Furan-Phenol Hybrid Resin

A choice for high-quality castings

2nd South African Metal Casting Conference
WFO Technical Forum 2017

C. Fourberg, Dr. I. Bacanu

HÜTTENES-ALBERTUS

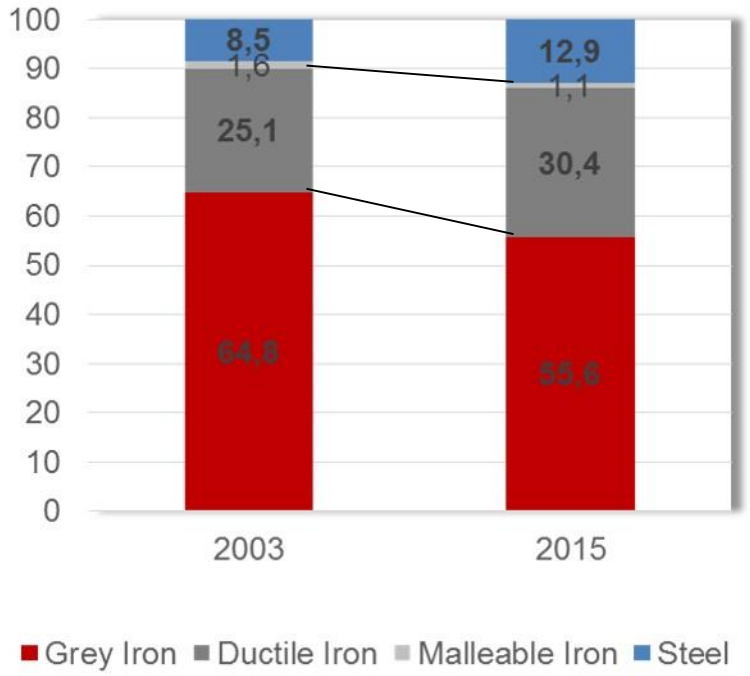
Agenda

- Market Needs and Trends
- Development of Specific Materials
- Chemistry behind Solution
- Overview & Comparison of Resin Types Hybrid versus Classics
- Success Stories in Ductile Iron & Steel Castings
- Review & Preview

Market Needs and Trends

- Focus of last 15 years: environmentally and economically solutions for foundries
- There are multiple ways to fulfil these requirements, but for binders and binding technologies, the following characteristics are decisive:
  - low addition rates
  - low (less) emissions
  - comfortable application range
  - economical advantages
- Modern Furan-Phenol Hybrid binders represent reliable alternatives, being suited for the manufacture of moulds and cores designed for the production of advanced ductile iron castings, but also for high-quality steel castings.

