Aalto University
School of Engineering

Quality and global purchasing of castings

Advanced Casting Technology

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Quality of castings - *What should one demand from a foundry?*

Purchasing cast products in global markets

Call for tenders – Request for quotation

Quality of castings

Inspection and testing

Inspection methods and quality levels of cast components

Flawless components do not exist in any manufacturing process!

Defects exist because:

- Properties of cast materials vary (e.g. shrinkage factors)
- Manufacturing process tolerances
- Design errors
- …

When designing inspection plans, required quality levels need to be kept in mind – Too strict – Too loose - … or just right?

Some factors that affect inspection

Required properties of component:

- Stresses, design loads etc.
- Risks of component failure **– What are the riskiest areas?**

Material choice, processing steps

Inspection methods should be chosen after all component requirements are known – Know what you need and find the cost-effective solution

Inspection

Quality level

- Standardized requirements are defined as levels from 1 to 5
- Level 1 is the strictest, as the size of the biggest allowable defect increases from 1 → 5
- Cost naturally increases when better quality is required (5 → 1)

Inspection methods

- Some inspection methods are only suitable for specific materials

Inspection frequency

- 100 %, batch sampling, prototype sampling? Costs vs. risks

Base recommendations for some cases

Carbon steels

- Base class 3, but if class 3 is not sufficient, choose a Q&T steel

Quenched & Tempered steels

- Base class 3, mechanically stressed areas class 2 and class 1 for extremely stressed areas (e.g. gears)

Stainless steels

- Base class 4

Gray cast iron, GJL

- Visual inspection

Ductile cast iron, GJS

- Visual inspection

Non-destructive testing (NDT) of castings

Visual inspection

Surface level inspection

- **Magnetic particle testing (MT/MPI)**
- **Penetrant testing (PT)**

Integral integrity

- **Ultrasonic testing (UT)**
- **Radiographic testing (RT) – X-ray**

Some standards for quality testing…

- BNIF 359 - Recommandation technique du Bureau de Normalisation des Industries de la Fonderie. Caractérisation d'états de surface des pièces moulées - Utilisation des échantillons types de 110 × 160 mm
- SCRATA surface comparators for the definition of surface quality of steel and iron castings
- MSS SP-55 Quality standard for steel castings for valves, flanges and fittings and other piping components
- SFS-EN 1370:2011 Founding. Examination of surface condition.
- SFS-EN 12454:1998 Valut. Pintavirheiden silmämääräinen tarkastus. Hiekkaan valetut teräsvalut.
- SFS-EN 1371-1: 1997 Valut. Tunkeumanestetarkastus. Osa 1: Hiekka-, kokilli- ja matalapainevalut.
- SFS-EN 1369:1996 Valut. Magneettijauhetarkastus.
- SFS-EN 12681:2003 Valut. Radiografinen tarkastus.
- SFS-EN 12680-1:2003 Valut. Ultraäänitarkastus. Osa 1: Teräsvalut yleiseen käyttöön.
- SFS-EN 12680-2:2003 Valut. Ultraäänitarkastus. Osa 2: Teräsvalut suuresti rasitettuihin kohteisiin.
- ASTM A802 / A802M - 95(2010)e1 Standard Practice for Steel Castings. Surface Acceptance Standards. Visual Examination.

