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Metallurgical Concept for Maximized Use of Recycled Scrap in the Production of Storage Packages

Wolfgang Kleinkröger, Dr. Dieter Bounin, Siempelkamp Giesserei – Krefeld, Germany
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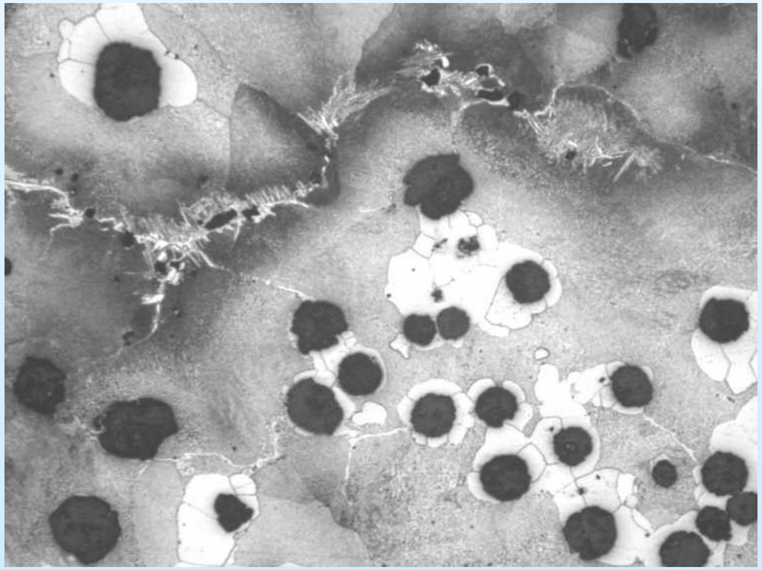
1. Background

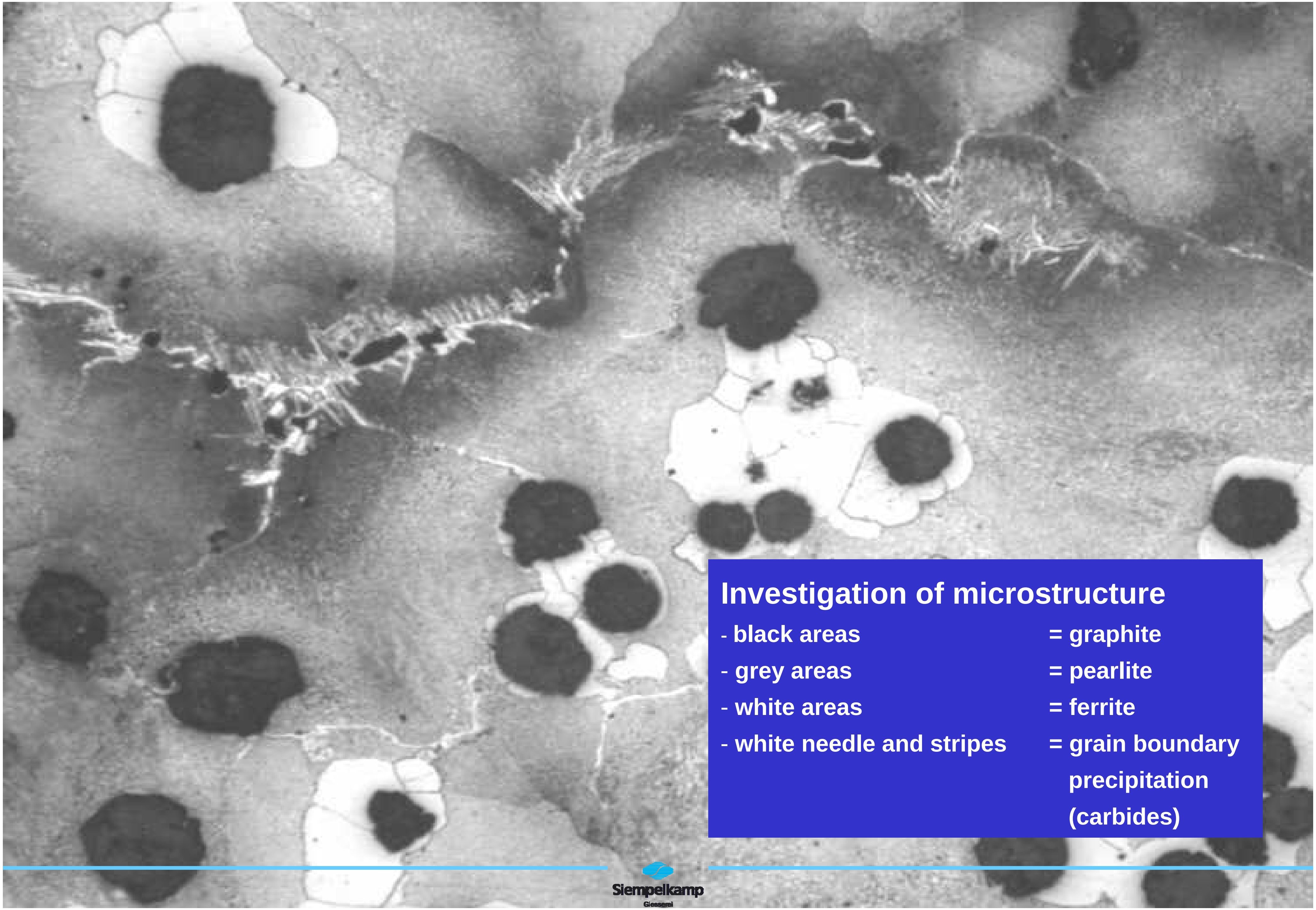
The decommissioning of nuclear plants will in the future increase the amount of metal waste that has to be disposed of. Due to their contamination these wastes cannot be used for conventional, non-nuclear applications. Aside from direct intermediate or final storage there remains the option for recycling the waste metals into other products that remain within the nuclear cycle.

