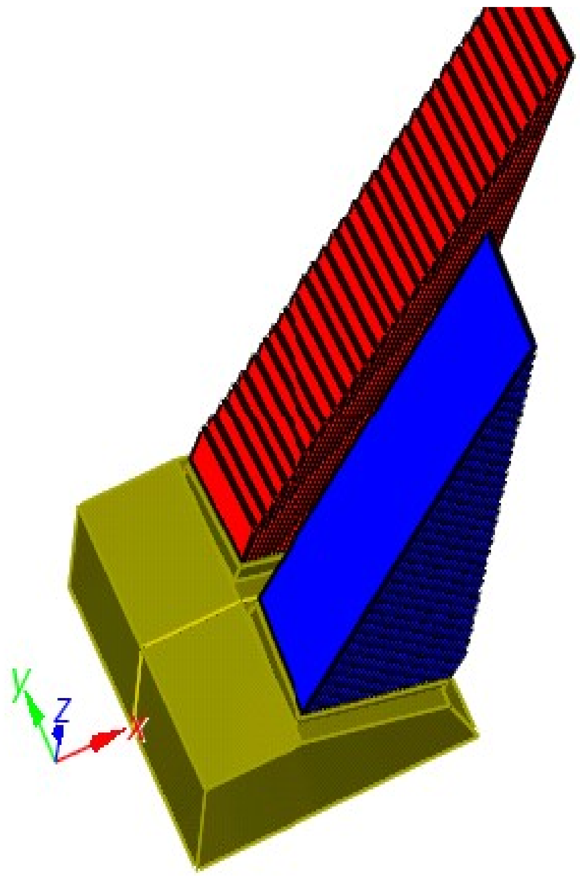
Twin Crystal probes



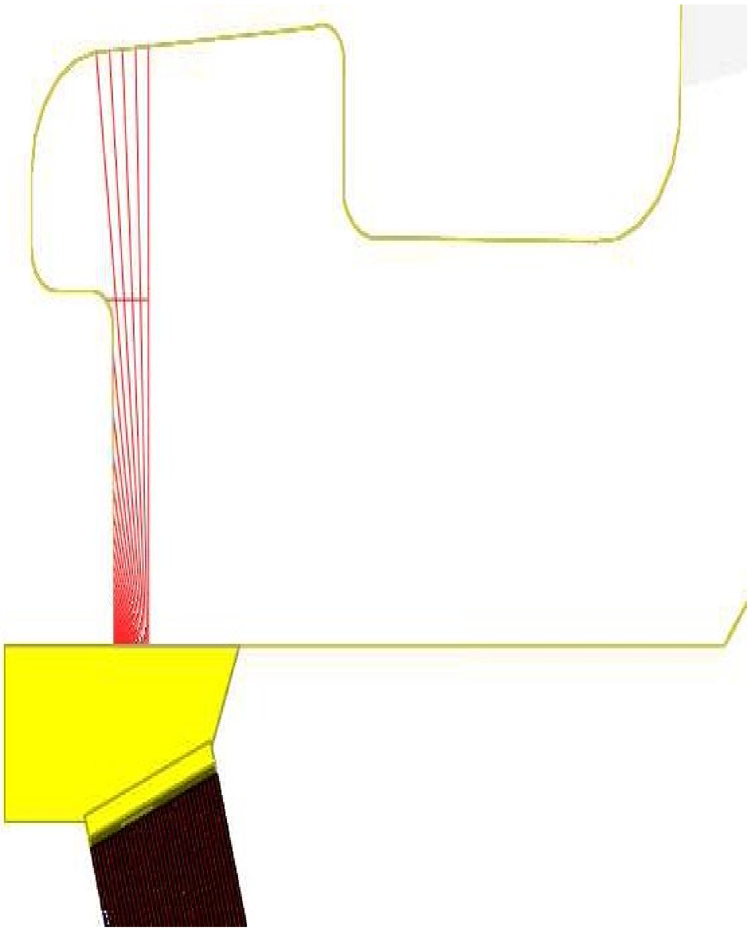
Echo type	Amplitude (% of screen)
Diffraction	5
Specular	weak
Wedge	weak