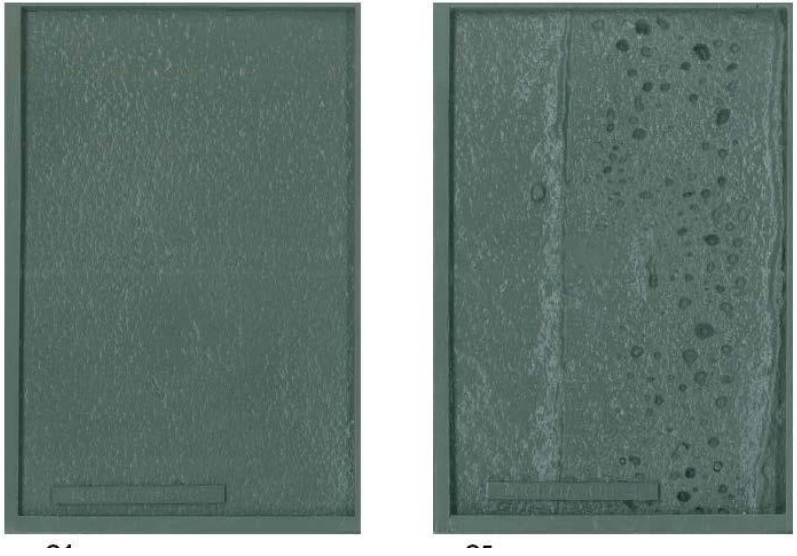
Visual inspection

Usually a normal procedure to check for surface abnormalities

Most common

Simplest and fastest

Doesn’t naturally give any info on internal defects

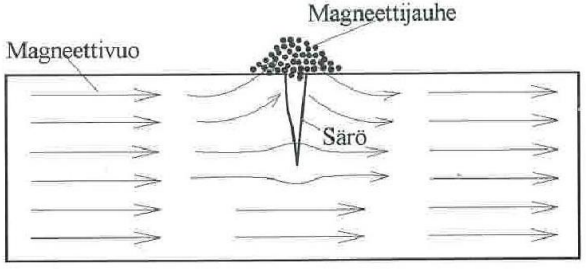


Magnetic particle inspection (MT/MPI)

Most satisfactory method for surface and near sub-surface defects

Quick, cheap and sensitive

Only suitable for specific ferrous (ferromagnetic) metals like many steels and cast irons



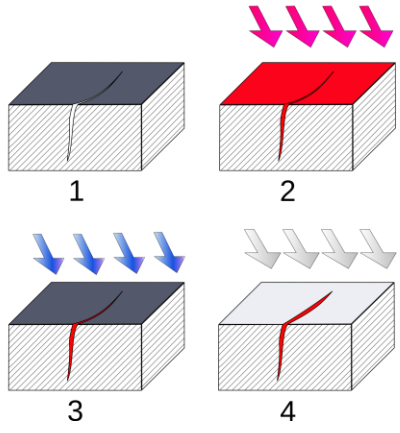
Magneettijauhetarkastuksen periaate.

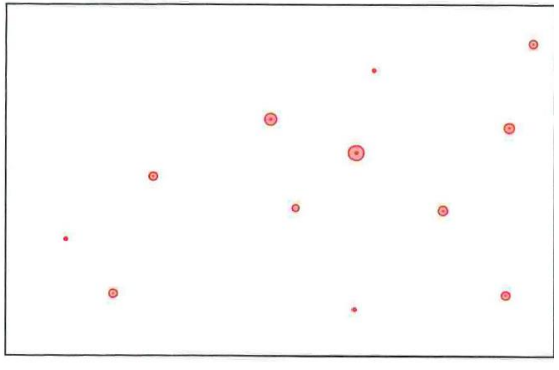
Penetrant testing

- Surface preparation (1)
- Penetrant application (2)
- Penetrant dwell
- Excess penetrant removal (3)
- Developer application (4)
- Indication development
- Inspection
- Clean surface

Quick, low cost and not material sensitive

Only for surface defects, some surface roughness limitations





Max. yks. indikaatio: halk 4 mm
Max. indikaatioiden pinta-ala 40 mm²

Quality level 3

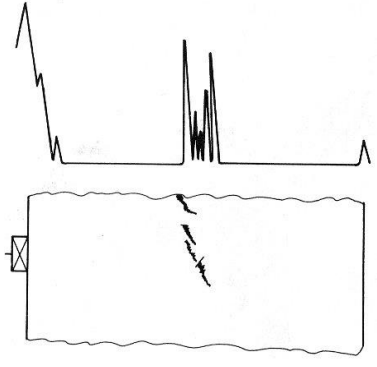
Ultrasonic testing (UT)

Defects reflect and create ’echoes’ in applied waves

Experienced inspectors can detect flaws deep in tested materials and analyse their shape and orientation