Market Needs and Trends



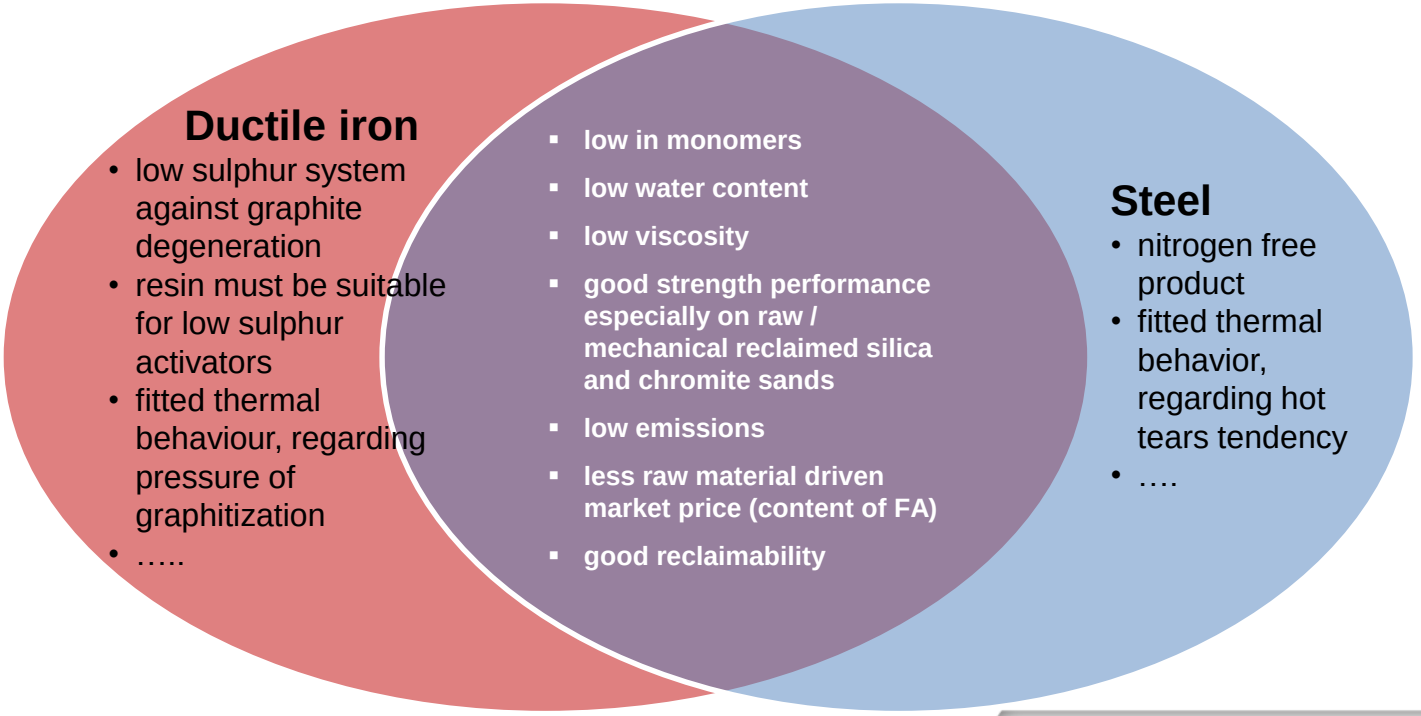
Total Iron castings worldwide

2003: 61.787.384 tons total
--------15.508.633 tons Ductile Iron (GJS)
-------- 7.970.572 tons Steel (GS)

2015: 84.087.077 tons total
--------25.575.894 tons Ductile Iron (GJS)
--------10.886.948 tons Steel (GS)

(source: Modern Casting)

Development of Material Specification



Development of Material Specification

Combine all material needs

↓

Formulation job of a special resin type (“hybrid-family”)

↓

In combination with selected activators

↓

suitable

↙ ↘

Ductile iron Steel

Chemistry

- The hybrid binder systems are connected systems
  - Binder and Activator must fit together
  - Resin is a “high” reactive modified binder (“polymer”) with dominant furan resin character
- The sulphur reduction leads to decreasing of curing power, which is usually coming and controlled by acids used for activators!
- The curing power is shifted to the resin by modification with a special phenolic-FA polymer, called Hybrid FR/PR or PRFuran
- The product formulation is designed to achieve a curing development analogues to classics (85% FA) and better
- Blending of classic PR and FA doesn’t work!

Chemistry

- Cold blended furans

  A + B + C + D → A + B + C + D

- Condensed Hybrid PRFuran (Hybrid FR/PR)

  A + B + C + D → E + F + G +……+ excess A

  E = ABCD

  F = ABCDA

  G =ABCDABCD……etc

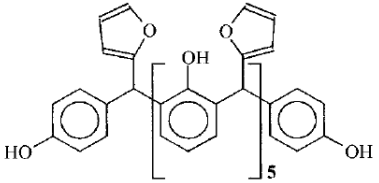
Diversity & Functionality
- performance -