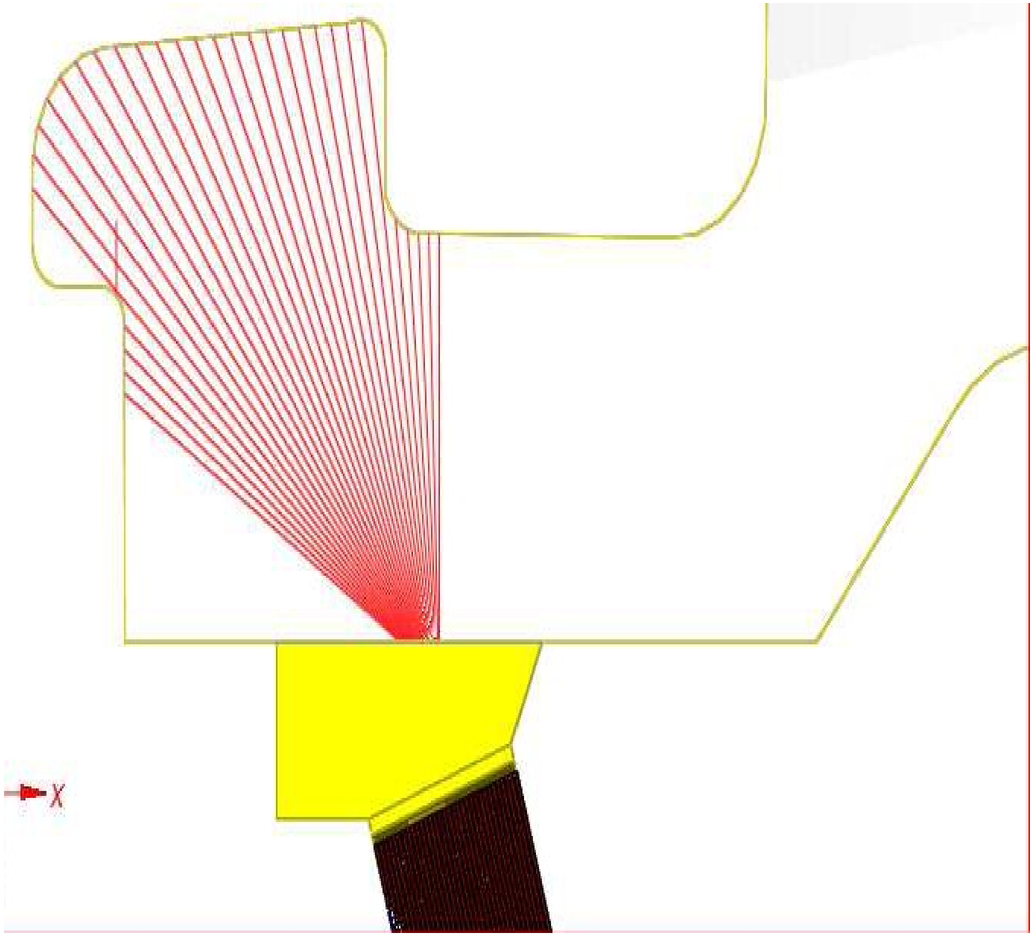
Twin Phase array probe

- Configuration simulation
- Angular deflection 0º to 60º step 2º
- Scanning along to surface
- Two linear array 32 elements
- Global size 8 x 5 mm



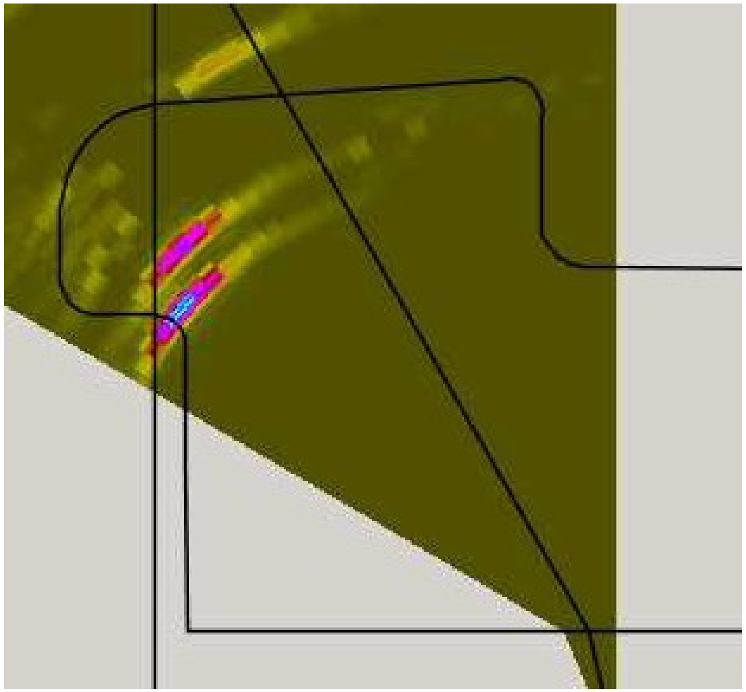
Twin Phase array probe





Rotek Engineering
A member of the Eskom Group

Twin Phase array probe



Echo type	Amplitude (% of screen)
Diffraction	5
Specular	weak
Wedge	weak

Synthesis for reference indication

Processing	Amplitude (% of screen)	Effect
TOFD backward 1	25 to 28	Diffraction
TOFD backward 2	8	Diffraction
DUAL probe	5	Diffraction
Twin Phase array	5	Diffraction