Requires extensive knowledge and sufficient surface preparation from the inspector

Ultraäänilaite

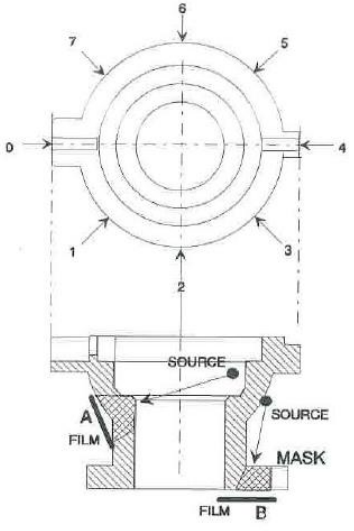


X-ray radiography (RT/XXR)

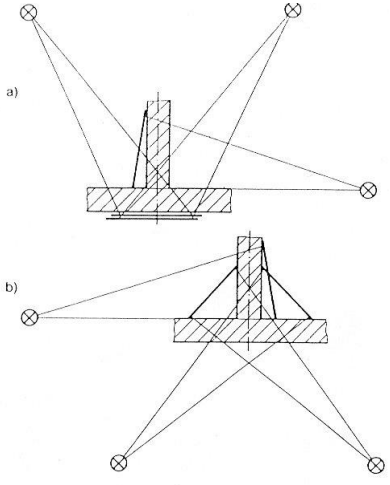
Effective in locating internal defects like inclusions, cracks and porosity

Suitable for all cast metals

High cost and safety issues



Esimerkki kuvaussuunnitelmasta



… and?

Inspection and quality levels are dependent on the bigger picture:

- **What is the part made out of?**
  - Chosen material affects possible inspection methods and normally attainable quality levels in a casting process
- **Where is the part used in?**
  - Higher mechanical requirements → Better quality level

Ask for what you need but nothing more! Demanding too much complicates everything and *you* pay for it.

Global markets

Purchasing of cast products

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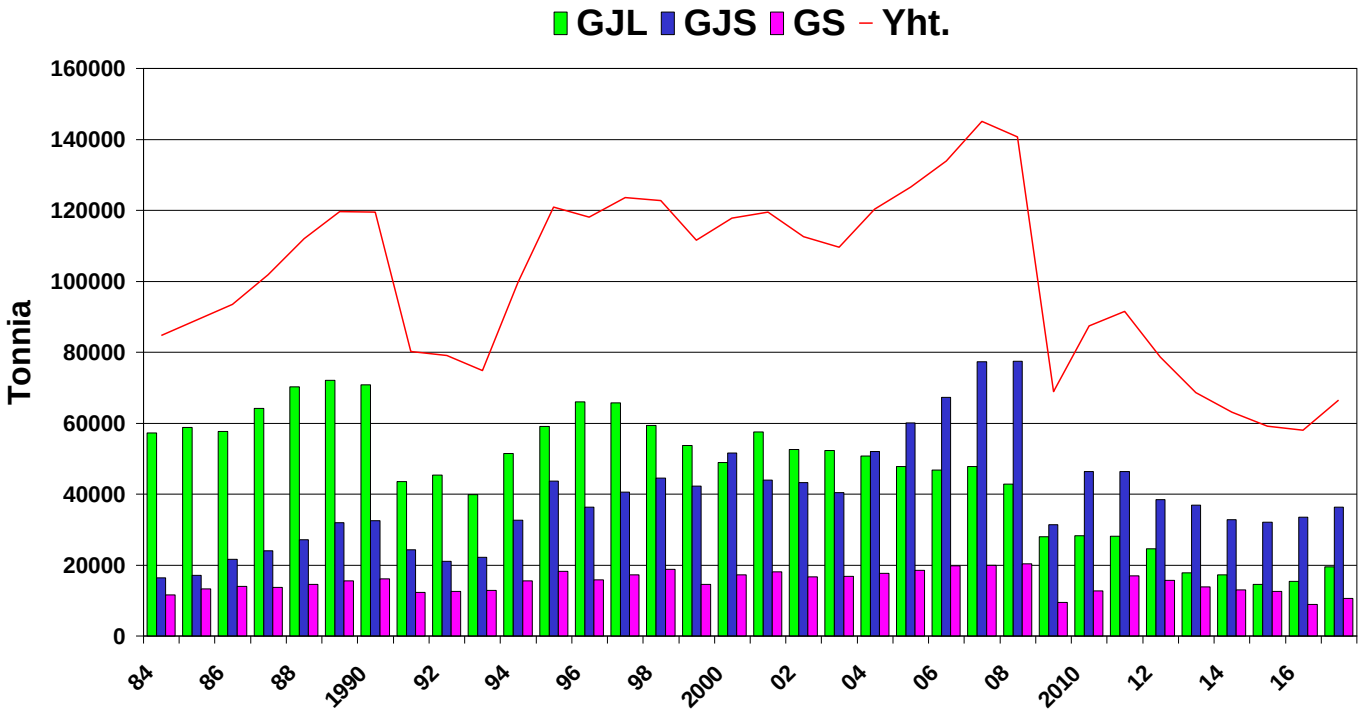
Production of castings in Finland

