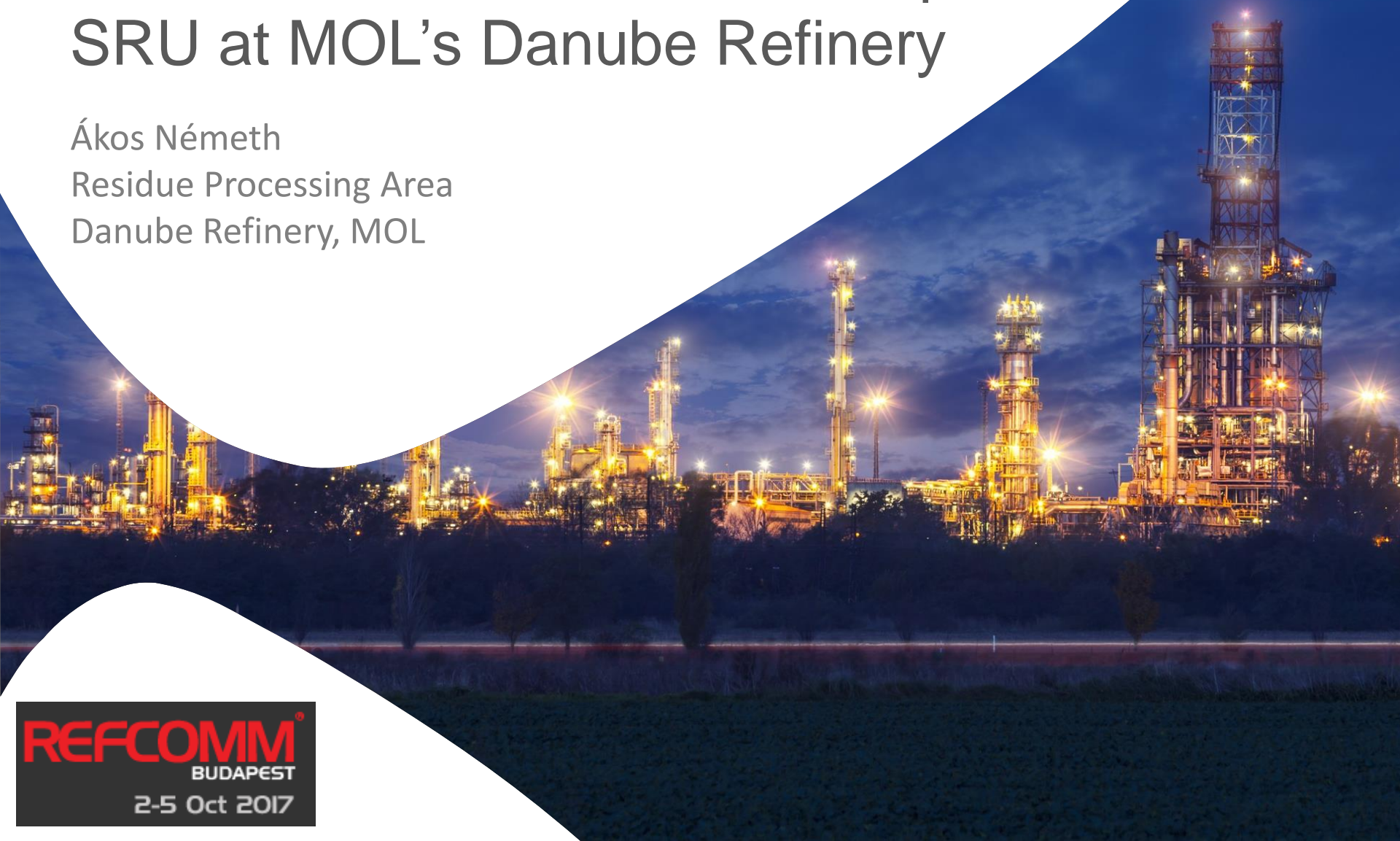


Root cause analysis and successful modifications to eliminate hot spots in SRU at MOL's Danube Refinery