Conclusions of Simulation

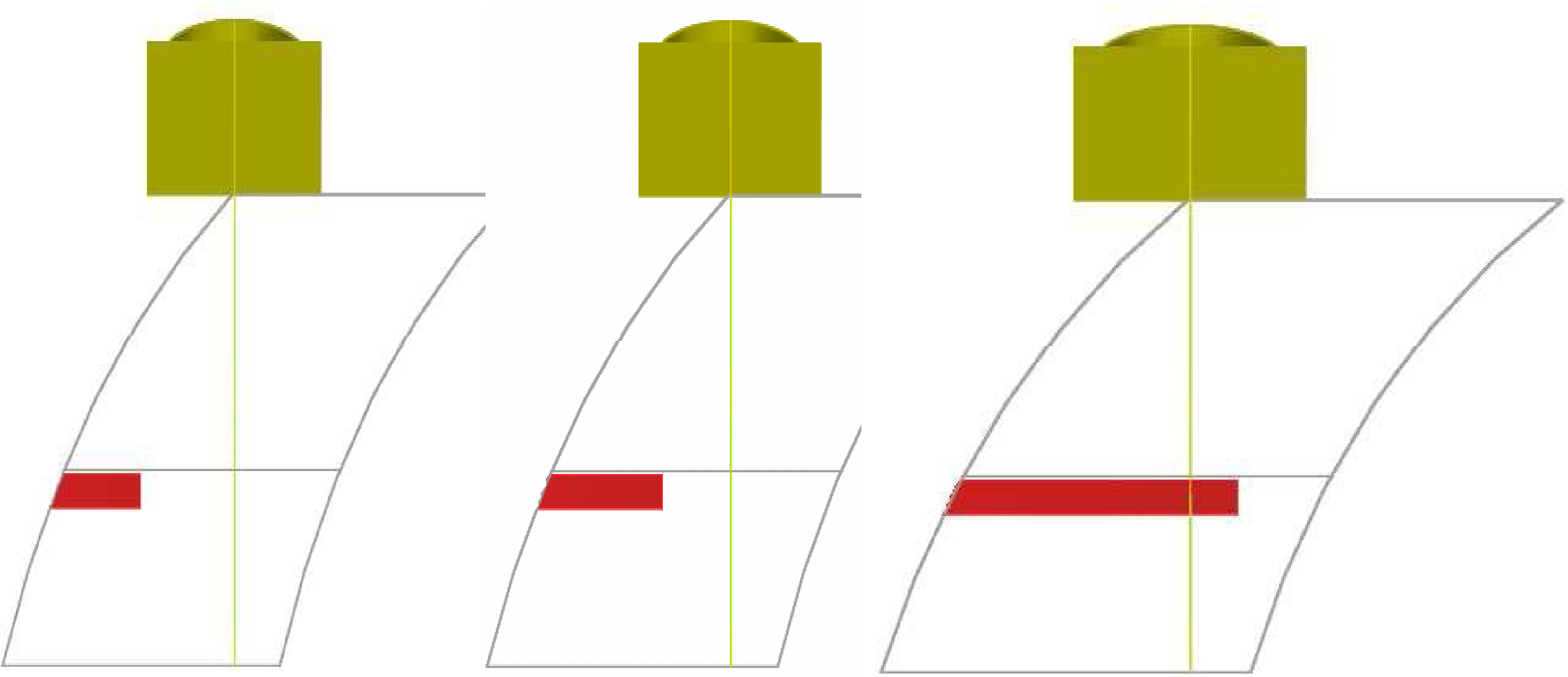
- For main orientation of probable crack Diffraction is on tip of crack is principal effect to detect and size
- TOFD backward 1 seems more efficient
- Essential variables are defined
- Size and kind of probes ,Refracted angles
- PCS , windows of data acquisitions

Shadow effect

- Inlet and outlet side are curved and intersect beam inducing blind area
- Evaluation is done with transmitter close to inlet side for indication starting from inlet side
- Beam is similar to beam of used transmitter TOFD

- 7,5 MHz Ø 10 mm refracted 45 °

Shadow effect



Scenario following different lengths 5 to 19 mm

Shadow effect

- Simulation according to response of each indication for seated probe on inlet side as demonstrated
- Sensitivity is not the same at constant gain
- At constant gain limit of detection:
  - Inlet side 12 mm
  - Outlet side 2 mm
- Increasing sensitivity needs Gain compensation

C onclusion