

Valumateriaalien Käyttö Wärtsilässä

Chief Engine Expert, Castings

Material & Tribology

Research & Technology Development

R&D and Engineering

Wärtsilä Marine Solutions

1999 DI Tampereen Teknillinen Yliopisto, Materiaalioppi

2018-2021 TkT Aalto yliopisto, Konetekniikka

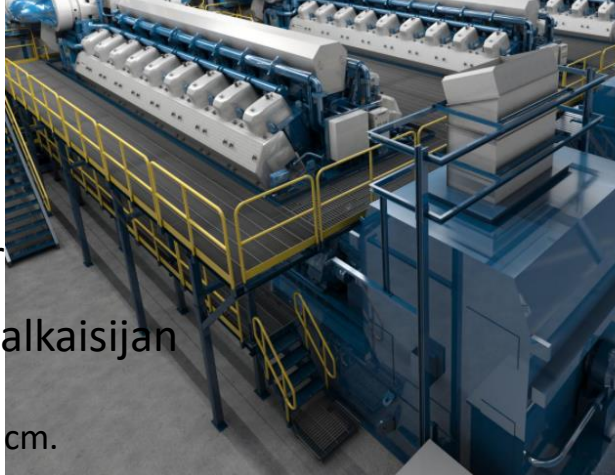
1998-2006 Tutkija Valimoinstituutti, Materiaaliopinlaitos TTY

2006-2012 Senior Foundry Expert, Manufacturing Technology Services/ME Finland

2012-2017 Senior Engine Expert, Power systems....

2017- Chief Engine Expert, Castings, Engines R&D, Marine Solutions Wärtsilä

Wärtsilän moottorit



- Ensimmäinen oma moottori

- Moottorit on nimetty sylinterihalkaisijan mukaan

Esim. W31:n sylinterihalkaisija on 31 cm.

- Nykyinen portfolio: W20, W26, W31, W32, W34,, W46, W50

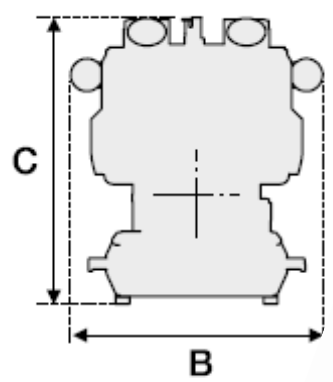
- Rivimoottorit: 4, 6, 8 ja 9 sylinteriä
- V-moottori: 8, 10, 12, 14, 16, 18 ja 20 cyl.


- Portfolion pienin W4L20

4x Ø20 cm sylinteriä
Teho 740 kW
Paino 7200 kg

- Suurin moottori W18V50

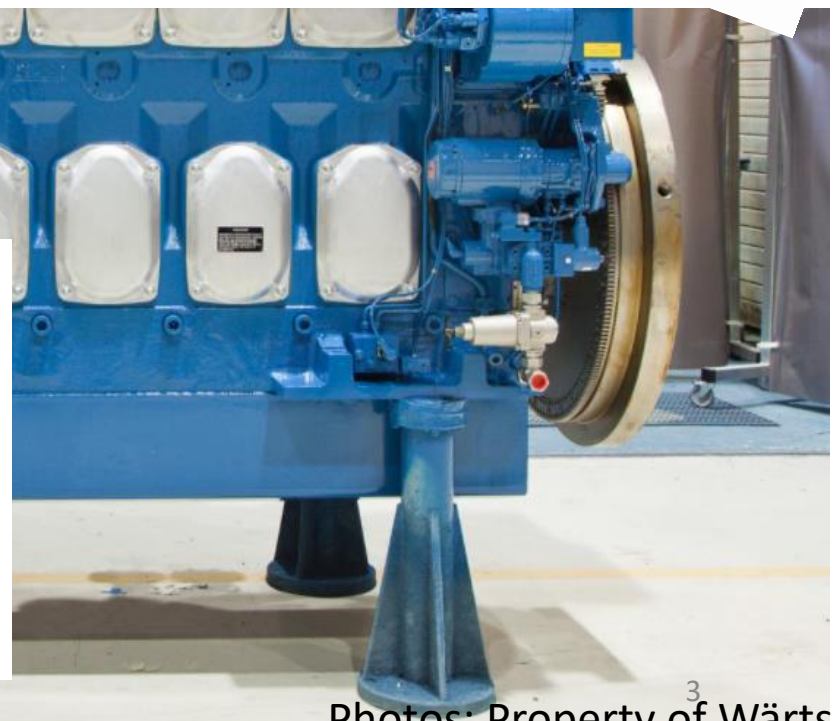
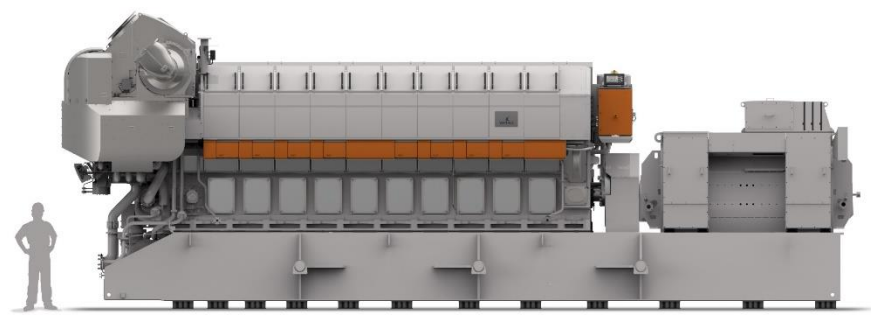
18 Ø50 cm sylinteriä
Teho 19260 kW
Paino 377 000 kg (sis. generaattori ja yhteinen alusta)



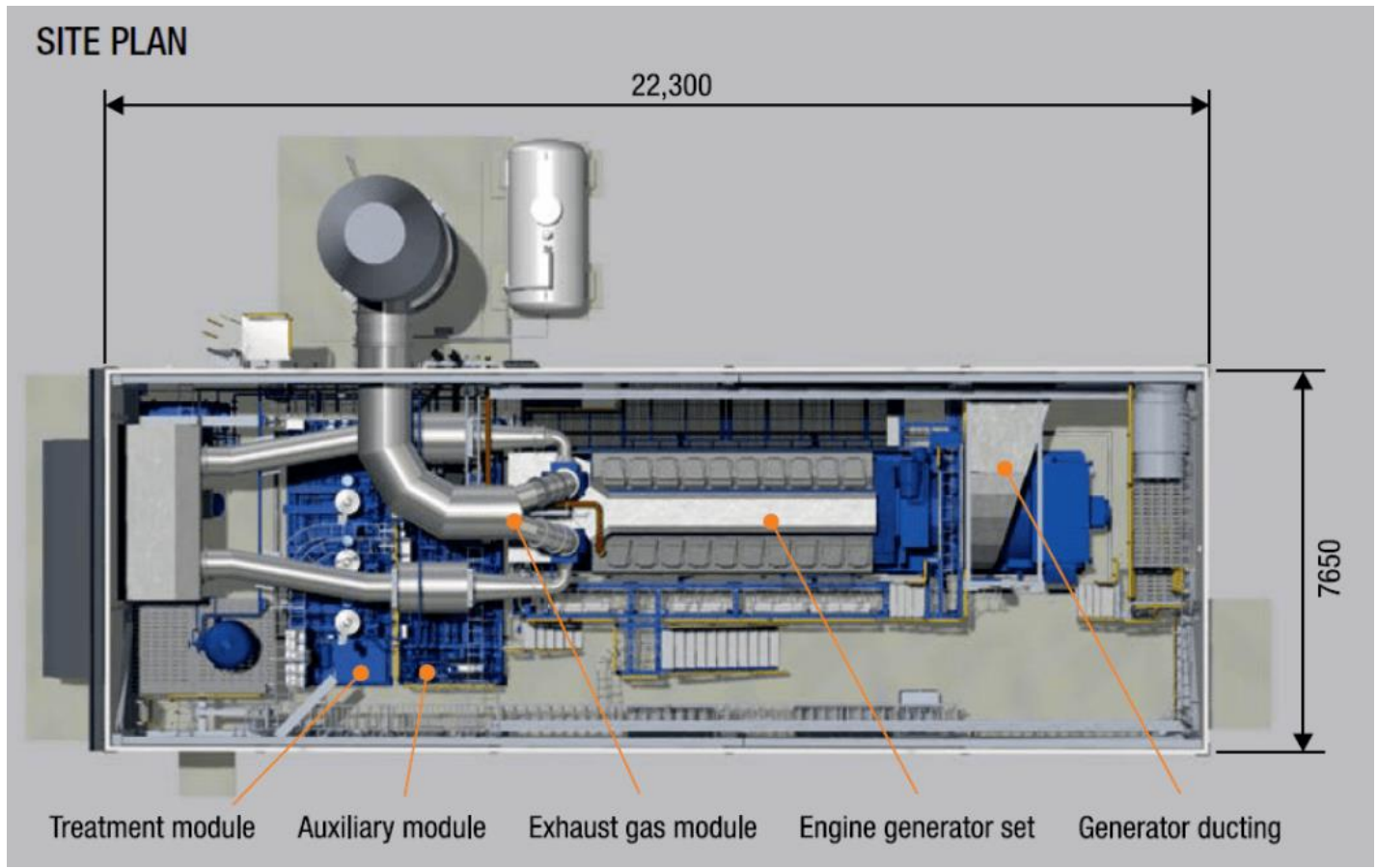
RECORD  **HOLDER**
MOST EFFICIENT 4-STROKE DIESEL ENGINE

Dimensions (mm) and weight

Generating set ² type	Length (A)	Width (B)	Weight (C)
20V31SG	14600	3900	5055



- Perusvoima
- Varavoimakoneet ja -laitokset
- Liikuteltavat laitokset



picture and price estimations https://www.uspowerco.com/generator_attachments/9190-uspe_2x10200kw_wartsila_20v32ts_hfo_diesel_genset.pdf

LAIVAT

Päämoottorit

Apumoottorit

Esim:

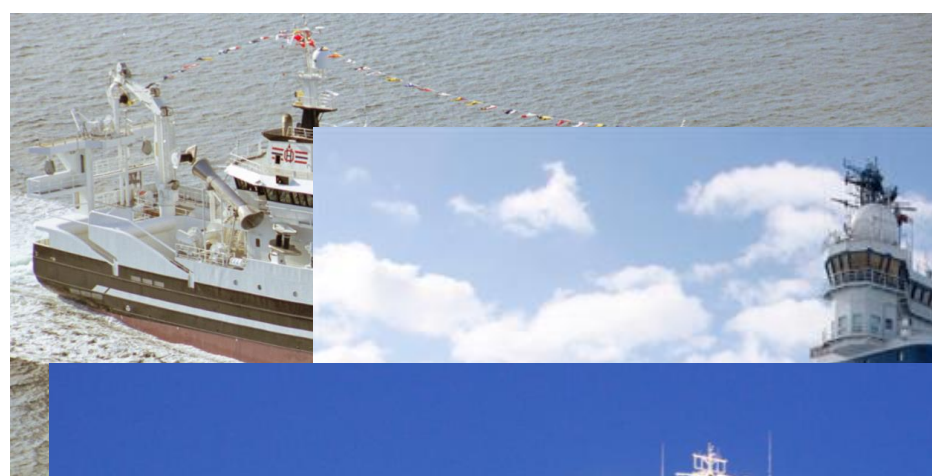
Kalastuslaivat

Rahtilaivat

Risteilijät

Jäänmurtajat

Autolautat



Optimised for flexibility, functionality and safety, Wärtsilä's GridSolv Quantum is here

Make Wärtsilä's next generation energy storage system your next smart investment.