Customers image of the foundry industry and some cases

What resources are needed for global purchasing?

Total Cost of Ownership –concept

Ferrous metals production in Finland



Foundry industry in Finland

- General downward trend in most sectors after the global financial crisis in 2008, but also some upwards trend in cases like aluminium alloys and cast copper alloys. Corona year 2020 caused almost - 20 % decrease in production. Steel foundries are struggling.
- This year some good signals. Order books are good and after corona situation seems to be promising
- Anyhow lots of uncertainty in global markets and exports

Customers' image of Foundry industry

Passivity

Conservatism

Casting vs. other methods

- High startup costs
- Not much investment into new technologies
- More quality issues compared to other methods

Observations about choosing suppliers

- **Good references are of great concern**
- **Environmental aspects and comprehensive quality systems aren't crucial requirements in choosing suppliers**
- **Significant purchasing volume gives power to negotiate and get better service**
  - Focus purchases on chosen supplier
- **Especially with a new supplier, it's *all about money***
- **Request for quotations will be made for every new cast product**
- **Interest in a long-term cooperation**
  - Amortization of start-up costs
  - Breaking in a new foundry is expensive and takes a lot of time

Customers' experiences of Finnish foundries, negative sides

- Supply problems, lack of capacity and delays
- High price level
- Foundries aren't interested in small volume production and prototype castings
- Lack of flexibility
- Indirect costs are left for customer to pay
- Foundries aren't ready to build special networks
- Foundries are "always late"
- Managing of capacity is weak
- Foundries aren't able to offer competitively priced machining
- Finding the right partner is challenging

Customers' experiences of Finnish foundries, positive sides

- Design cooperation
- Technical know-how
- Flexibility
- Easy to stay in touch through whole organization
- With Finns they develop the product, with others they solve problems
- Deliveries daily when needed
- Taking advantage of 3D-models in production chains
- Availability and fast delivery times
- Management of product variations

Notice any similarities to the last slide?

Evolving trends of global purchasing

- **Cost competition is increasing**
- **Global purchasing seen as self-evident for more and more customers**
- **Customers want to reduce purchasing costs**
- **Delivery times force customers to search for new alternatives**
  - *New competitive chains won't be easily changed back to domestic chains*
- **Inquiries about purchasing single castings from China**
- **World has become smaller and smaller for young purchasers**
  - *No more extra points for Finnish production*
- **Purchasing of full-service packages**
  - *All cast-using interviewees are looking for this!*
  - *Customers want foundries to take care of machining, finishing and installation of additional parts*

Case: Konecranes
Applications of castings

Ductile and gray cast iron

- Pulleys
- Bearing wheels
- Cable guides
- Gear box housings
- Motor parts

Aluminium castings

- Gear box housings
- Motor parts
- Coupling boxes

Few steel- and zinc die castings

- Bearing caps

Most of the castings come through component suppliers!