Performance is controlled by resin and not by content of furfurylalcohol

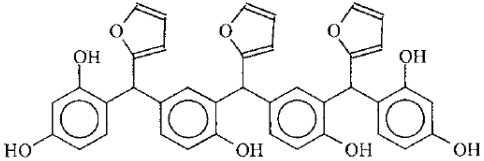
Term „polymer“ → „poly“ - many

Chemistry

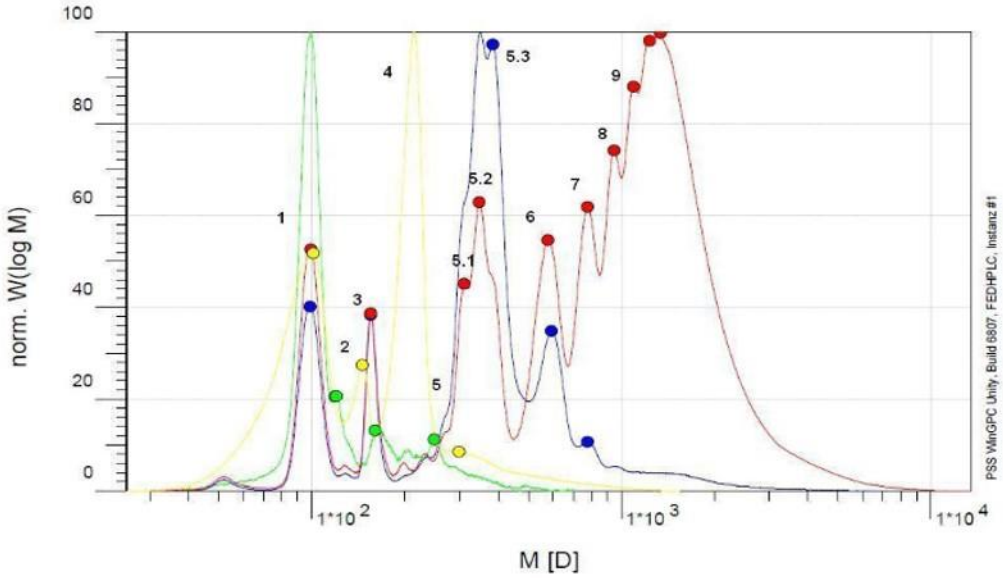
Sample of structure for Hybrid FR / PR



The type of PFuran (1134 Da) and PRFuran (650 Da) species present are:



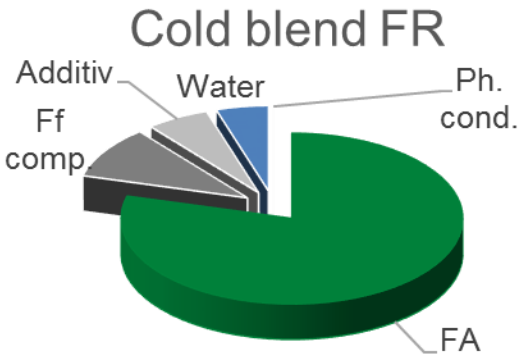
650 Da

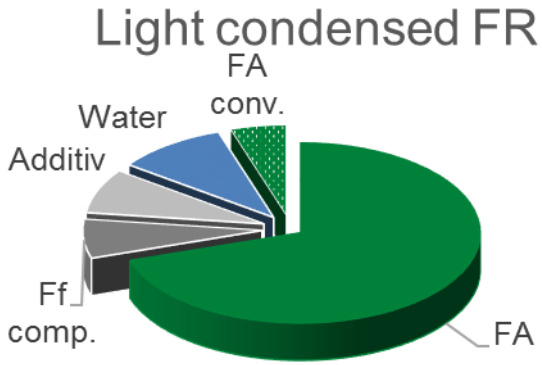


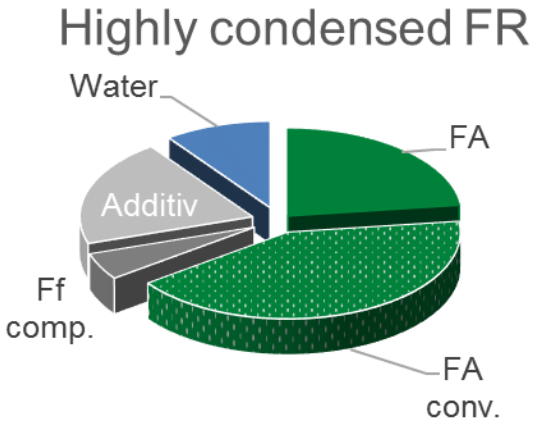
Kurve 1 :	N10050;	---------- Example for cold blended furan
Kurve 2 :	N 10240;	---- Examples for hybrids
Kurve 3 :	N 10241;	
Kurve 4 :	9827;	

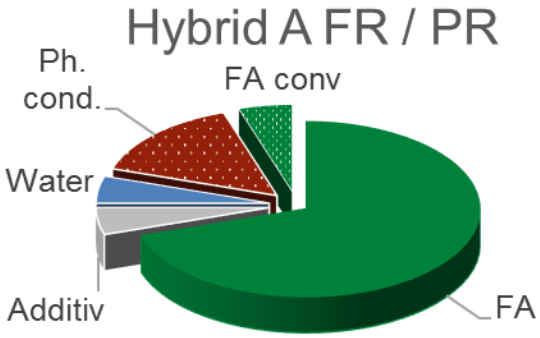
Examples of identified structure of Hybrid PFuran & PRFuran by Maldi-Tof and 13C NMR (Journal of Applied Polymer Science, Vol. 92 (2004)