GridSolv Quantum introduces modular flexibility as a holistic, fully integrated system. Compact and minimalist in design, it ensures the lowest lifecycle costs and the smallest system footprint, plus minimised scope and complexity of EPC activities across locations and market applications.

The system comprises the following main parts:

- **Battery enclosure** with pre-installed liquid cooled battery racks and all sub-systems such as HVAC
- **AC and DC outdoor rated cabinet**, which interfaces battery strings with the inverter and provides an interface for auxiliary power and communications
- **Interconnection busbars and cables**



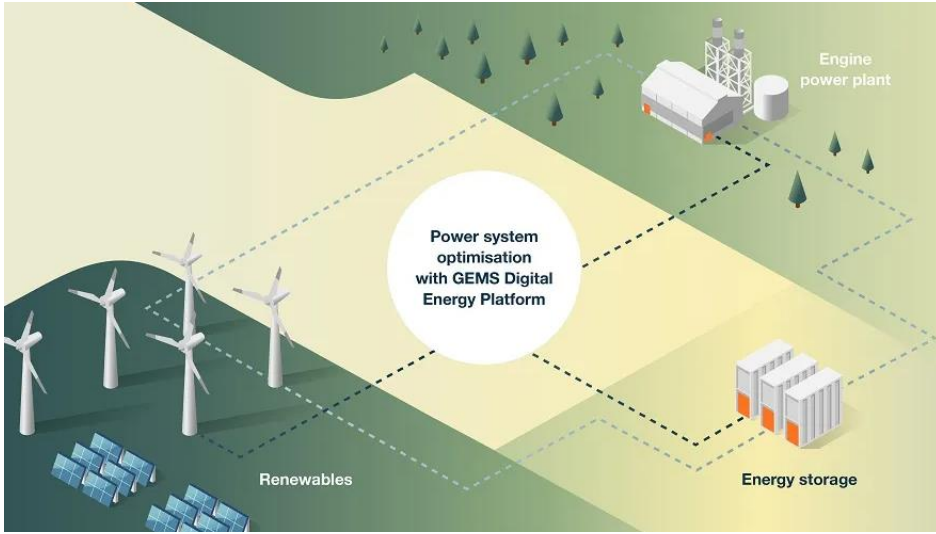
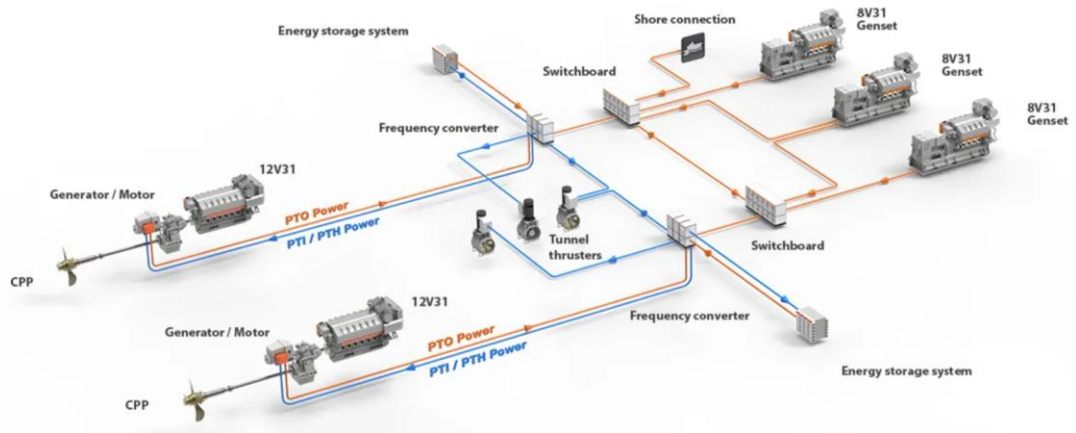
Wärtsilältä ja Stenalta maailman suurimmat hybridialukset

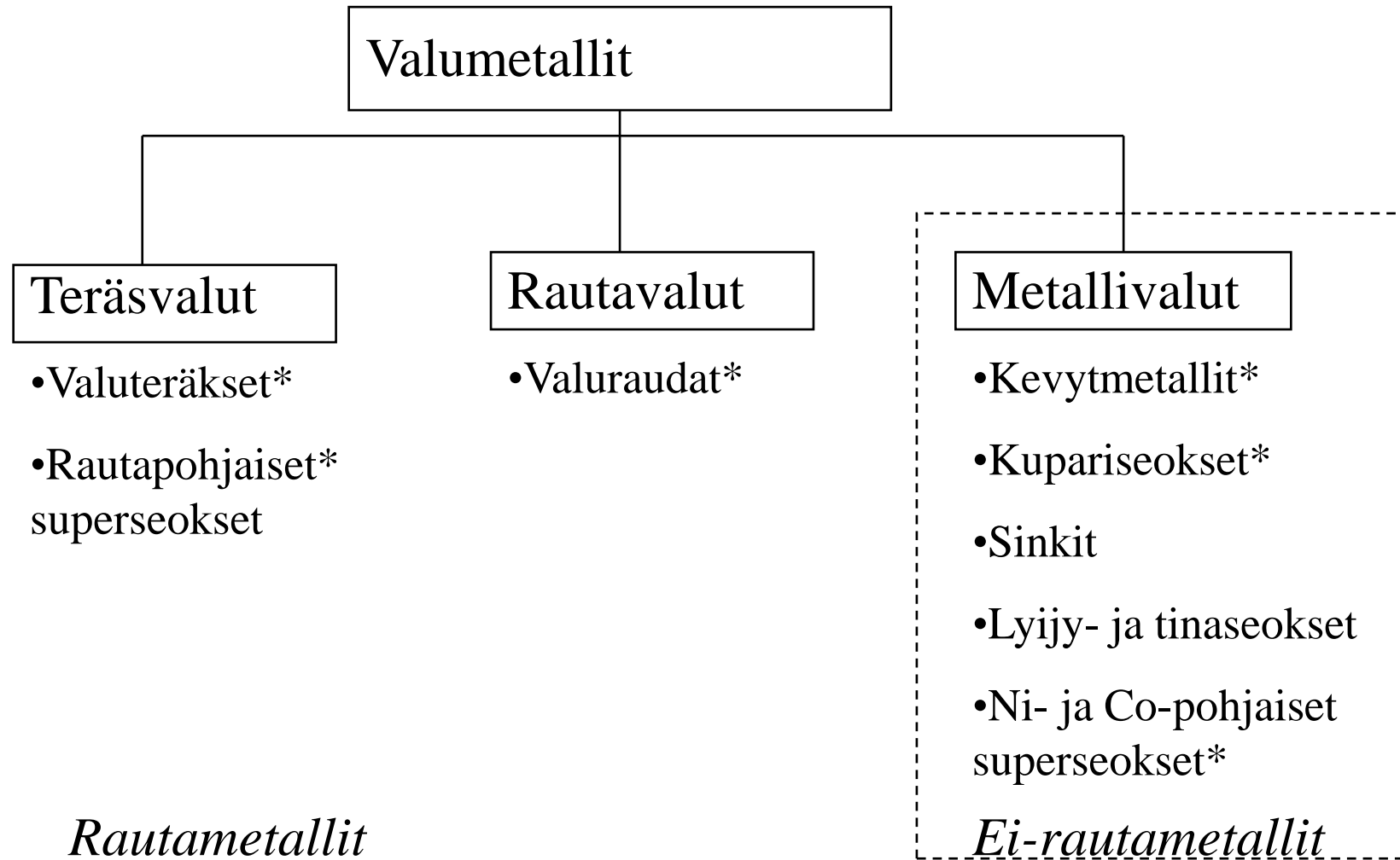
Wärtsilä Corporation, Lehdistöiedote, 21 kesäkuuta 2022 at 10.30 UTC+2



“Perinteiset:”
Raskas polttoöljy
Kevyt polttoöljy
Maakaasu

Biokaasut
Metanoli
Ammoniakki
Hybridi-ratkaisut





- Mekaaniset vaatimukset; lujuus
- Lämmönkesto
- Saatavuus/hinta
- Hinta
- Hinta
- Muut esim. luokitussäänöistä tulevat vaatimukset -> GJL:n käyttö vähentynyt

Table 1 Classes of piping systems

Piping system for	Class I ¹⁾		Class II ²⁾		Class III ¹⁾	
	p (bar)	t (°C)	p (bar)	t (°C)	p (bar)	t (°C)
Steam	> 16	or > 300	≤ 16	and ≤ 300	≤ 7	and ≤ 170
Thermal oil	> 16	or > 300	≤ 16	and ≤ 300	≤ 7	and ≤ 150
Fuel oil, lubricating oil, flammable hydraulic oil	> 16	or > 150	≤ 16	and ≤ 150	≤ 7	and ≤ 60
Other media ²⁾	> 40	or > 300	≤ 40	and ≤ 300	≤ 16	and ≤ 200

p = Design pressure, as defined in Sec.9 [1.3.3]
t = Design temperature, as defined in Sec.9 [1.3.4]

1) For class II and III piping both specified conditions shall be met, for class I piping one condition only is sufficient.
 2) Cargo oil pipes on oil carriers and open ended pipes (drains, overflows, vents, boiler escape pipes, etc.), independently of the pressure and temperature, are pertaining to class III.
 3) Cargo piping systems for flammable liquids on offshore supply vessels are pertaining to the same pipe class as fuel oil systems.
 4) Outside machinery spaces of category A, class II piping is sufficient.

Note:

Cargo piping for chemicals or liquefied gases are not covered by the table. Requirements for these piping systems are given in Pt.5 Ch.6 and Pt.5 Ch.7.

1.4 Grey cast iron

1.4.1 Grey cast iron shall not be used for piping subject to pressure shock, excessive strains and vibration.

1.4.2 Grey cast iron shall not be used for class I and II piping with the following exceptions:

- components in hydraulic piping systems where failure would not render the system inoperative or introduce a fire risk

Rules for classification: Ships — DNVGL-RU-SHIP Pt.4 Ch.6, Edition January 2018
Piping systems

Page 21

DNV GL AS

- pump and filter housings in fuel and lubrication oil systems where the design temperature does not exceed 120°C.

1.4.3 Grey cast iron may be used for class III piping, with the following exceptions:

- pipes and valves fitted on ship sides and bottom and on sea chests
- valves fitted on collision bulkhead
- valves under static head fitted on the external wall of fuel tanks, lub. oil tanks and tanks for other flammable oils
- valves for fluids with temperatures in excess of 120°C.