Ákos Németh
Residue Processing Area
Danube Refinery, MOL



SRU units

	SRU4	SRU5	SRU6
Startup	1992	2000	2007
Capacity	85 t/d	90 t/d	90 t/d
Feed	AAG: amine acid gas SWS: Sour water stripper gas	AAG: amine acid gas SWS: Sour water stripper gas	AAG: amine acid gas SWS: Sour water stripper gas
Steam pressure	18 (14) barg	52 (45) barg	52 (45) barg
Steam temperature	~180°C	263°C	263°C

SRU1,2,4,7 units had shown no problems with bundle walls

SRU3,5,6 units developed serious problems within short operation times

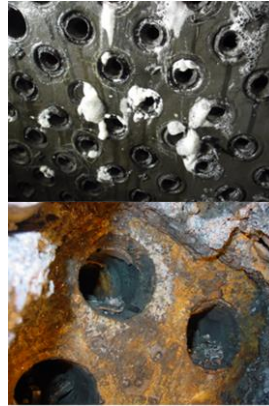


Timeline

SRU5
Check-
up: no
problem

SRU5
Water
flooding

- Bundle
replacement



SRU5
Check-
up:
broken
ferrules



2006

2007

2008

2011

2011

2012

SRU6
Startup



SRU6
Water
flooding

- Bundle
replacement



SRU6
Check-
up:
broken
ferrules



Damage details: SRU5 unit



Refractory wall separated from bundle wall



Large percentage of ceramic ferrules were broken or cracked



Outlet bundle wall intact



Refractory wall support pins corroded away



Bundle wall and tube weldings corroded



Tube endings funnelled in, thinned around the ending



More than 57 leaking welding



Repairs of SRU5 unit (2008)

Bundle lining was replaced according original design

Inlet side bundle wall was replaced

Ceramic ferrules and refractory wall were replaced according original design

Refractory wall support pins were modified



Damage details: SRU6 unit (2011)



Refractory wall separated from bundle wall



Large percentage of ceramic ferrules were broken or cracked



Refractory wall support pins burned away



Outlet bundle wall was intact



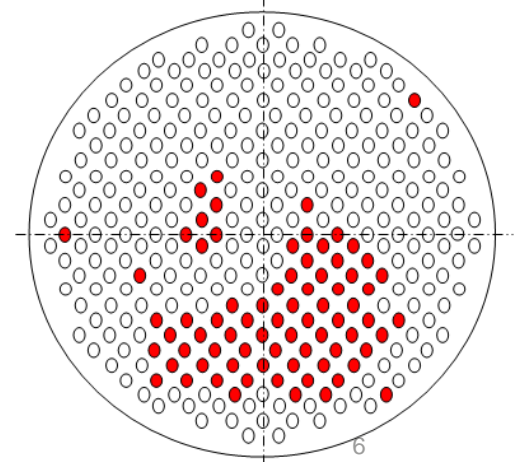
Bundle wall and line endings were corroded



Tube inlets were funnelled, thinned around the weldings



More than 75 inlets leaked at low pressure testing, replacement needed



Damage investigation

Possible damage mechanism:

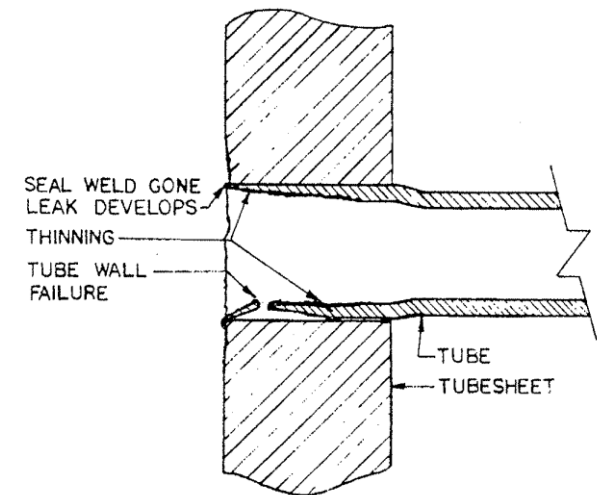
- High temperature S-corrosion damages overheated areas like bundle wall and tube inlets and weldings (high prob.)
- Acid dew corrosion during S/U and S/D. (low prob.)