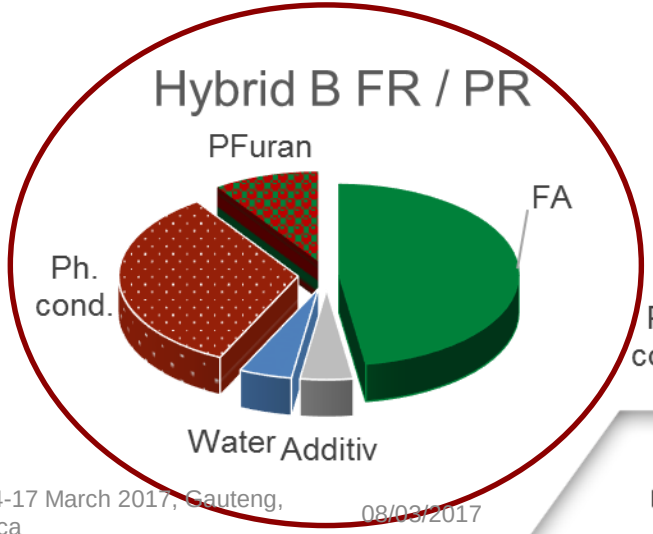
Overview of Resin Types (simplified)

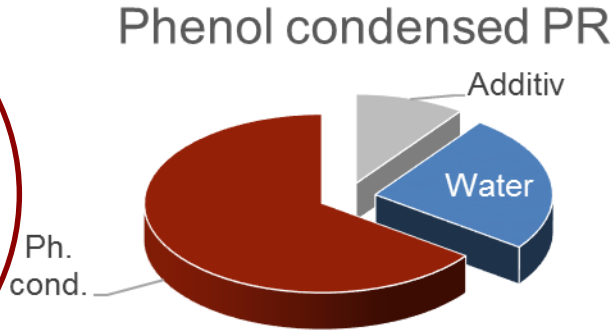




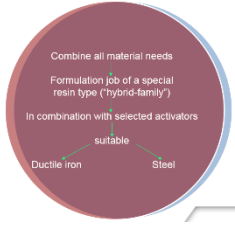






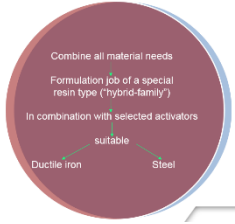


Comparison of Hybrids versus Classics



	Resin for ductile iron	Hybrid FR / PR Type: Kaltharz 8500	Resin for steel castings
Density	1,16 g/cm³	1,18 g/cm³	1,13 g/cm³
Viscosity	15 – 25 mPa*s	30 – 70 mPa*s	5 – 15 mPa*s
Free Formaldehyde	0,1 – 0,3%	0,1 – 0,2%	0,1 – 0,3%
Furfurylalcohol	75 – 85%	55 – 57%	≥ 85%
Nitrogen	≤ 4%	0%	≤ 1%
Water content	≤ 10%	< 10%	6 – 10%

Comparison of Hybrids versus Classics



Ductile Iron

Classic activators:
Sulphur content **12-15%**
Free sulphuric acid up to **3%**
Phosphoric acid presence possible

Sulphur reduced activators:
Sulphur is between **5-8%**
Free sulphuric acid below **0,3%**
No Phosphoric acid needed

Steel

Classic activators:
Sulphur content **12-15%**
Free sulphuric acid up to **3%**

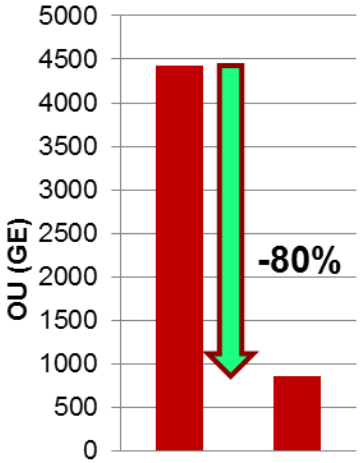
Sulphur reduced activators:
Sulphur could be lowered **10%**
Free sulphuric acid below **0,3%**

Hybrid
Kaltharz 8500

Comparison of Hybrids versus Classics

Parameter odour emission

- Detecting of smell/odour in olfactometrically odour units



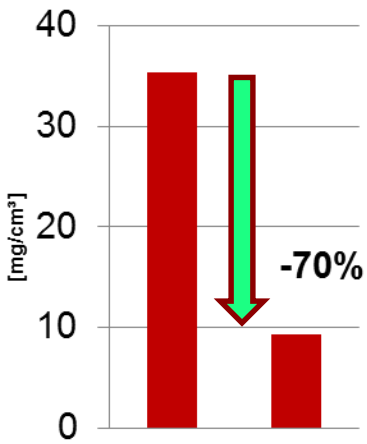
	Odorimetry evaluation [GE]
1. Measurement (standard system)	
No 1-4	**4430**
2. Measurement (Kaltharz 7830/ Activator 7674)	
No 1-4	**850**