1.5 Nodular cast iron of the ferritic type

1.5.1 Nodular cast iron of the ferritic type, with specified minimum elongation of 12%, may be used in class II and III piping and in pipes and valves located on the ship's side and bottom and valves on the collision bulkhead. The use of nodular cast iron in class I piping shall be subject to consideration for approval in each case.

1.5.2 Nodular cast iron shall not be used for media having a temperature exceeding 350°C.

1.5.3 The use of nodular cast iron for media having a temperature below 0°C shall be considered in each particular case.

1.6 Nodular cast iron of the ferritic/pearlitic and pearlitic type

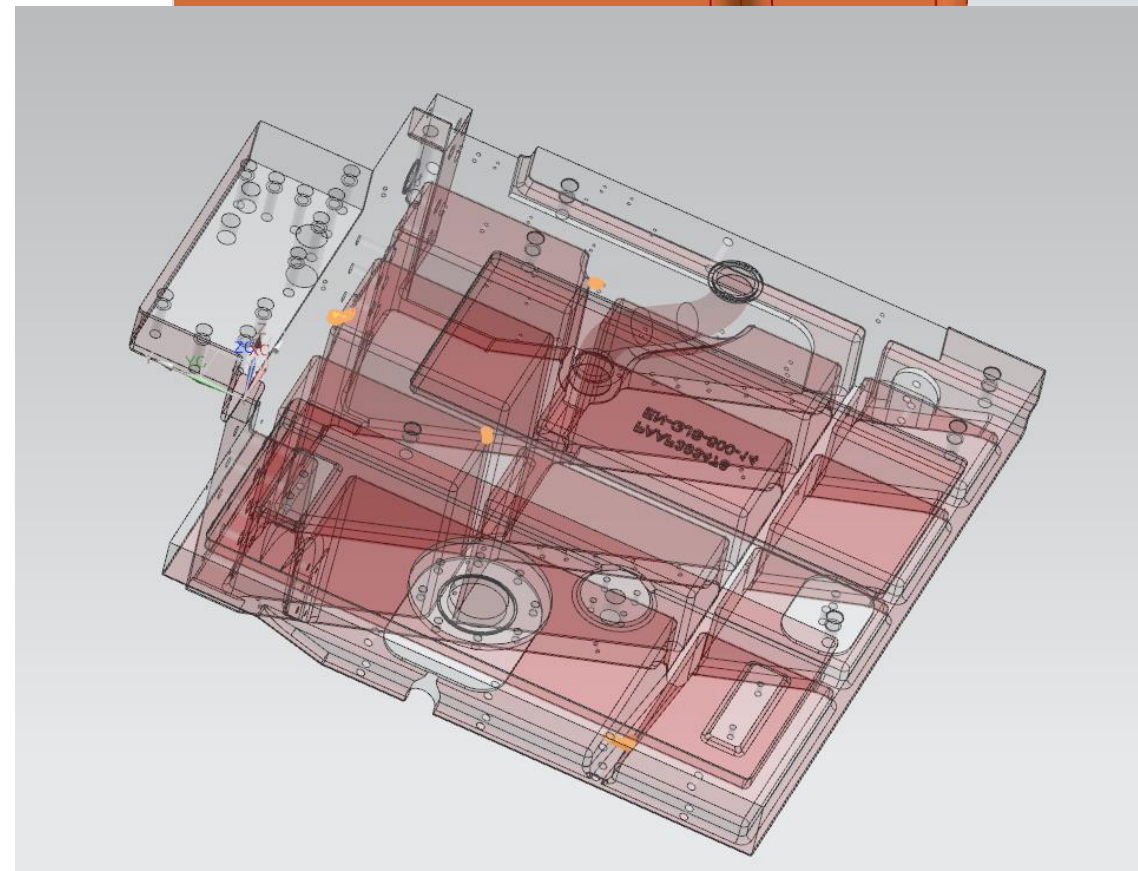
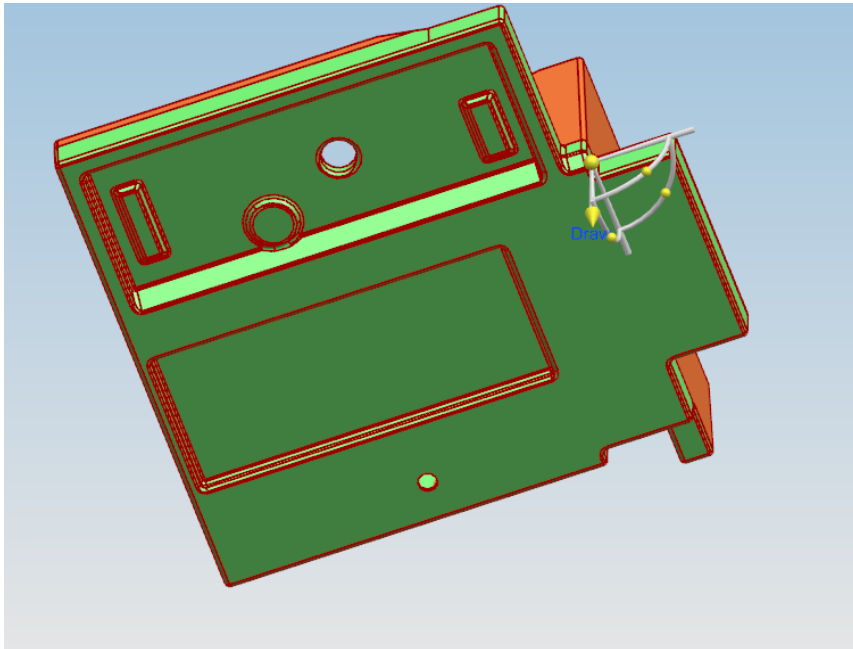
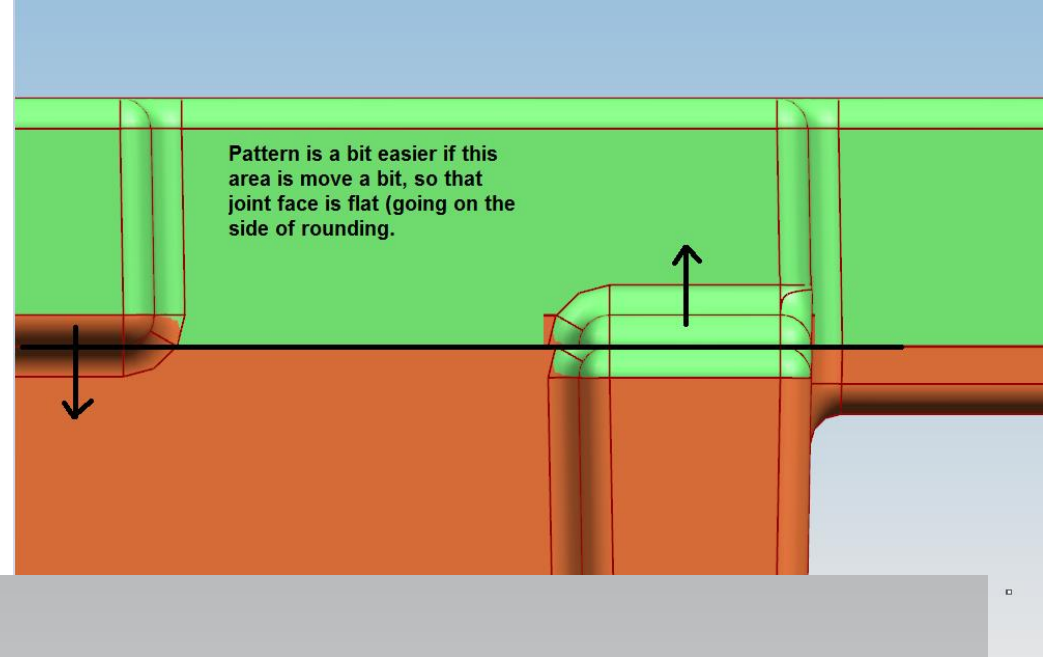
1.6.1 Nodular cast iron of the ferritic/pearlitic and pearlitic type shall be subject to the limitation of use as grey cast iron as specified in [1.4].

- Valut vaihtelevat 15 grammasta 88 000 kiloon.
- Valumateriaalit:
 - Pallografiittivalurauta GJS (~85%)
 - Suomugrafiittivalurauta GJL (~10%)
 - (valu)Alumiinit (~3%)
 - (valu)Teräkset (~1%)
- Valumenetelmät:
 - Käsin kaavaus
 - Konekaavus
 - Tarkkuusvalut
 - Kokillivalut (kokilli-, matalapaine- ja painevalut)



Lähes aina erillinen 3D-valu ja -koneistusmalli

- Valmistettavuus analyysi sisältäen
 - Valun simuloinnin ja huokosennusteen



- Tiheys alle 5 kg/dm³
- Valettavat kevyt metallit:
 - Alumiiniseokset
 - (Magnesium seokset)
 - (Titaani seokset)

Käytetään luukuissa, yms. komponenteissa, joissa ei ole erityisiä lujuusvaatimuksia.

Tyypillisesti matalapaine- ja kokillivaluja

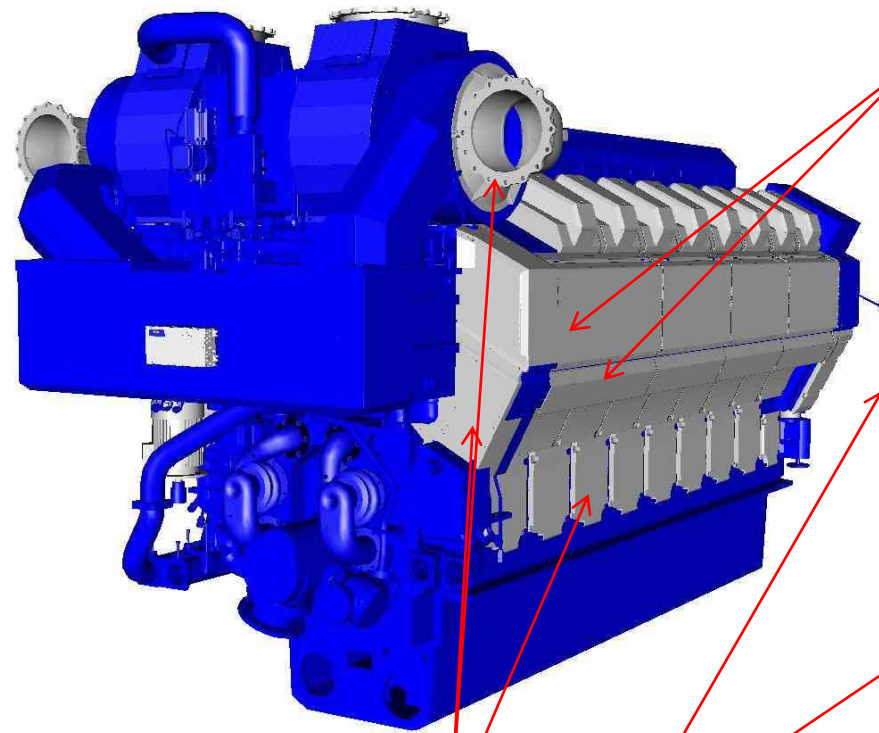
Tyypilliset materiaalit:

AlSi7Mg, AlSi10Mg, AlSi12 (EN 1706)

Milloin?