Case: Konecranes

Status of purchasing

Dozens of casting suppliers

- Heavy growth through acquisitions → new suppliers

Large size variations

- Small chain elevator vs. harbor crane

Batch sizes vary depending on product from single castings to multiple thousands

Different materials

Objectives

Reducing the number of suppliers

At least two sources for critical castings

Location of the suppliers from the Konecranes-supply chains' point of view

Machining of the castings as close as possible to the foundry

Revealing of possible problems much faster

Possibilities of part finishing

Flexibility and swiftness of delivery times

Case: Wärtsilä

Tonnage of year 2009 product purchases about 50.000 tons

The number of casting suppliers altogether is 200 including services of so called spot-foundries

Cost of purchasing about 100 M € including machining of castings

About 10% from emerging markets (EM)

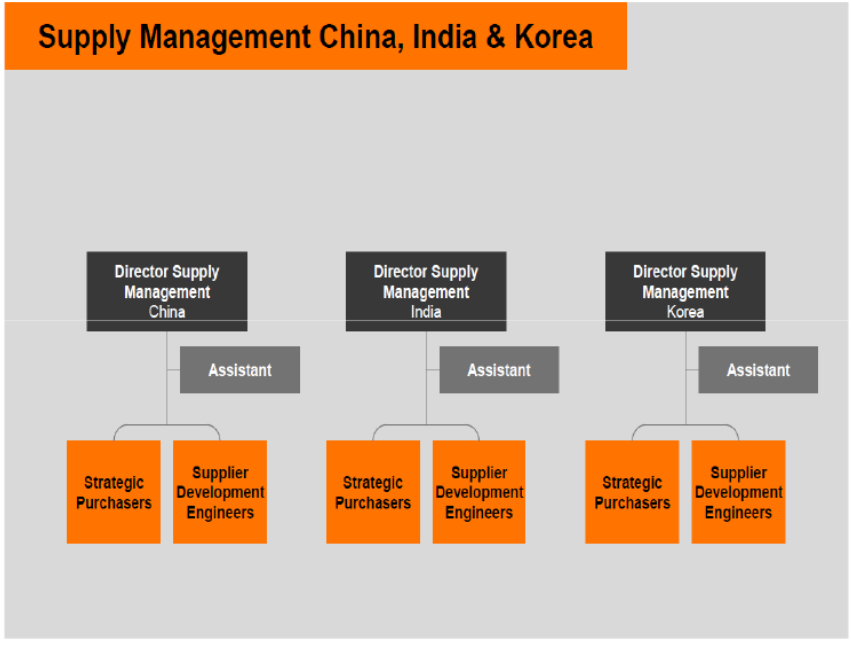
About 30 % of the medium size castings are purchased from EM countries

The most used materials are ductile and grey cast iron, in addition to heat-resistant iron such as SiMo (Silicon-Molybnenum) and aluminium castings

The amount of steel castings in engine production is low

Engine blocks represent 50% of the total volume, covers and other castings are both 25%

Case: Wärtsilä
Global purchasing organization structure



Case: Wärtsilä
Assets of Finnish supplier foundries

Casting patterns
– Patterns have modern design- and production methods
– Accuracy
– Materials in use are better, especially the quality of wood
– Lifetime of the patterns and maintenance intervals are longer.
– Plastic patterns.

Communication
– Finnish language
– Contractual usage, respecting the contracts, business culture
– Supplier visits are easily arranged

Comissioning of castings
– Co-engineering
– Need for test series is substantially smaller
– Swiftness of corrective actions of flawed castings
– Response time days instead of months

Transportation
– Transportation prices, logistics
– The swiftness of cargo, delivery in days instead of months
– No material damage like corrosion etc. caused by long transport times

Challenging castings
– Expertise in domestic foundries is much better than in EM countries
– Use of common sense

What resources are needed in global purchasing?

”How expensive is spheroidal graphite cast iron compared to grey cast iron?”