For each test 4 moulds; new sand and casted without cores.
Binder addition was: 0.4% Activator / 0.8% Resin
Measuring position: exhaust pipe
Measurement period: 3,10, 20 and 30 minutes after casting

Comparison of Hybrids versus Classics

Parameter SO_2 emission

- Monitoring of SO_2 emissions by selective detection



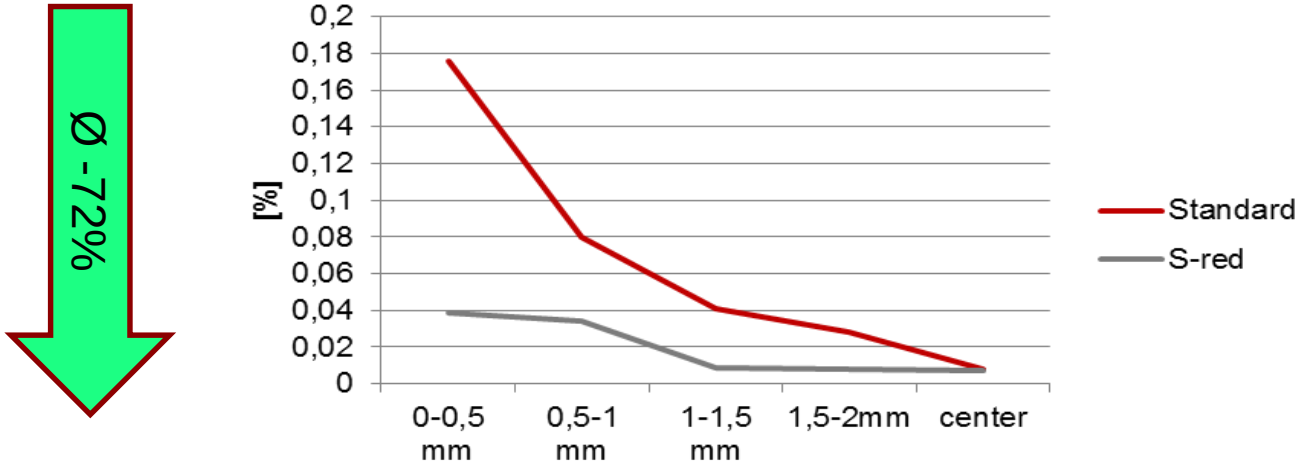
	sulphur dioxide [mg/cm³]
1. Measurement (standard system)	
No 1	**37,7**
No 2	**32,9**
2. Measurement (Kaltharz 7830/ Activator 7674)	
No 1	**8,8**
No 2	**9,9**

Formation of SO_2-emissions (measured by IWL, Hürth)
Both measurements were performed under comparable conditions during casting.
This was approved by the identical amount of total carbon found.

Comparison of Hybrids versus Classics

Parameter Sulphur – from mould/metal interface to centre

- Significant lower sulphur pick up (“casting edge zone”)



Measurements were performed by IFG Düsseldorf on several castings. Each 5 moulds were prepared with the standard system and a hybrid system with sulphur reduced activators. System sand was used

Success Story A (ductile iron)

	Kaltharz 7830	*Kaltharz classic*		Activator 7674	*Activator classic*
Density	1.17 g/ml	*1.15 g/ml*	Density	1.23 g/ml	*1.22 g/ml*
Viscosity	52 mPas	*40 mPas*	Viscosity	25 mPas	*23 mPas*
Free Formaldehyde	≤ 0.03%	*< 0.15%*	Free sulphuric acid	0.25%	*1- 2%*
Furfurylalcohol	80%	*80%*	Total sulphur	6.1%	*12.5%*
Nitrogen	0.9%	*~2%*			

Success Story A (ductile iron)

	Resin (pbw)	*Activator (pbw)*	Bending strength [N/cm²] after 1h	Bending strength [N/cm²] after 2h	Bending strength [N/cm²] after 4h	Bending strength [N/cm²] after 24h
reclaimed sand	7830 0.70%	*7674* *0.30%*	100	130	*160*	*180*
reclaimed sand	7830 0.70%	*8033* *0.30%*	60	75	*125*	*200*

Success Story A (ductile iron)

round no	pH value	*Conductivity [µS/cm]*	Residual acid [mg NaOH/100g]	Nitrogen content [%]	*Sulphur content [%]*
onset	2,6	*1910*	59	0,15	*0,21*
1	2,8	*1180*	58	0,13	*0,14*
2	3,7	*300*	24	0,10	*0,11*
3	3,2	*560*	42	0,09	*0,11*
4	3,2	*700*	61	0,07	*0,1*
5	3,0	*560*	48	0,06	*0,08*
6	3,5	*410*	48	0,07	*0,08*
7	3,4	*350*	40	0,06	*0,08*
8	3,6	*300*	31	0,06	*0,06*

Success Story A (ductile iron)

- The characteristics of the reclaimed sand, especially the sulphur content, were noticeably improved. A better casting surface could be observed.