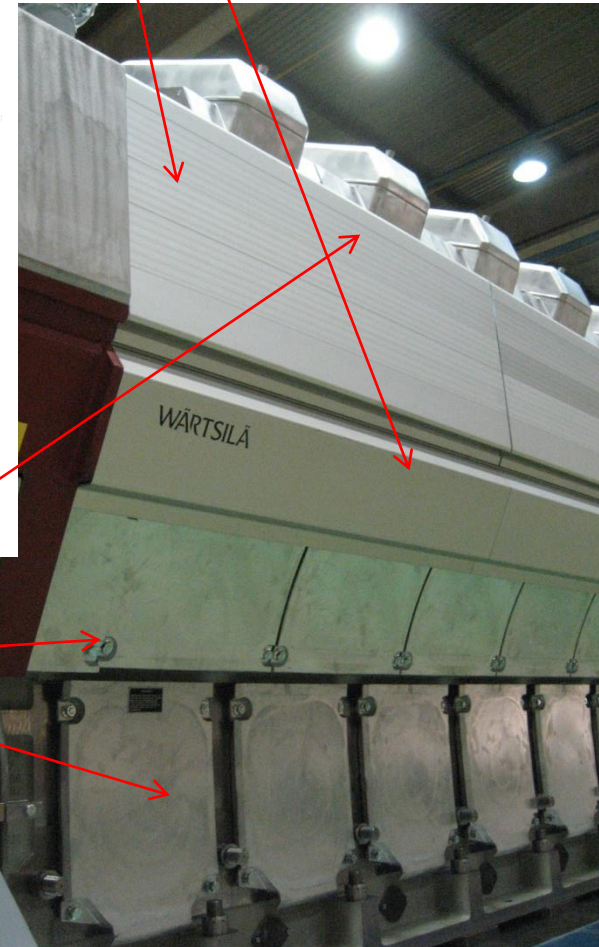
-Hinta

-Keveys



Al-casting

Al-profile



Kuumalujat teräkset

- Matala seosteiset teräkset
 - Cr noin 1,5% ja Mo ca 0,5%
- Hyvät lujuusominaisuudet
- Hyvä hitsattavuus
- Kohtuullinen valettavuus
- G17CrMo5-5 +QT, G17CrMo9-



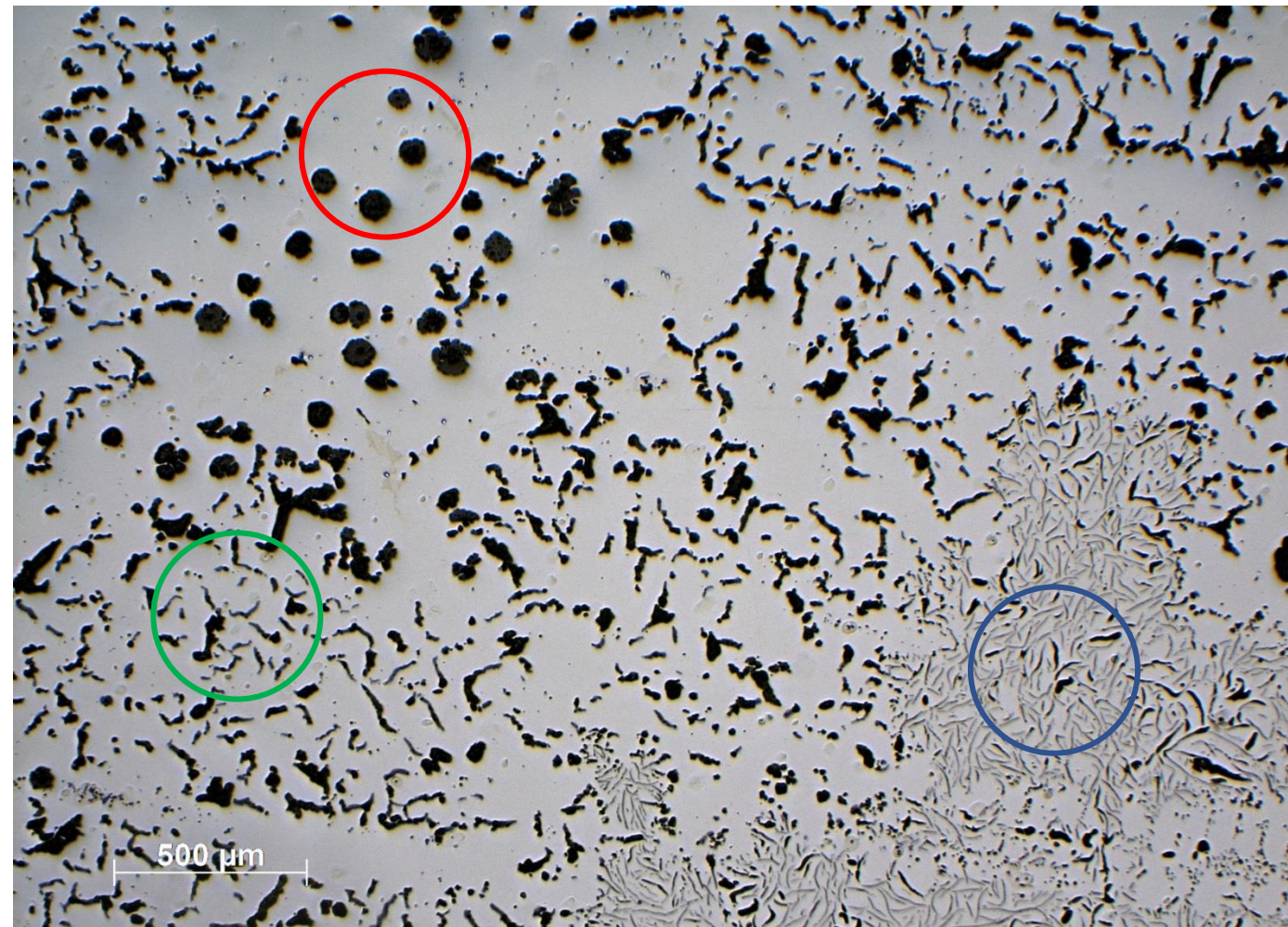
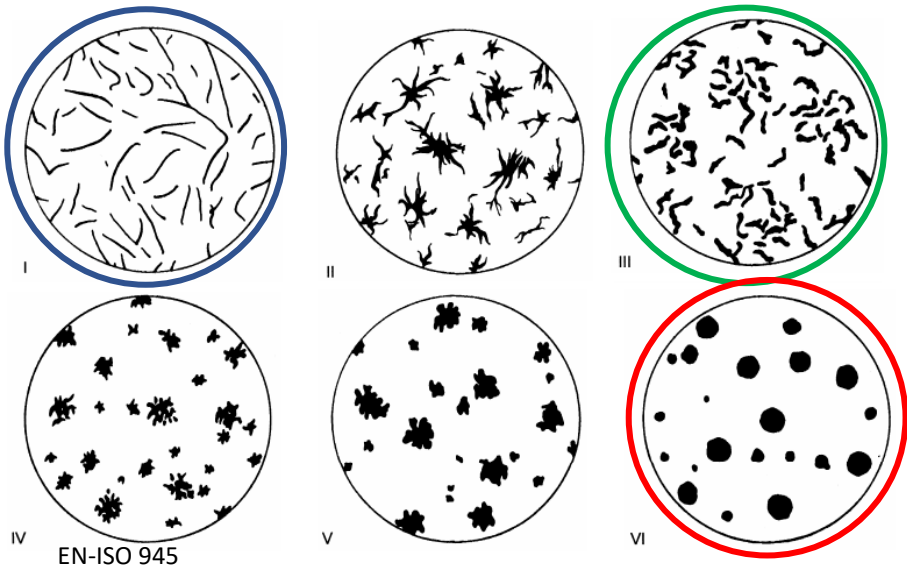
Ruostumattomat teräkset

- Korkeasti seostettuja
 - Cr 12-25%, Ni 5-13% ja Mo 0,5-3%
- Martensiittiset ruostumattomat teräkset
 - YS 500-850 MPa, UTS 700-1200 MPa
- Austeniittiset ruostumattomat teräkset
 - Matalahko lujuus YS n. 200 MPa
 - Erittäin hyvä korroosionkesto
- Duplex teräkset
 - YS 300-500 MPa
 - Korroosionkesto melkein yhtähyvä kuin austeniittisissä teräksissä
- GX12Cr12, GX2CrNi19-11, GX4CrNiN26-7... EN 10283

Kalliita, käytetään vain kun on ehdoton pakko

- Teräsmatriisi, grafiitti sulkeumat
- Luokitellaan grafiittirakenteen mukaan

- Suomugrafiitti (harmaa) valurauta (GJL) muotoa 1
Murtolujuus 150-300 MPa
Erinomainen lämmöjohtavuus
- Tylppägrafiittivalurauta (GJV) muotoa III
Murtolujuus 300-500 MPa
Hyvä lämmönjohtavuus
- Pallografiittivalurauta (GJS) muotoa VI ja V
Murtolujuus 350-700 MPa