Already now there exists a useful concept for recycling contaminated iron scrap by melting and re-using it for nodular cast iron transport and storage packages. In the melting process the metal fraction is separated from the non-metals (dust and slag). The chemical composition of the blocks of raw metal reflects the great variety of the recycled steels. Depending on their composition the blocks are selected for particular melts. At present the level of recycling is rather limited and the cast iron packages are heat treated in order to obtain a microstructure with the maximum achievable amount of ferrite which raises ductility.

2. Metallurgical Concept

This paper reports about the concept studied in the research program FORM that permits to maximize the recycling content in the packages. The investigation focuses on the quantitative influences of alloying elements from the metal waste on microstructure and material properties of the finished product. With the result, the required material characteristics can be produced by selecting for the charge the proper metal blocks with specific chemical compositions. The usual ferritizing heat treatment for quality adjustment of the casting that increases the cost of present production will no longer be necessary.





Investigation of microstructure

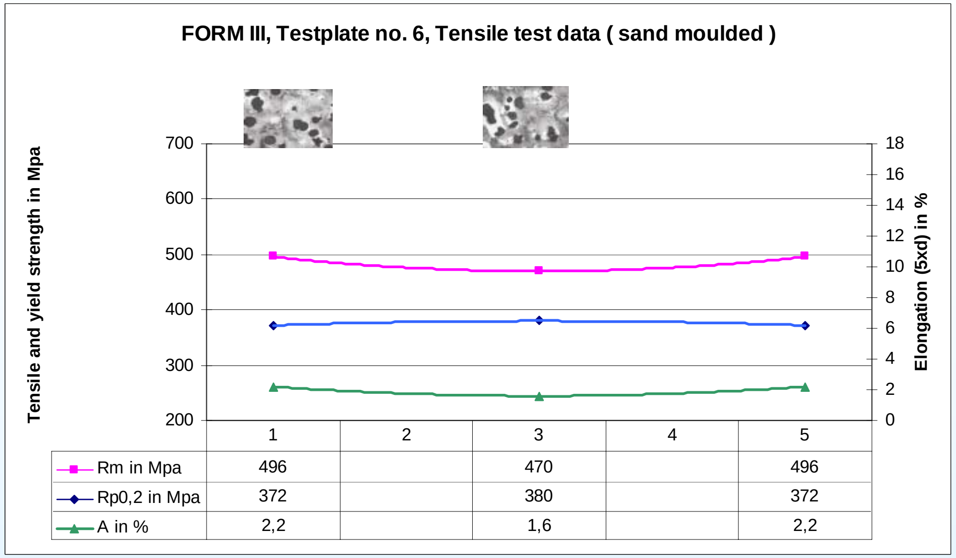
- black areas	= graphite
- grey areas	= pearlite
- white areas	= ferrite
- white needle and stripes	= grain boundary precipitation (carbides)