- The graphite shape in the ductile iron was improved considerably. This allows additionally the replacement of the expensive zircon coating by a silicate coating.

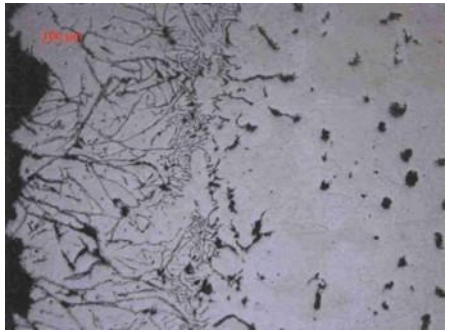
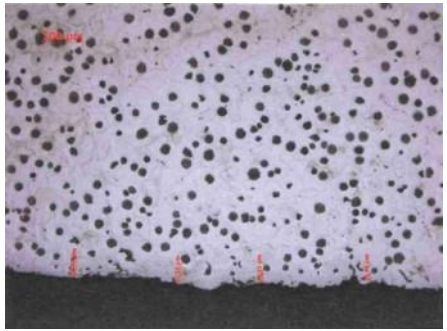


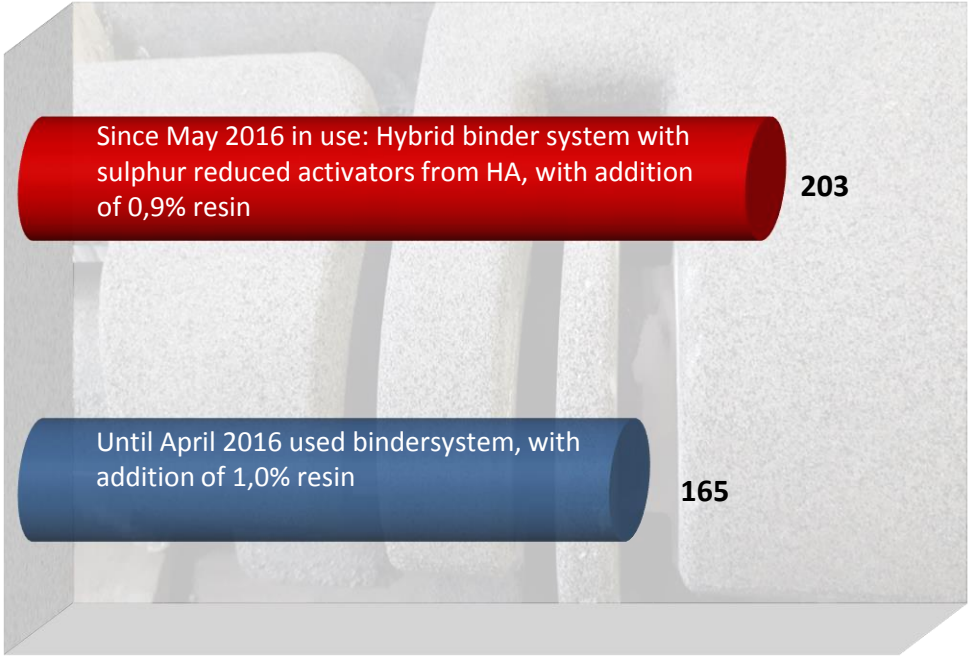
Image 1: Graphite degeneration up to **500 µm** beneath the casting surface when using a classic furan resin system and **zircon coating**.

Image 2: Graphite degeneration up to **100 µm** beneath the casting surface when using a sulphur-reduced furan resin system and a **silicate coating**.