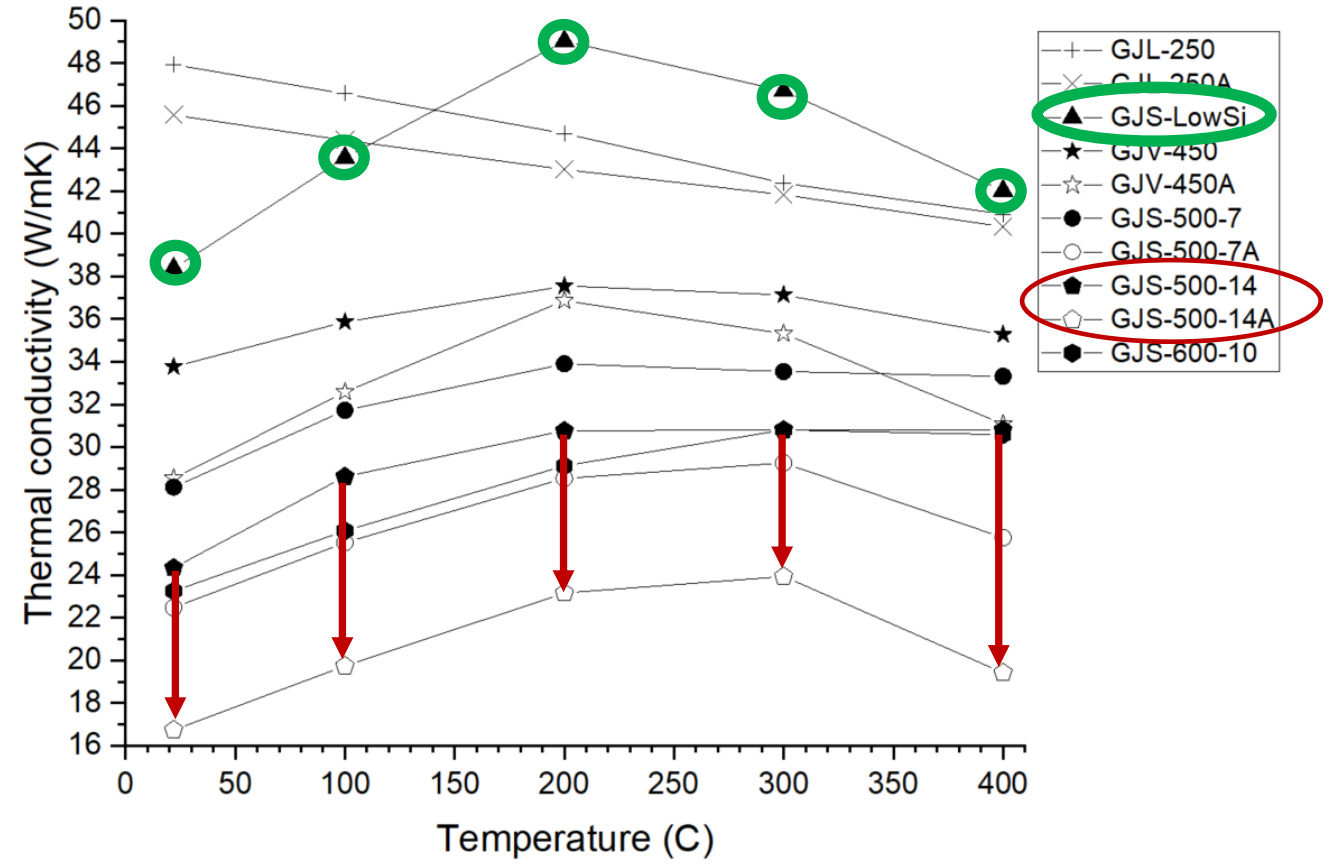
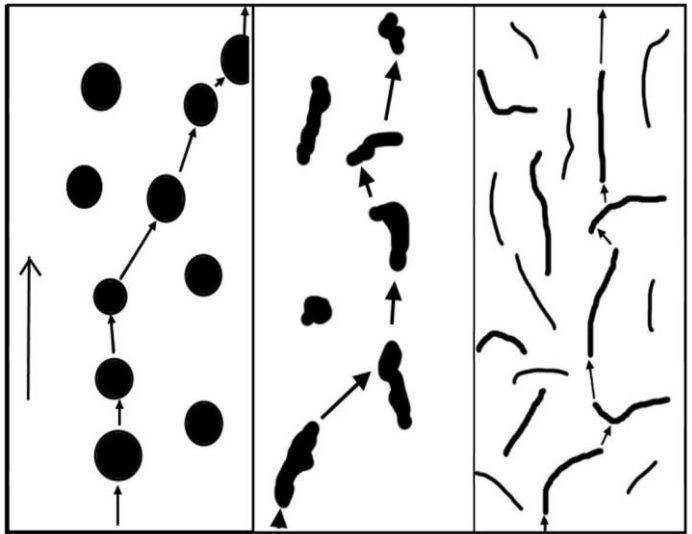


Huom: Materiaalin pitäisi olla pallografiittivalurautaa...

Valutilaisten ja autemperoitujen valurautojen lämmöjohtavuuksia

Useita eri tyyppisiä valurautoja testattiin
Joko valutilaisina tai autemperoituina

Austemperointi on lämpökäsittelyprosessi, jossa matriisi muuttuu spheriittiseksi



GJL 200 –GJL 300

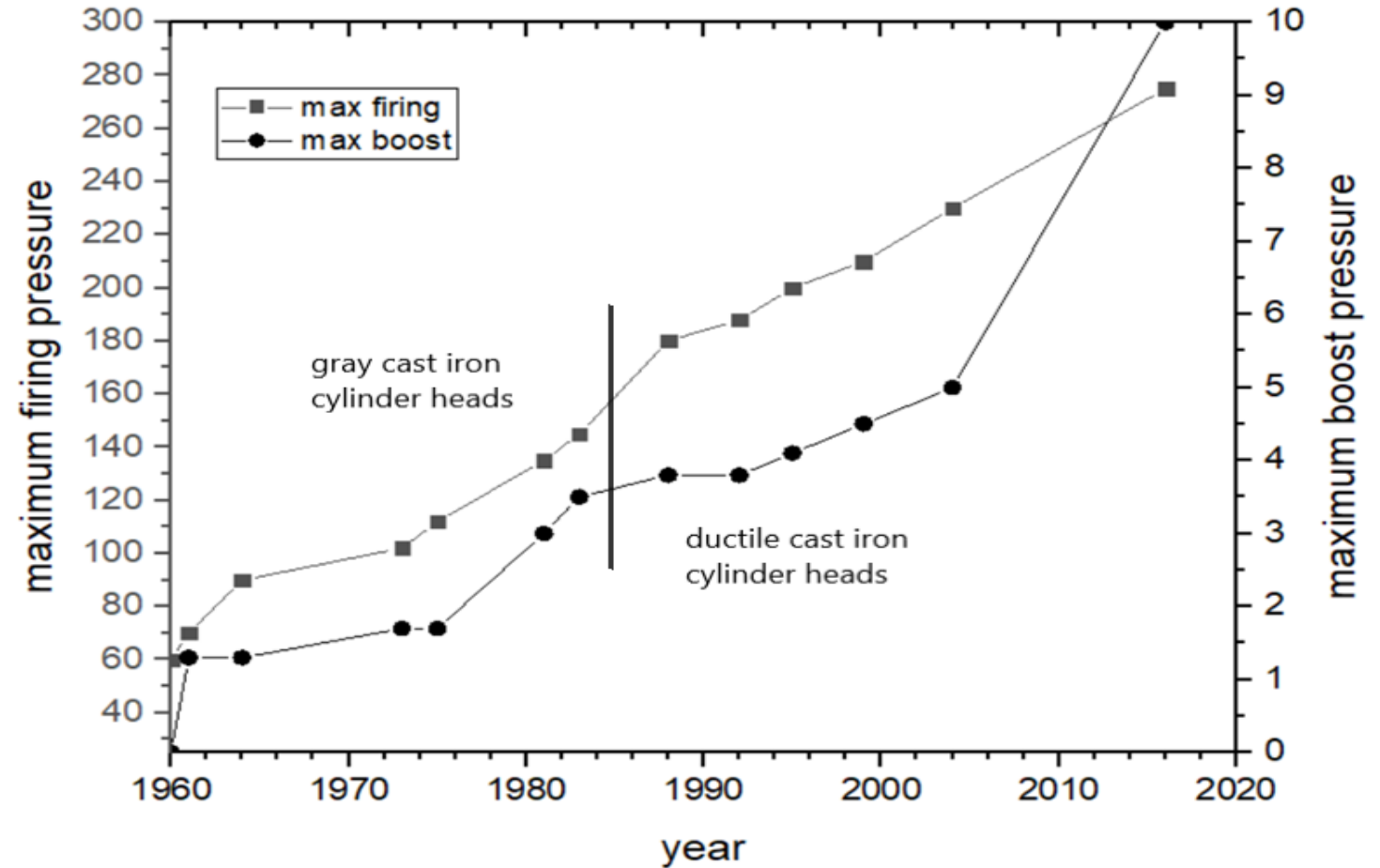
- Yleisesti ottaen halvin valumateriaali
- Erinomainen valettavuus
- Hyvä koneistettavuus
- Hyvät vaimennusominaisuudet
- Hyvä lämmönjohtavuus

- Keskinkertainen lujuus, olematon murtovenymä

- Käytetään kun mekaaniset ominaisuudet riittävät, eikä luokitussäännöt estä
- Vesiputket, kotelot, kanattimet kun kappaleessa ei ole paineellista öljyä.