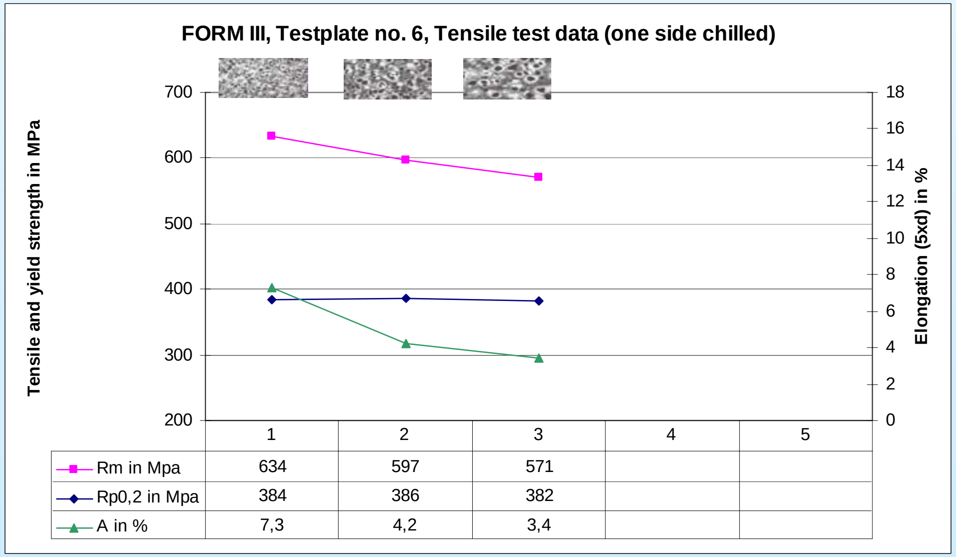
3. Testing

Five selected chemical elements were investigated for their influence on lowering the quality of the iron matrix of nodular cast iron material. These five elements were manganese, copper, nickel, chromium and molybdenum. These elements, which appear in the iron scrap, are responsible for the limits on their use in the charge, i.e. on the recycling level. For establishing the statistical-mathematical relations the design of experiments method (DOE) was applied. The material data was determined on specimens taken from 16 test plates (16 being the number required by DOE for 5 elements) that

had different chemical compositions. One half of each test plate was cast against chills. The 16 test plates thus allowed to also investigate the effect of sand and permanent molds on mechanical properties and microstructure. The specimens were machined from different locations in the 160 mm thick test plates.