Possible counteractions

- Cr alloy materials instead of carbon steel
- Reducing surface temperature
 - Lower bundle wall thickness
 - Reduced welding distance from feed water
- Prevent ferrule and refractory wall cracks, protecting the less cooled areas from high S gases

FIGURE 2

TYPICAL TUBE END DETERIORATION AND FAILURES



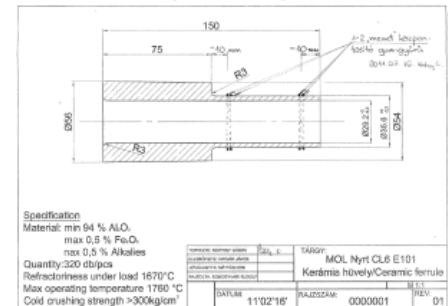
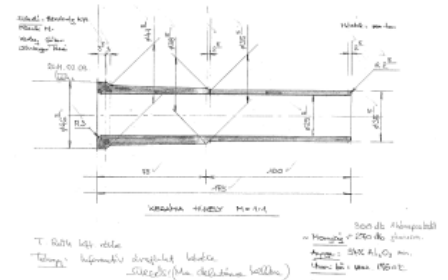
Repairs and modifications: SRU6 unit (2011)

Bundle lining replaced according original design

Tube ending welds were modified for better cooling

Ceramic ferrules were changed to more robust type, refractory wall remained original design

2012: Ferrules were coated with thick heat-resistant fibre insulation to avoid stress fractures due to wall movements



Internal benchmark: Ferrule+Refractory types



Similarities:

- Fix bundle
- Concrete refractory + ceramic ferrules over the bundle wall
- Boiler material quality
- Processing capacity (90 t/d)



Differences

- Inlet side bundle wall thickness



Modifications:

- Additional 5 mm fibre insulation between bundle and refractory walls
- Stronger ferrules and wall support pins, weldings



Results

- Cracked ferrules within a few years of operation
- Beginning or leaking corrosion and funneling



Internal Benchmark: Block ferrules and Other protections



Similarities:

- Fix bundle
- Boiler material quality
- 30 mm bundle walls



Differences

- Tube size and number
- Waterside pressure
- Heat distributor wall



Modifications

- Replacements of ferrules to block type in 2 units



Results

- No breaking or corrosion

Summary

Damage mechanism:

- High temperature S-corrosion at hot parts of the inlet side tube endings

Suggestions:

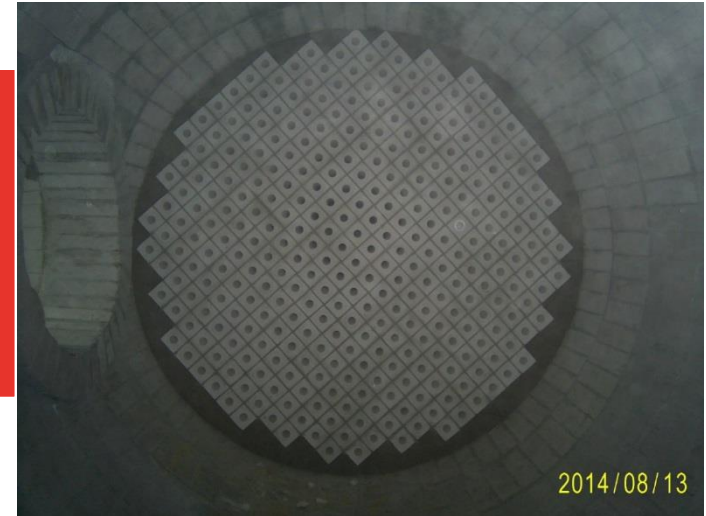
- Thin bundle wall
- Corner of half V welds at tube endings
- Block type ferrules instead of tubular ferrule+refractory wall
- Fibre insulation coated ferrules
- Heat distributor wall (optional)



Results



2 SRU unit modified during 2014-2015



Modifications:

- Bundle wall replaced (35 mm)
- Bundle lines replaced
- Tube weldings: corner welds
- Refractory+ferrules replaced by block type ferrules
- Heat distributor wall deemed unnecessary.



Testing:

- 2017 check-up found 2 cracked ferrule after extreme testing

