

# Sourcing Castings

A look at the global casting industry and  
some issues relating to sourcing and  
purchasing castings

*SUBCON 2009*

Dr Pam Murrell

ICME

(The Institute of Cast Metals Engineers)

- What is ICME?
- Why casting
- Casting processes
- Castings industry trends
- Cast materials
- Advice in sourcing and specifying castings
- Where to go for help/advice/training

# What is ICME?

ICME is the Institute of Cast Metals Engineers  
It is the professional members institute for  
individuals in the castings industry.

Our members are castings engineers, foundrymen,  
diecasters, metallurgists, patternmakers,  
researchers, designers, users of castings and  
suppliers to the industry.

# What is ICME?

ICME is a charity and aims to provide support, information and training to professionals working in the Cast Metals Industry as well as networking opportunities.

Like most professional institutes we can offer recognition of qualifications and experience (CEng, IEng and EngTech) in addition to our own grades of professional membership

# Why castings?

Essentially metal casting involves pouring molten metal into a cavity close to the final dimensions of the desired component.

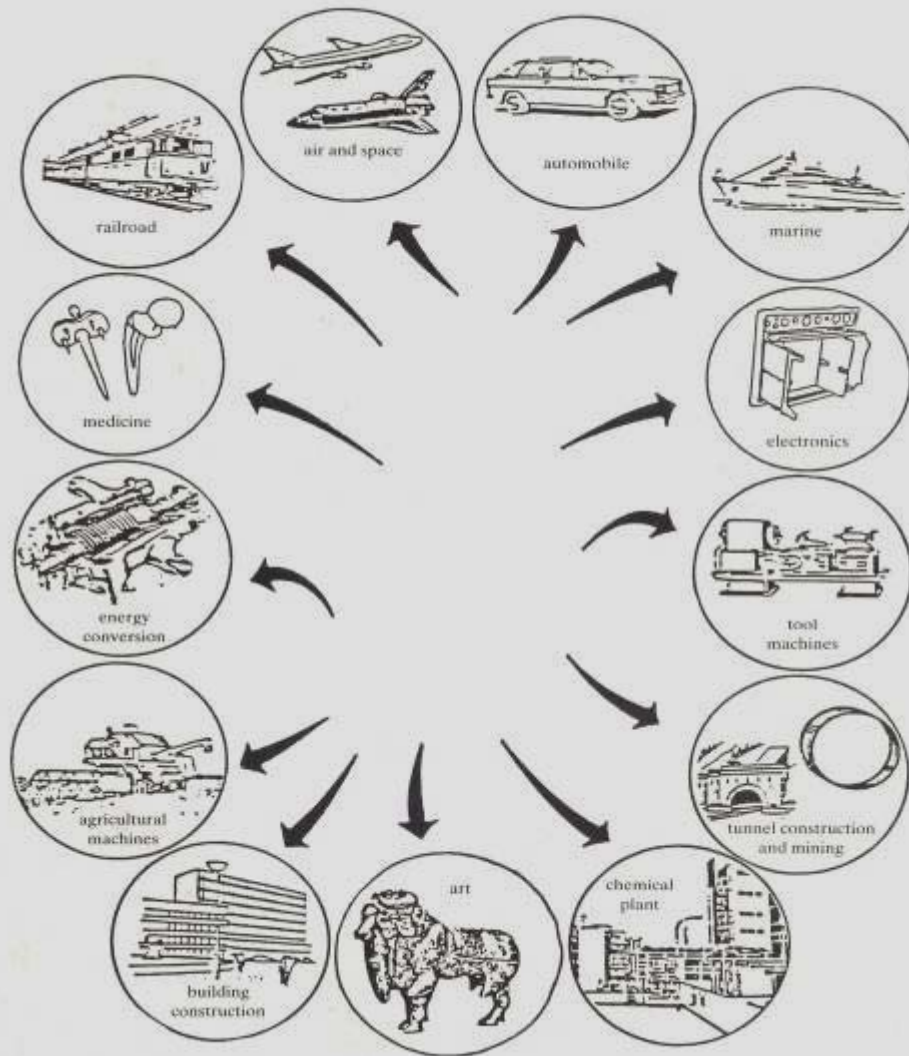
Casting still represents the most cost effective way of producing a wide range of components in metal and is the simplest forming method for metal parts

In fact casting represents the only way to make some components with complex internal cavities and hollow channels

# Why castings?

Consider for example cooling channels in engine blocks which would be impossible to machine.





Source:  
 Horacek,  
 WTF 2009

## Advantages:

Complex cavities and hollow sections

Machining reduced - cast in hollow sections

Good quality as-cast surfaces – process selection

## Other advantages

- Reduce process steps in production - remove welding and assembling.
- Alternative to machining from solid - which can also produce a one step operation, but which may not be cost effective, particularly for higher volumes.
- Weight reduction - thinner wall thickness

## Other advantages

- Use of 'cast-in' inserts to control properties within components - such as wear resistant faces.
- Avoid design weakness - introduced by welded joints.