Sylinterikansi

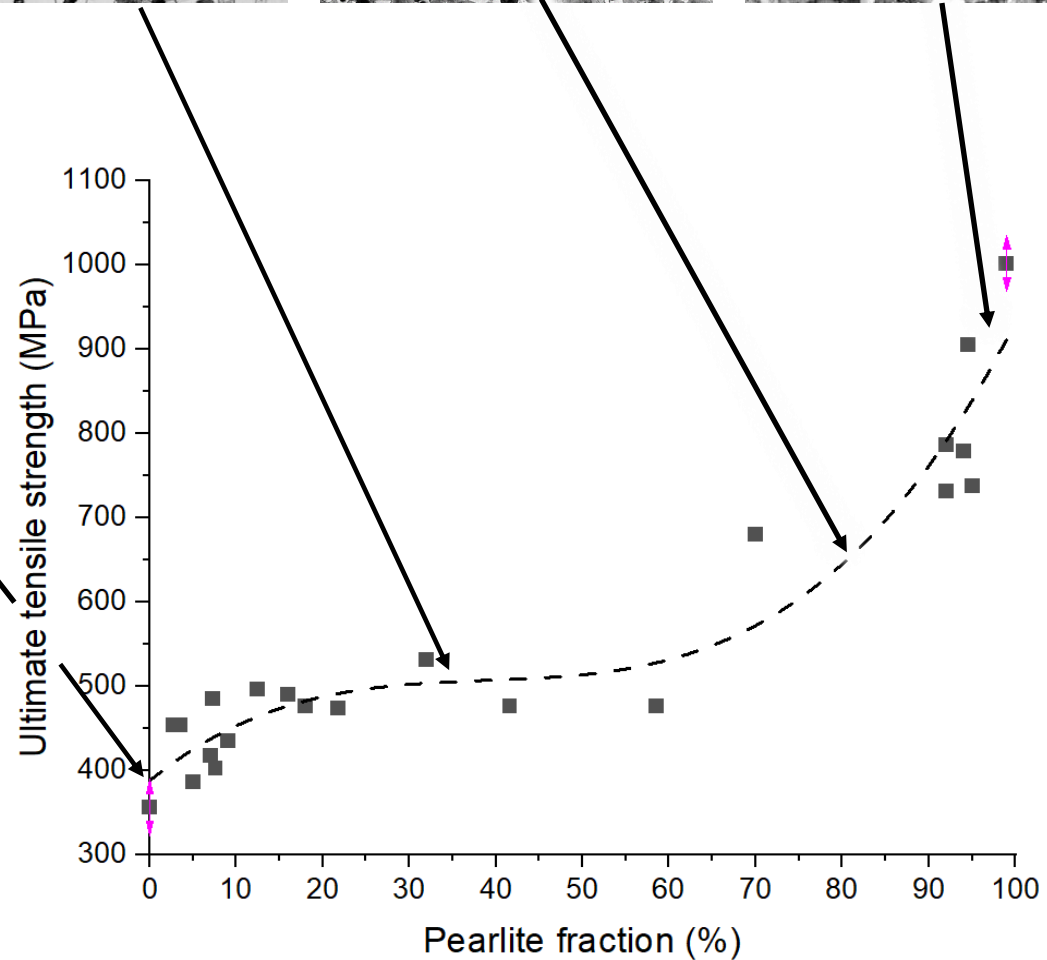
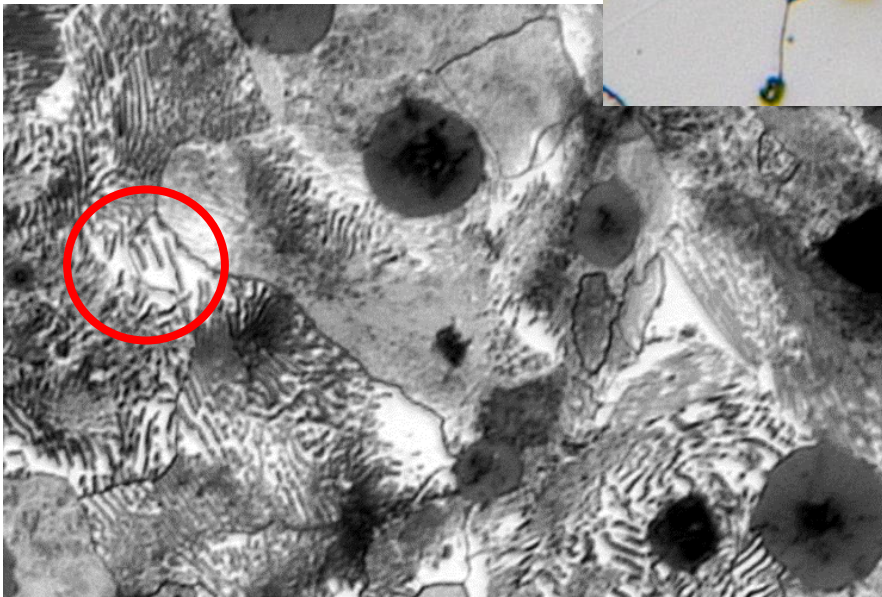
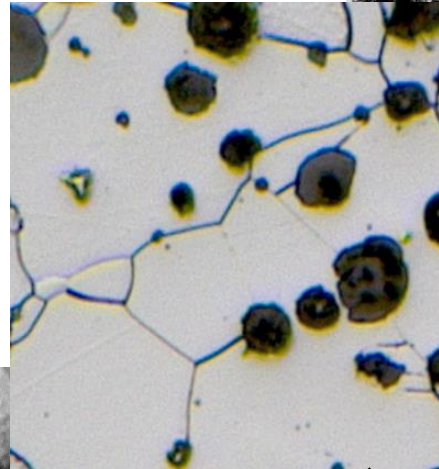
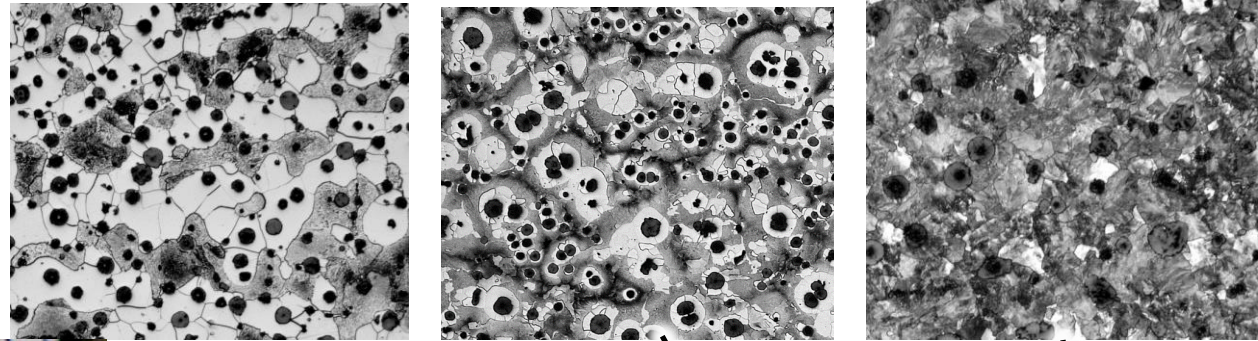
- Moottorin pääkomponentteja
- Mekaaninen ja terminen kuomitustilanne
 - Esikiristys, sytyspaine
 - Lämpökuormat
- vesijäähdytetty
- Paino (valu) 100-1100 kg
- Odotettu elinikä >10 vuotta
- Ennen suomugrafiittivalurautaa, nykyään pallografiittivalurautaa



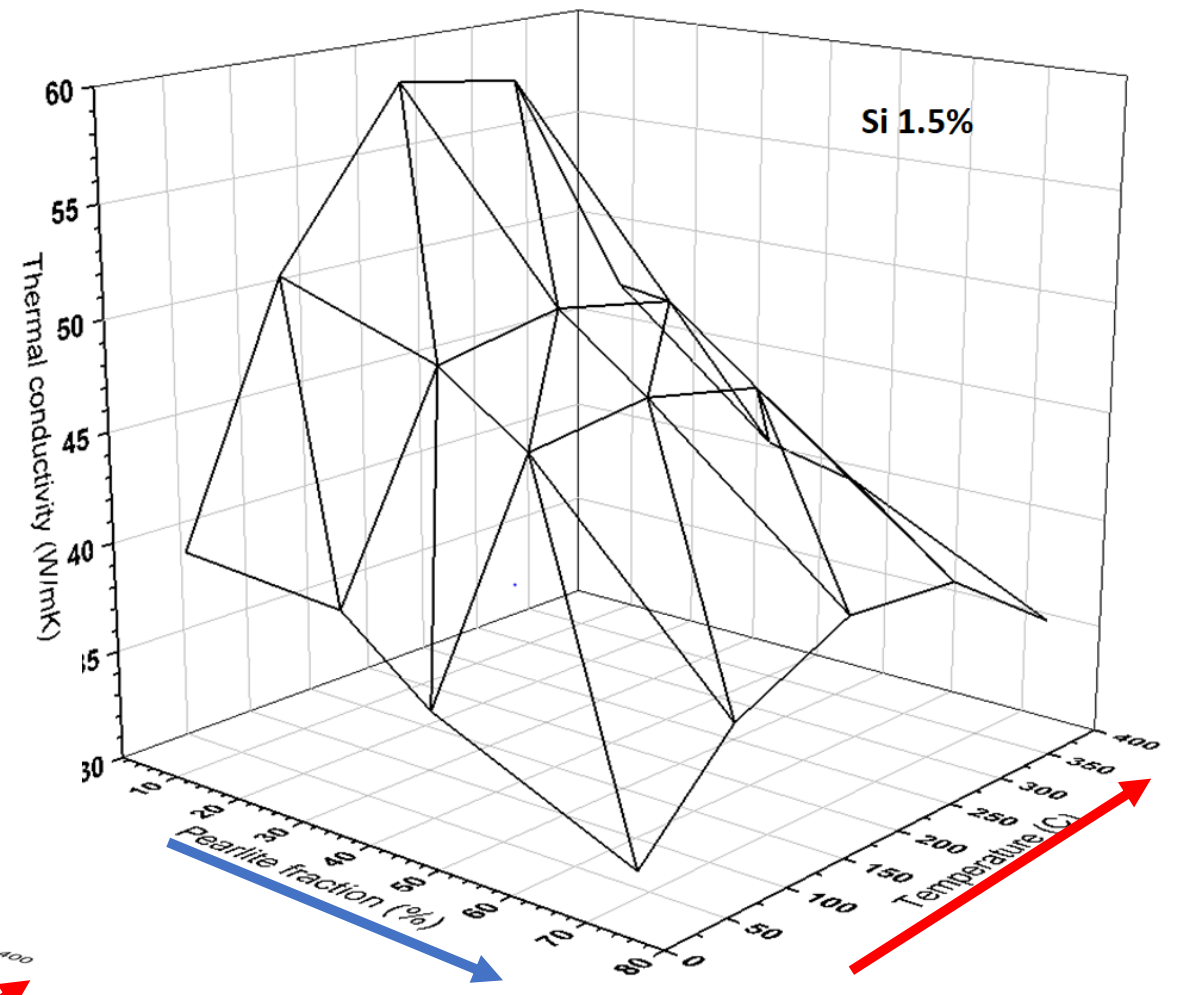
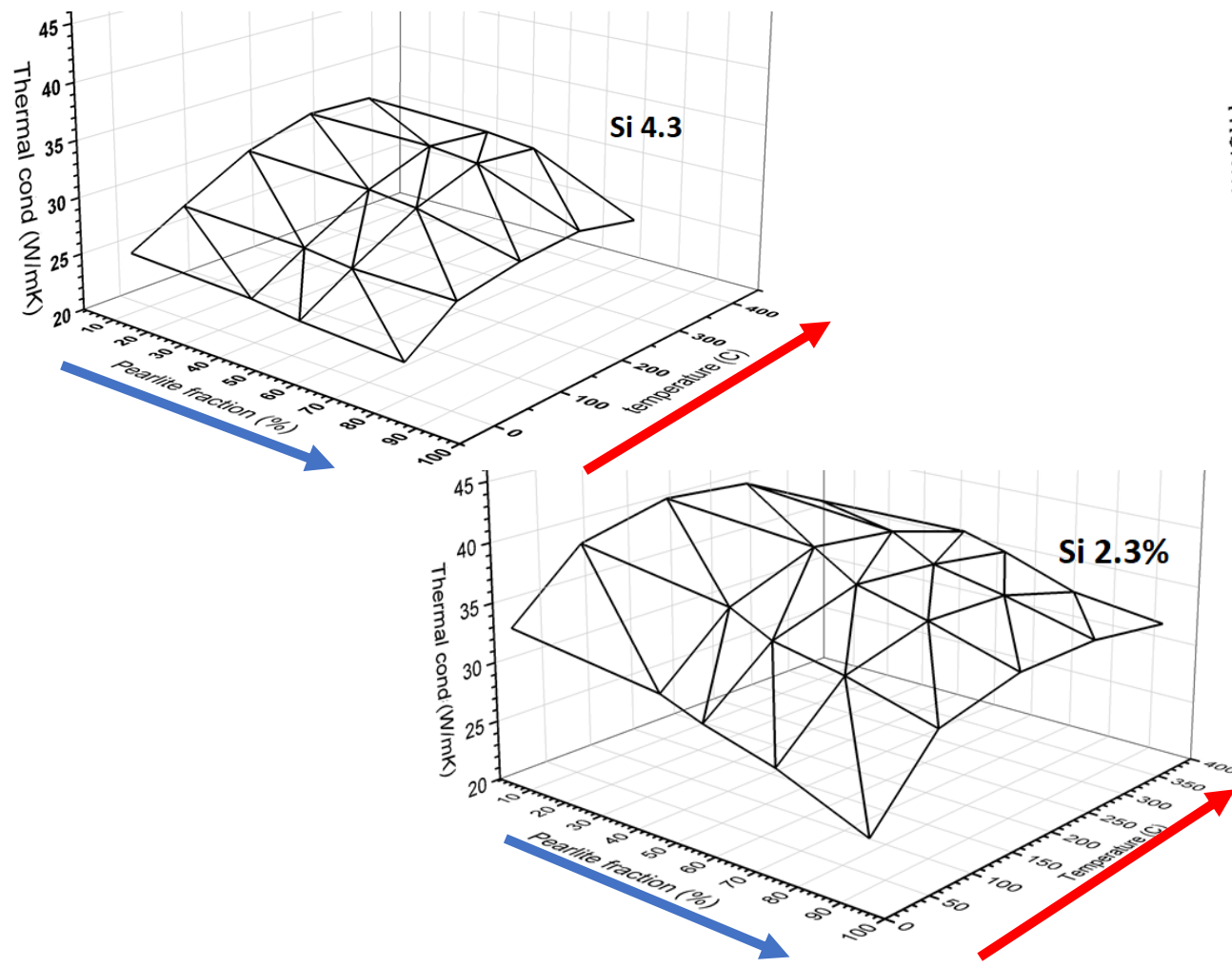
<https://www.youtube.com/watch?v=KnNX6gtDyhg>