Anonymous

”Buy from a foundry until it’ll go out of business. Then move on to buying from the next foundry.”

Direktör Gösta Mattsson

Thuresson & Mörch

”I’ll buy prototype castings and pre-series from Finland, then I’ll transfer the mass production to low-cost countries.”

Anonymous

”Purchasing of castings is extremely easy - there is no mystique in it. If a new foundry won’t manage to deliver on time, I’ll be a returning customer for the previous supplier.”

Anonymous

”Delivery times and -punctuality are not listed in my job description.”

Senior Buyer Eddy de Vriese

Spicer Clark-Hurth

What resources are needed in global purchasing?

Adequate volyme

Methodical manner of working and perseverance

Possibility of big investments at the beginning

Language proficiency in whole organizations:
All instructions, forms and papers in English

Total Cost of Ownership (TCO)

”We never buy new castings from a new supplier.”

”Our principle is that we give the order and responsibility of deliveries goes to the most critical part of production chain - almost always it is a foundry.”

Inköpschef Arne Steen

Volvo Lastvagnar

”Purchasing cast products is extremely easy – cheapest offer wins.”

Anonymous

Total Cost of Ownership (TCO)

TCO = Purchase price + (O + T + M + W + E - S)

O = Operating costs
T = Transport costs
M = Maintenance costs
W = Warehousing costs
E = Environmental costs
S = Salvage value

Riggs et al 1998. The Executive's Guide to Supply Management Strategies. s. 77

Cheapest offer always wins?

…so?

Procedures when starting-up co-operation with new foundry

- Foundry Visit Report and Audit
- Paperwork or ”homework” has to be made well
- Don’t forget the people behind the papers
- Test deliveries with a known product, careful and truthful reporting

Common sense might save you from a costly mistake!

Ignorant purchasers make ignorant foundries

Call for tender

Request for quotation

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Shortly

You provide all the needed information that a foundry needs, and they'll make you an offer with costs to produce your product.

The foundry makes all calculations based on the information you have given, so the more you can provide the more specific of an offer you will get.

Critical things to convey

Own company details (and contact details)
Short description of what you are looking for
How many products is needed
- When are the parts needed?

What is the chosen material for your product
- What standard is it based on? Do you have additional material requirements?

What are the tolerances
- What standard are those based on?

Who will be responsible of tooling?
How the products should be inspected
- What is standard it is based on?

Other needs
Drawings

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Example

Company Oy
Address line 1
Address line 2
XXXXX City
Telephone number
Email

Foundry Oy
Contact Person
Address line 1
Address line 2
XXXXX City

Call for tenders

We would like to get the quote from your foundry for cast product, which is described in attached cast drawing 12345.67XX. Size of the series is 600 pieces in a year. We would like to discuss with you if you have some improvements to the manufacturability of the product.

1. Size of the series is 600 pieces in a year
    a. First delivery of 55 +/- 5 pieces no later than week 50
    b. Later deliveries can be agree on separately
        i. Monthly series will be around 55 +/- 5 pieces.
2. Cast material is spheroidal cast iron:
    a. Material is from standard SFS-EN 1563
    b. Name based on standard is GJS 400 – 15
3. Tolerances is based on standard SFS-ISO 8062 -3 (CT 10, RMA 2,5 (F))
4. We can agree on separately the delivery of the tools. Breakdown the costs of these tools.
5. Visual inspection based on Standard SFS-EN 1370 on every piece.
6. *Other demands*

Best regards

Company Person
Company Oy

Attachments

- Cast Drawing number 12345.67XX
- Machining Drawing 12345.89XX

Additional requirements

A foundry is able to make castings in such a way that basic requirements are met (based on the standards you've given), but *it may not be enough*. Test pieces give an indication of the castings' mechanical characteristics, but are only references.