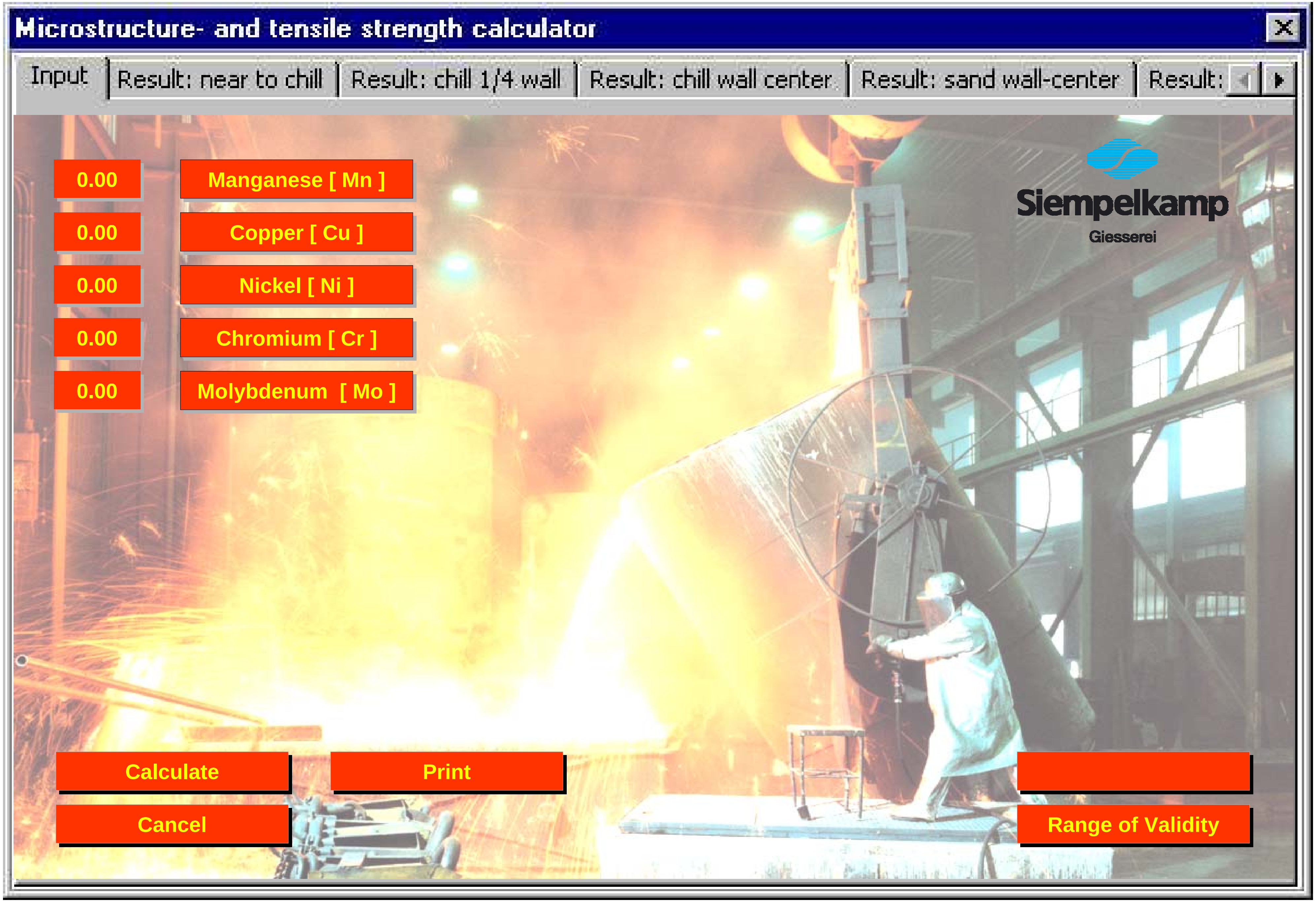
Plate-No.	C [%]	Si [%]	Mn [%]	Cu [%]	Ni [%]	Cr [%]	Mo [%]	Boron
Charge **1**								
2	3,55	2,25	0,25	-	0,50	-	-	10 ppm
3	3,55	2,25	0,80	0,60	0,50	-	-	10 ppm
4	3,55	2,25	0,25	0,60	-	-	-	10 ppm
5	3,55	2,25	0,80	-	-	-	-	10 ppm
Charge **2**								
6	3,55	2,25	0,25	0,60	0,50	-	0,40	10 ppm
7	3,55	2,25	0,25	-	-	-	0,40	10 ppm
8	3,55	2,25	0,80	-	0,50	-	0,40	10 ppm
9	3,55	2,25	0,80	0,60	-	-	0,40	10 ppm
Charge **3**								
10	3,55	2,25	0,80	-	0,50	0,70	-	10 ppm
11	3,55	2,25	0,80	0,60	-	0,70	-	10 ppm
12	3,55	2,25	0,25	0,60	0,50	0,70	-	10 ppm
13	3,55	2,25	0,25	-	-	0,70	-	10 ppm
Charge **4**								
14	3,55	2,25	0,25	0,60	-	0,70	0,40	10 ppm
15	3,55	2,25	0,80	0,60	0,50	0,70	0,40	10 ppm
16	3,55	2,25	0,80	-	-	0,70	0,40	10 ppm
17	3,55	2,25	0,25	-	0,50	0,70	0,40	10 ppm
Plan: Variation of analysis								