Lujuus riippuu pääsääntöisesti matriisirakenteesta:

1. Perliitin määrästä
 - Perlitissä on rautakarbidi (sementiitti, FeC) lamelleja ferriittipohjalla
 - Perliitin määrää voidaan kontrolloida seosaineilla (+Cu, +Sn, -Si)



Effect of silicon and microstructure on spheroidal graphite cast iron thermal conductivity at elevated temperature



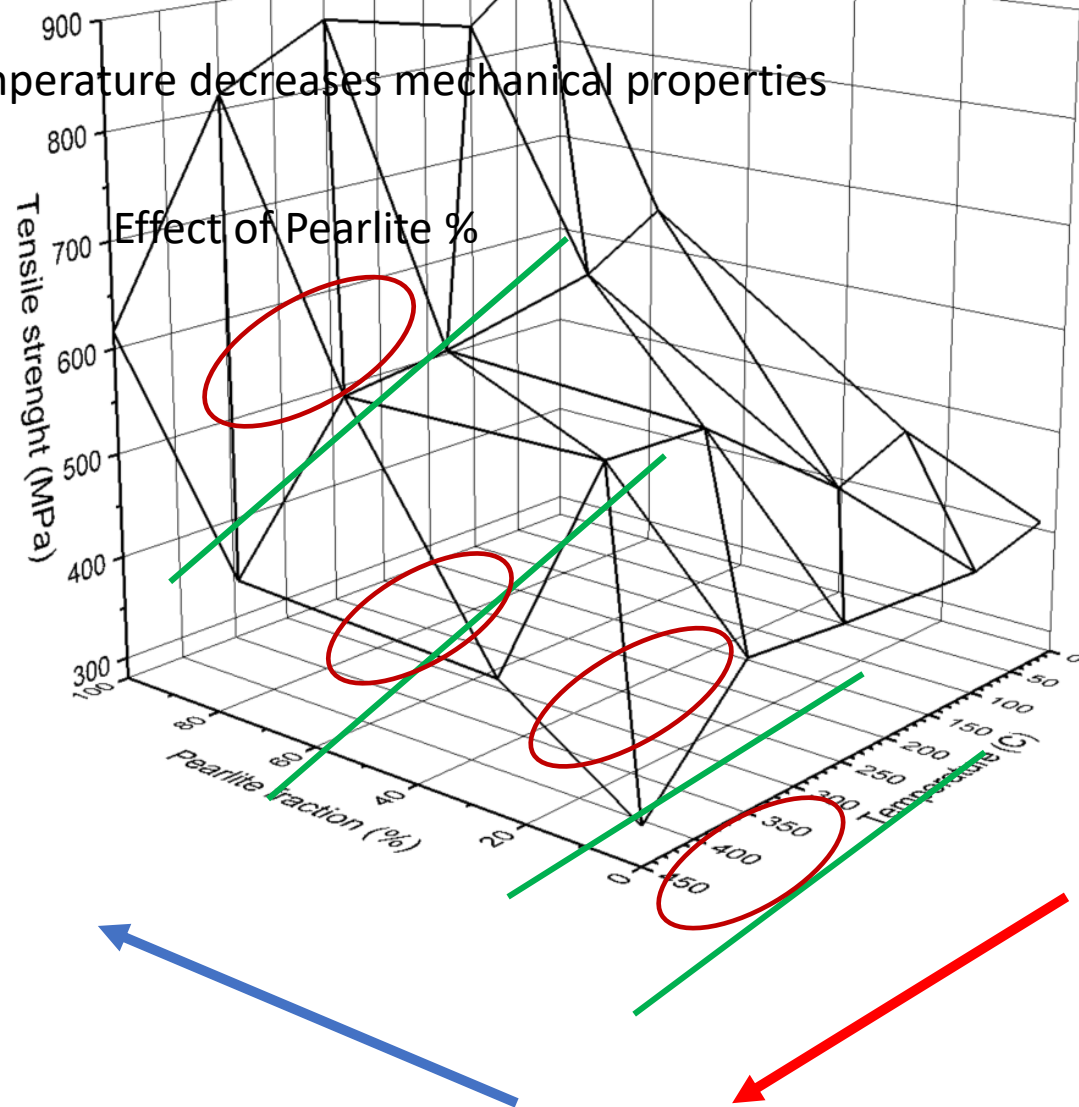
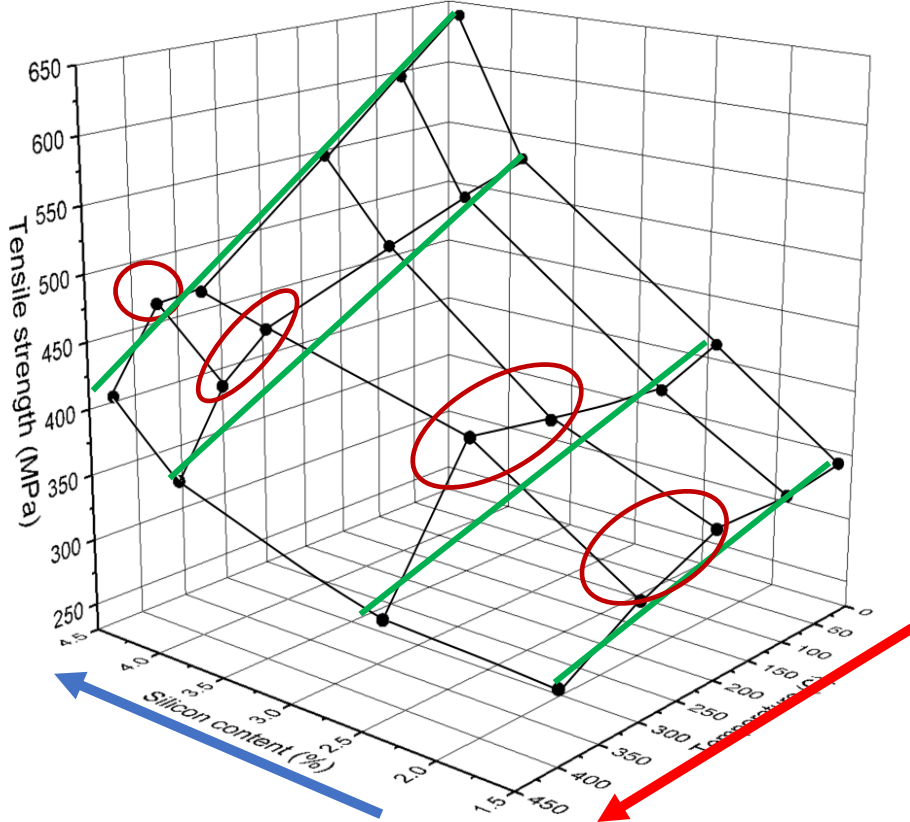
The mechanical properties of ductile iron at intermediate temperatures

Increase of silicon content and pearlite fraction increases tensile- and yield strength.

Increase of temperature decreases mechanical properties

HMM?

Effect of Silicon %

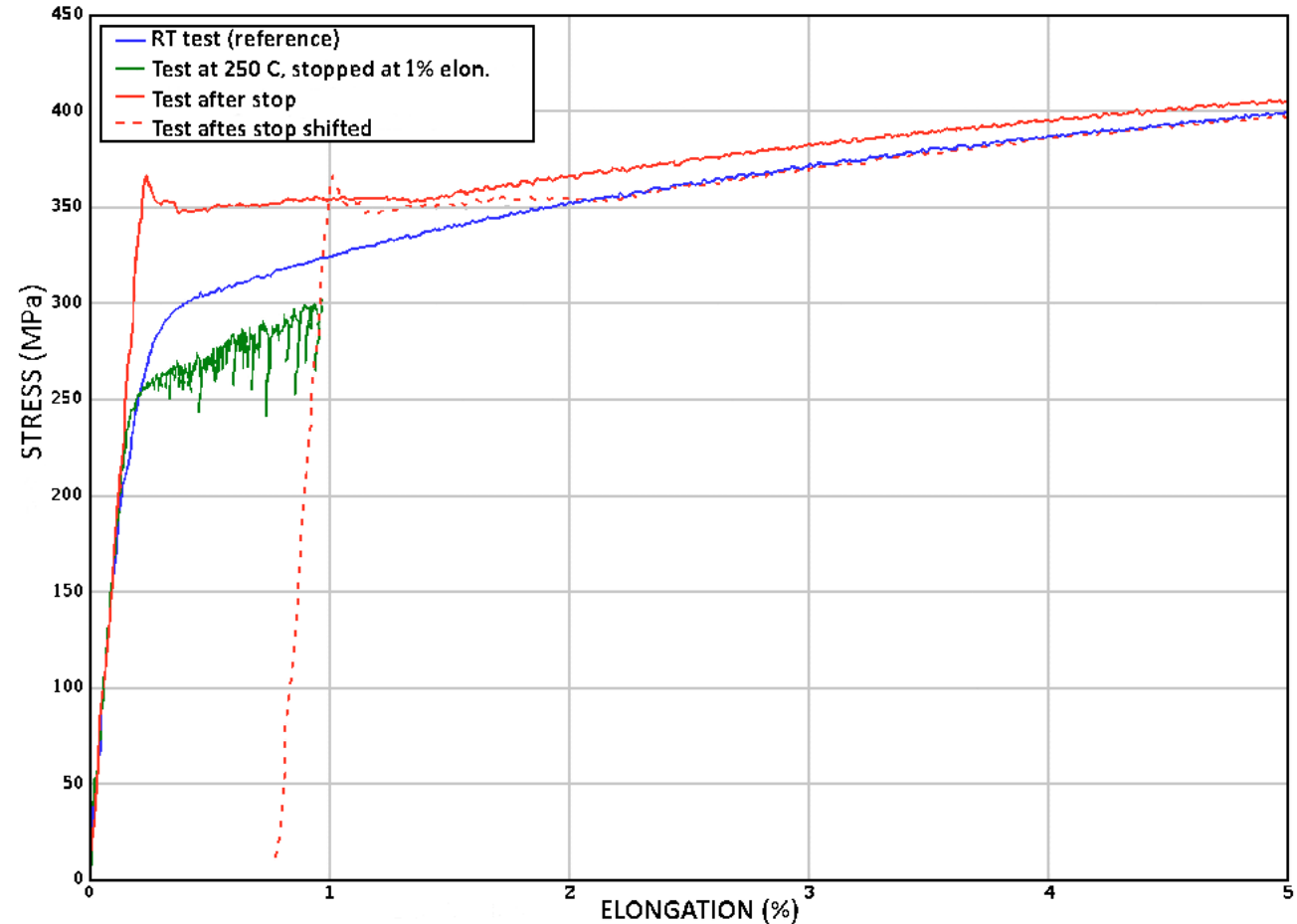


Investigation on dynamic strain ageing (DSA) behavior of ferritic-pearlitic ductile cast irons

Dynamic strain ageing is a hardening effect that occur under plastic deformation at elevated temperatures. Studied mainly with steels.