Success Story B (ductile iron)

Approximately Bending strength in N/cm^2 after curing

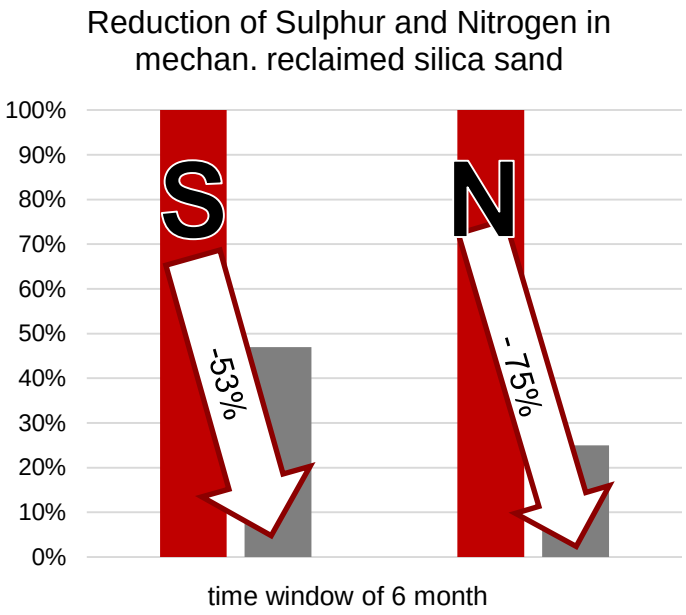


Pump insert parts for heavy water pumps

Marine gear unit GJL 200, weight appr. 19 tons

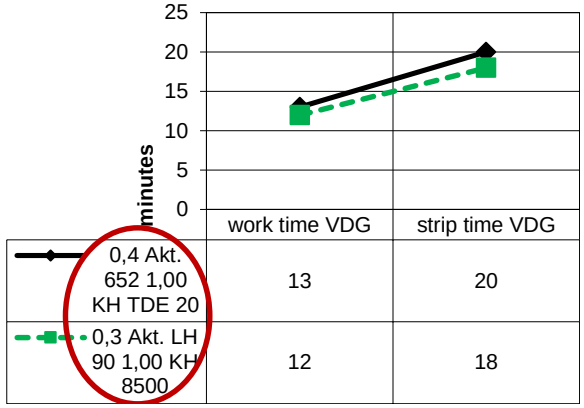
Success Story B (ductile iron)

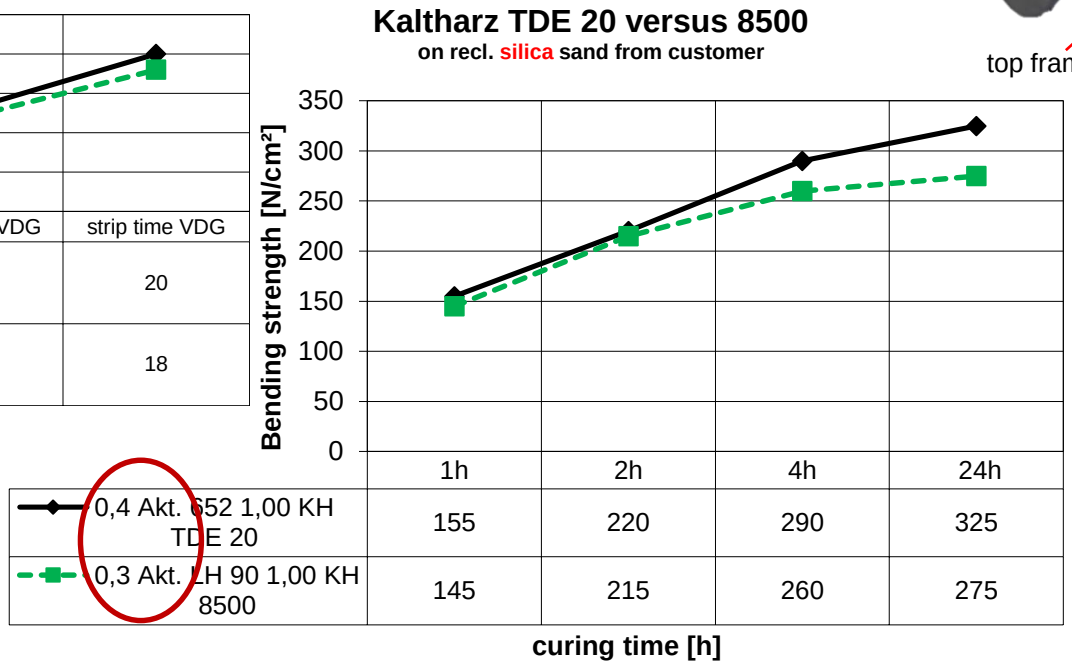
Hcross-beam for a squeezing machine GJS 400-18 highest surface quality