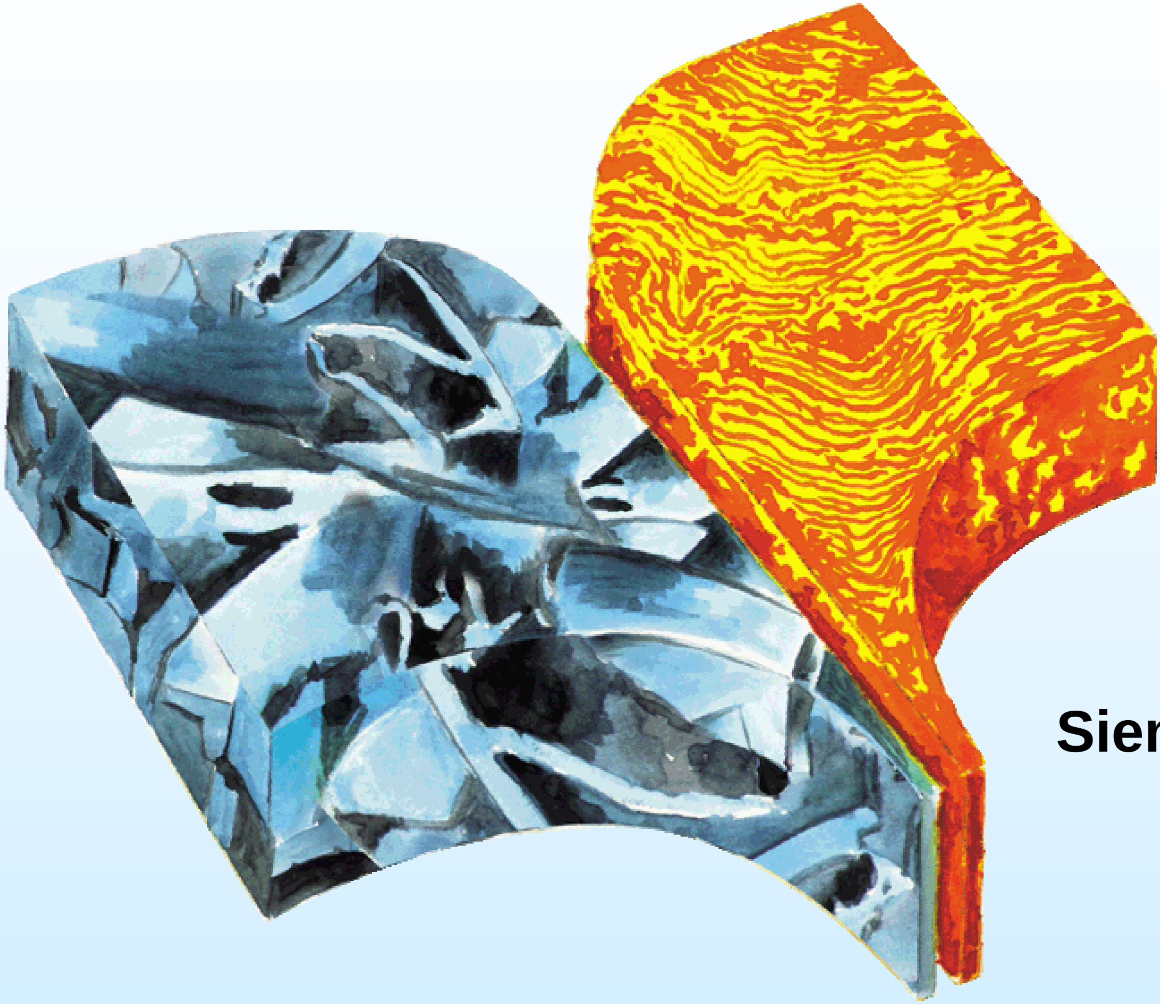


4. Conclusions

The evaluation of the test matrix by regression analysis yields high levels of r-square data for the targets tensile strength, yield strength, elongation and for the microstructure components pearlite and free carbides. For use of the mathematical functions in the quality based production of castings for packages, the equations will be implemented in a charge optimization program. Based on a list with the composition of the recycling blocks on stock, such a program would select the charges for the melting furnace that represent an optimum with respect to the recycling level.



Microstructure- and tensile strength calculator
Input
Result: near to chill
Result: chill 1/4 wall
Result: chill wall center
Result: sand wall-center
Result:
0.00
Manganese [Mn]
0.00
Copper [Cu]
0.00
Nickel [Ni]
0.00
Chromium [Cr]
0.00
Molybdenum [Mo]
Siempelkamp
Giesserei
Calculate
Print
Cancel
Range of Validity



Siempelkamp Giesserei GmbH
Siempelkampstr. 45
47803 Krefeld – Germany
Tel.: 02151 / 894-210
Fax: 02151 / 894 –456
E-mail: giesserei@siempelkamp.com
www.siempelkamp.com