Critical properties are defined in the order specifically the so-called *additional requirements.*

Additional requirements

Additional requirements should be recorded as clearly andunambiguously as possible

What is the required feature and how will it be tested

- If there is a standard for testing, a reference is made to it

Use test samples if you want to make sure that additional requirements have been met

Open and honest communication throughout the process of both parties save time and money

Casting design principles and standard foundry practices should be taken into account

- There might be problems that can not be solved in any other way than by modifying construction

Additional requirements

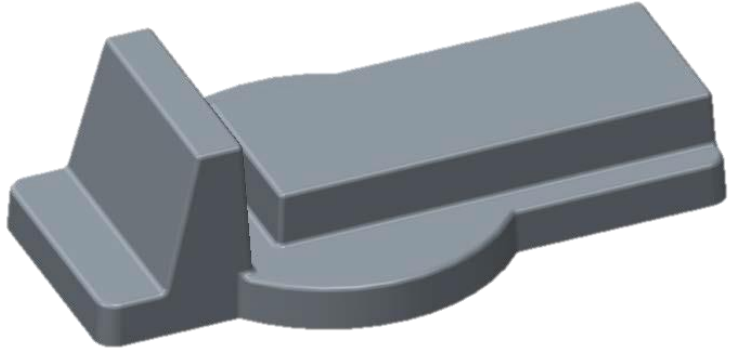
Additional requirements could be such as:

- Additional features defined in the standard, determined, for example, elongation in the specified location on the casting and the elongation of the test piece directly
- Other special tests in foundry
- Criteria for acceptable number of casting defects and quality
- Special requirements such as structure, corrosion resistance, and machinability
- Inspection and testing methods, evaluation criteria and how to test cast products
- Inspections and tests, and how to report them
- Special measures, such as castings for the production of stressed weld inspections
- Traceability, charge number, etc.
- Agreement on production welding
- Machining of products by foundry
- Surface protection and packaging
- How to follow ISO 9000 standards

Cast drawing

Shows what kind of products come out from the foundry

IT IS NOT THE END PRODUCT



Cast drawing

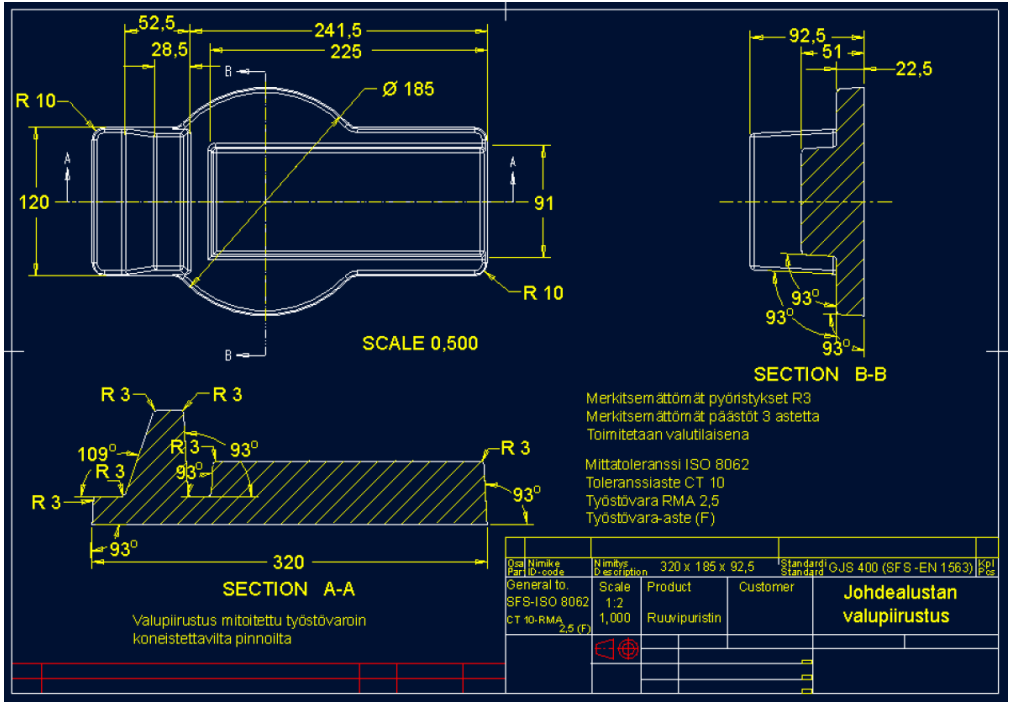
Cast drawing shows

- the external dimensions of the casting
- the required drafts and rounding
- required machining allowances (RMA-value) of the surfaces to be machined.