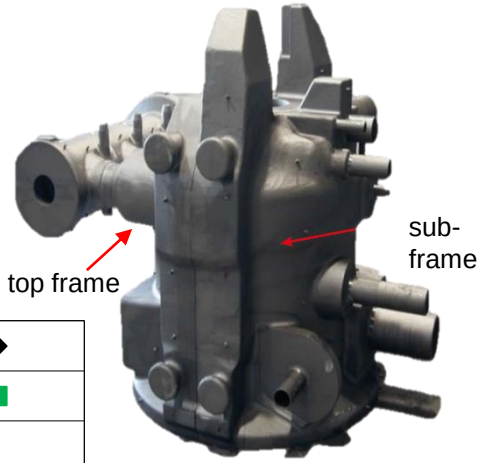


Guide vane housing made of GJS 400, weight appr. 7 tons

Success Story (steel)





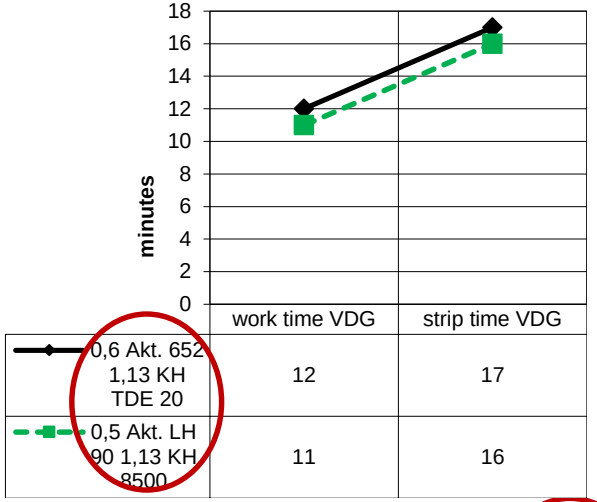


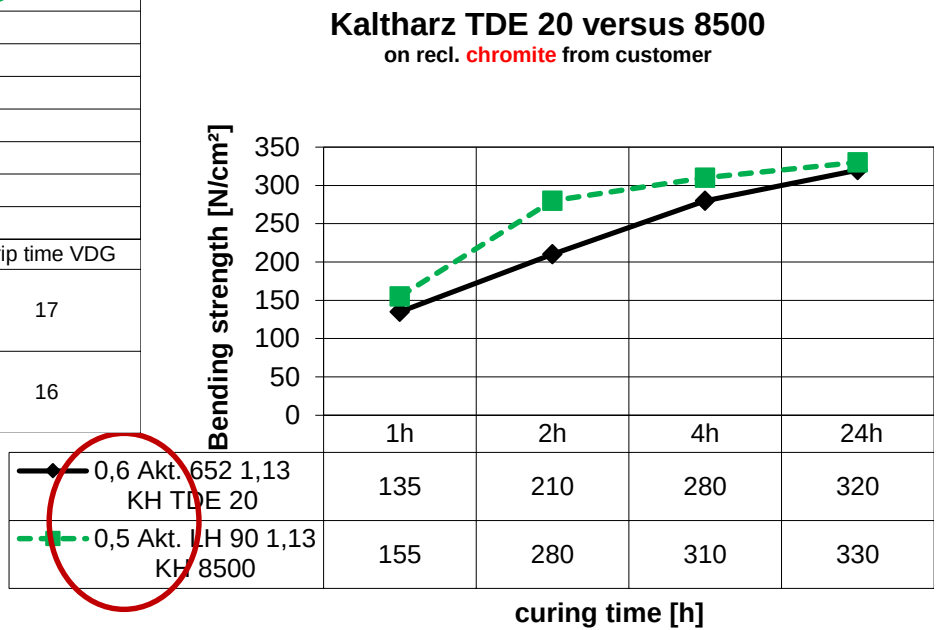
Steam turbine housing
5.2 tons G17CrMoV5-10

- Change from 652 to LH90
- 25% demand on activator

Activator 652	LH90
2% H_2SO_4	< 1% H_2SO_4
14% Sulphur	11% Sulphur

Success Story (steel)





- Change from 652 to LH90
- 16% demand on activator

Activator 652	LH90
2% H_2SO_4	< 1% H_2SO_4
14% Sulphur	11% Sulphur

Review & Preview

- The classic, still valid view on Furan No Bake Systems changes. In the past the quality of a Furan Resin System was driven by the FA content.

  That means high FA > high quality > high productivity > high casting quality

- This changes by considering the new Hybrid Systems because

  Low FA > high quality > higher productivity > higher casting quality

- A Furan No Bake binder is not Furfurylalcohol! A modern Furan No Bake binder is a technological resin.
- Environmentally & technological advantages could be achieved by using Hybrid Systems with connected activators

Review & Preview

- Picking up the perspective as technological resin…
  - Offers the way for tailor made solutions
  - Opens the way for low emissions in future
  - Enables the way for hybridization of organic and inorganic

Thank you for your attention.