Foundings:

- DSA occurs at all studies strain amplitudes, strain rates, temperatures and pearlite fractions at studied temperatures (250, 350°C)
- Hot-working at DSA temperature improves RT strength properties



CFD and FE optimisation

An elastic material model was used in the finite element calculations, the contacts being nonlinear with friction. The plasticity correction for fatigue life was performed with Ramberg–Osgood postprocessing

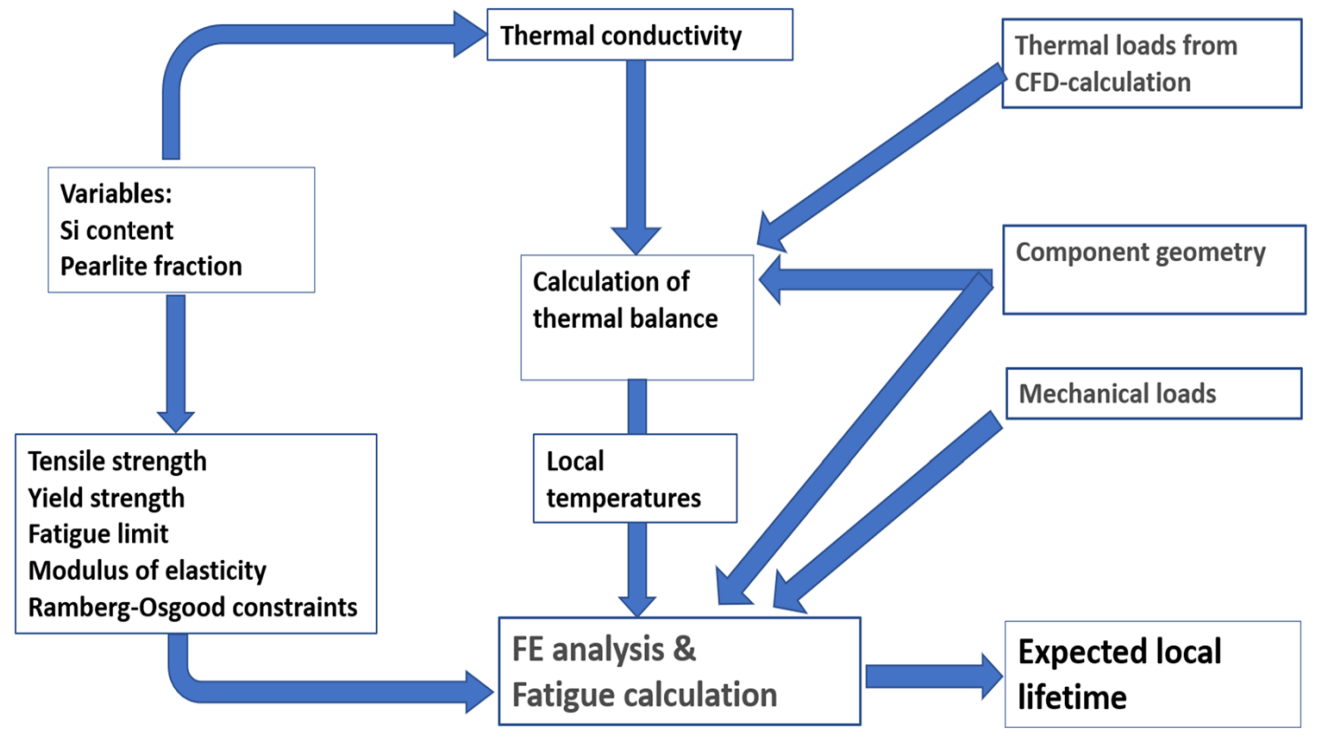
$$\epsilon = \frac{\sigma}{E} + \left(\frac{\sigma}{K}\right)^{\frac{1}{n}}$$

ϵ = true strain

σ = true stress

n = hardening effect and K = strength coefficient

(k and n were calculated based on fatigue tests of DI with 2.3% Si with different pearlite fractions from RT to 450°C.



Optimisation of the cylinder heads critical areas

The most critical

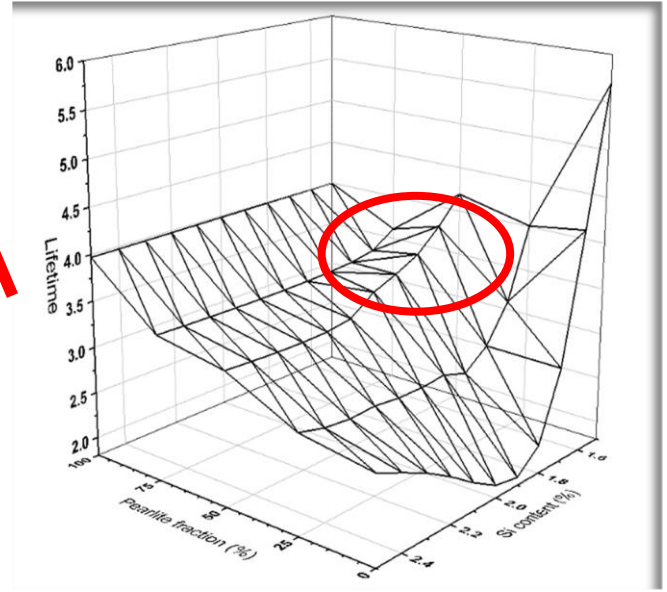
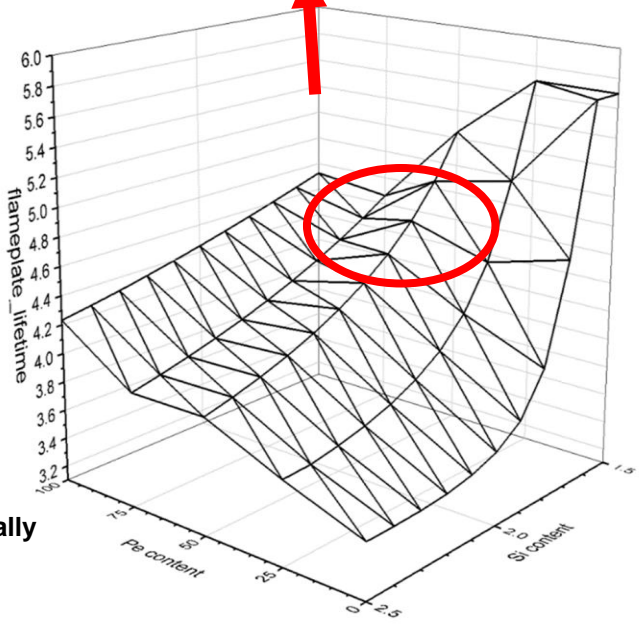
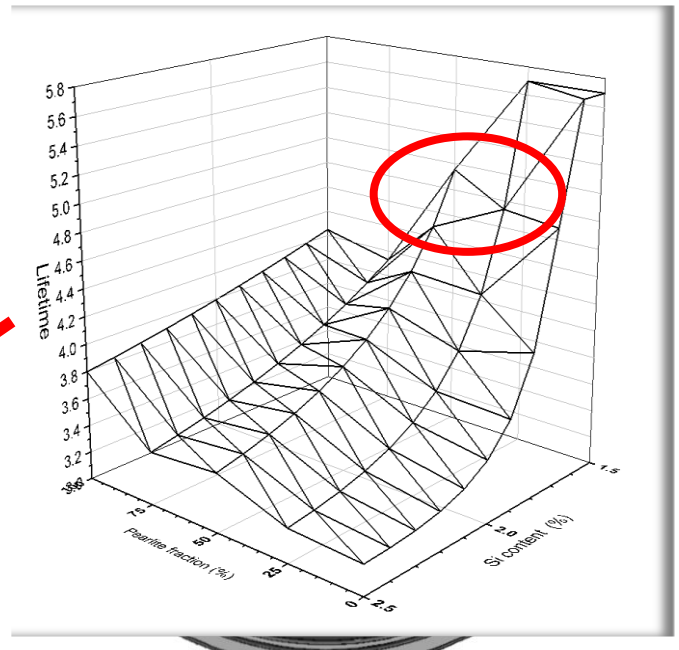
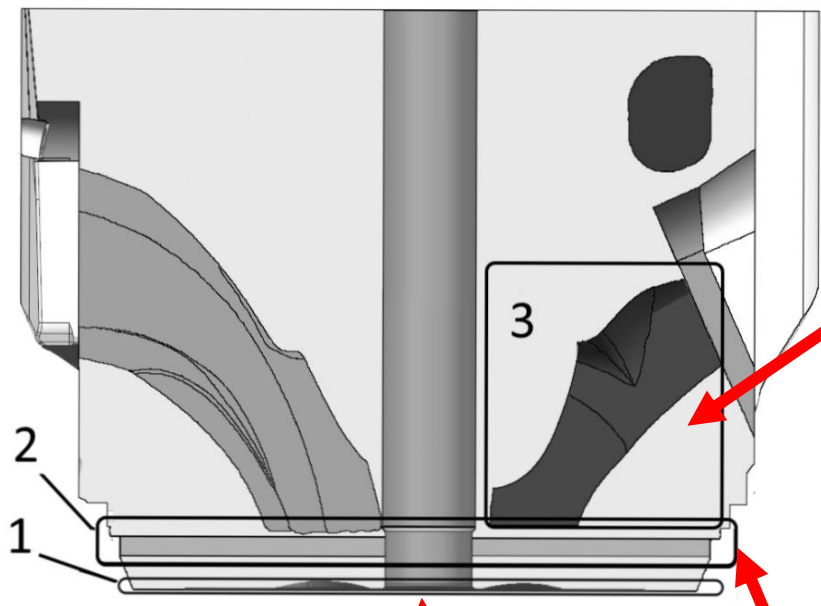
- 1. Flame plate area
- 2. Cooling drilling area
- 3. Exhaust channel area

Based on optimization target was

1.8% silicon (lower values might come some extra challenges)

and

targetting 50% pearlite content



Laine, Jarkko; Leppänen, Anton; Jalava, Kalle; Vaara, Joonas; Frondelius, Tero; Orkas, Juhani. 2020. Ductile iron optimisation approach to mechanically and thermally loaded components. International Journal of Metalcasting. e-published 22-10-2020. DOI :10.1007/s40962-020-00529-9



WÄRTSILÄ