It shall also communicate verbally, for example, what kind of dimensional tolerance (CT value) is wanted

Required machining allowances, machining allowance grades, dimensional tolerances and dimensional tolerance rates can be found from the standard (ISO-8062-3).

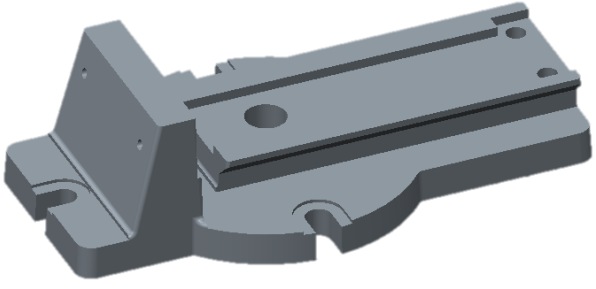
Cast drawing



Machining drawing

Shows what the *END PRODUCT* looks like

A raw casting is machined into and end product

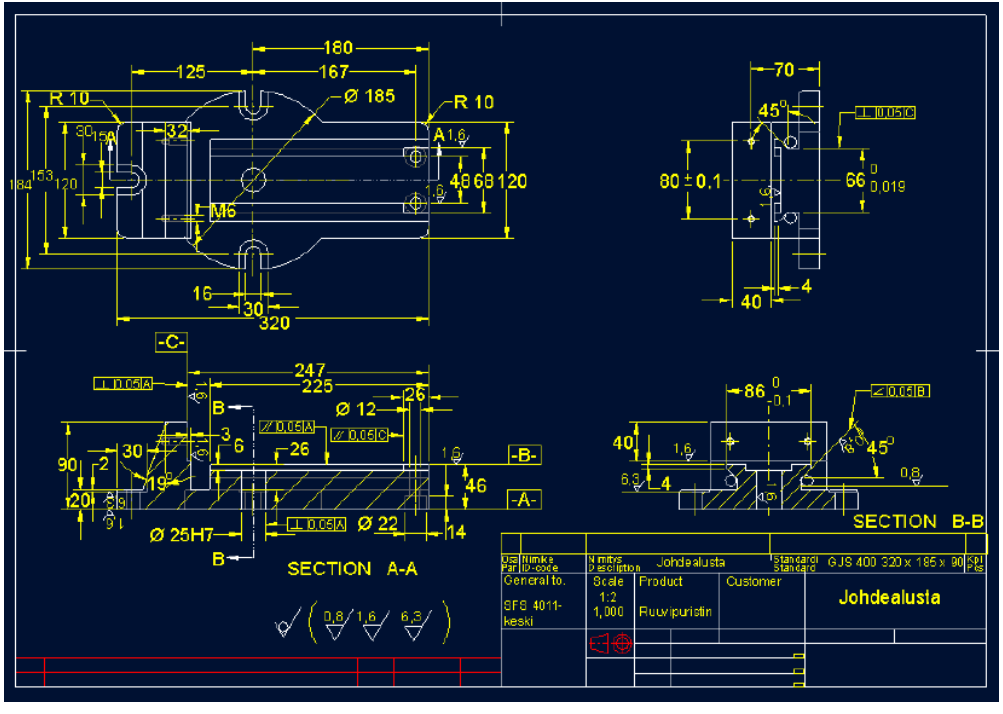


Machining drawing

Machining drawing must contain all the relevant information what the machinist needs:

- required dimensions
- surface roughness
- machining symbols
- tolerances

Machining drawing



Summary

In the end it is all about communication!

- You will communicate what you need
- The foundry will communicate what they can do to satisfy your needs

Drawings are part of the call for tender, with drawings you communicate what your product looks like