Can be a very cost effective way of producing high volumes of components (hence use in automotive industry)

# Range of processes

Wide range of processes –

- sand casting,
- die casting, (gravity, low and and high pressure),
- investment casting,
- Newer processes, eg thixoforming, rheocasting

Also many rapid prototyping methods – most of which are based upon producing patterns and moulds quickly for one-offs or prototyping (resin patterns, direct machining of sand)

# Patternless Process®

Moulds are directly machined  
from blocks of sand:

No patterns or core boxes

Reduced time to manufacture

Reduced total manufacturing  
costs

Suitable for one-offs of small  
production runs

# Rapid Prototyping

Resin patterns are built up layer by layer – complex internal shapes are possible

Direct metal laser sintering – whereby complex metal parts are built up in fine layers



Image courtesy of 3T RPD LTD

# Full Mould Process

Pattern machined and assembled from expanded polystyrene blocks, surrounded by un-bonded sand in a casing. Liquid metal is poured in without removing the foam pattern, which vapourises



Image courtesy of Laceta et al,  
WTF 2009

# Castings Processes

Majority of castings are produced using the more traditional methods, sand, die, investment....

# How to choose the right process?

Factors include:

- Volumes / number off (tooling/pattern costs, capital)
- Parts per hour
- Component properties – (mech properties)
- Alloy – relates to properties
- Net shape
- Surface finish
- Castings size
- Component value

Eg high pressure diecasting would not be suitable for low numbers of parts due to the high capital costs involved with tooling and so on.

## 7 Considerations for potential casting conversions

- Geometry - is the component complex enough to warrant a redesign to a casting?
- Amount of welding - more welding in a component more likely it is suitable for conversion
- Number of parts - has the component been made up of several smaller parts - would a single casting reduce this number, freeing up in-house operations

## 7 Considerations for potential casting conversions, cont.

- Dimensional consistency - how tight are the tolerances, is warping an issue - dimensional inconsistency with fabrications can be eliminated by using a single casting
- Scrap rates - out source to reduce in house scrap
- Appearance - is a clean, streamlined appearance desirable - if so casting?

## 7 Considerations for potential casting conversions, cont.

- In service failure rates - castings can provide consistent properties throughout each component, eliminating the variability that can be inherent in assemblies and weldments

# Global Castings Industry, 2007\*

Total: 95 million tonnes  
(4% increase on previous year)

Germany	5.8 M tonnes
USA	11.8 M tonnes
China	31.3 M tonnes
Russia	7.8 M tonnes
India	7.8 M tonnes



\* Source: Modern Castings, Dec 2008

# Global Castings Industry, 2007\*

## Other significant players:

- Japan and USA both saw reductions in production.
- Big gains (>10%) in China, Russia, Poland,
- Gains – Turkey, India, Spain and Brazil

## Europe:

- Germany is the leader with 5.8Mt. It is also has by far the highest level of productivity per plant of all the other top 10 nations, followed by Italy and France
- Italy is one of the top four aluminium casting producers

\*Source: Modern Castings, Global Census, Dec 2008

# Global Castings Industry, 2007

Germany	596 foundries ↓
USA	2 130 foundries ↓
China	26 000 foundries →
Russia	1650 foundries →
India	4 550 foundries ↓

# Global Castings Industry

## Type of Casting:

Ferrous castings 79 Mt

Non-ferrous castings 16 Mt

**Total 95 Mt**

Source: Modern Castings World Census, Dec 2008

# UK Castings Industry

420+ foundries in the UK (0.7 Mt)

Geographically spread - main concentrations are in the West Midlands and South Yorkshire areas

Employs around 22 000 people

Wide range of products:

Paper rolls, rolls used in steel processing, medical implants, pumps and parts for nuclear and power industries (exported to China), automotive, machine tool etc.

# UK Castings Industry

Wide range of products produced in UK:

Paper rolls, rolls used in steel processing, medical implants, pumps and parts for nuclear and power industries (exported to China), automotive including F1, Aston Martin and motorsport, machine tools, wind energy components, turbochargers, pumps and valves etc etc...

# Trends in the Global Castings Industry

Prediction is for reduction in the EU for all market sectors during 2009 with the biggest reduction being in automotive - between 20 and 40%!

Machine building (-15% to -20%)

Construction and tubes (0 to -5%)

Wind Energy (Static or small rise (Germany))

This is a dramatic change since last summer

# Costs analysis – based on an automotive casting, produced in Germany \*

Materials – 22%

Operating materials – 7%

Energy – 20%

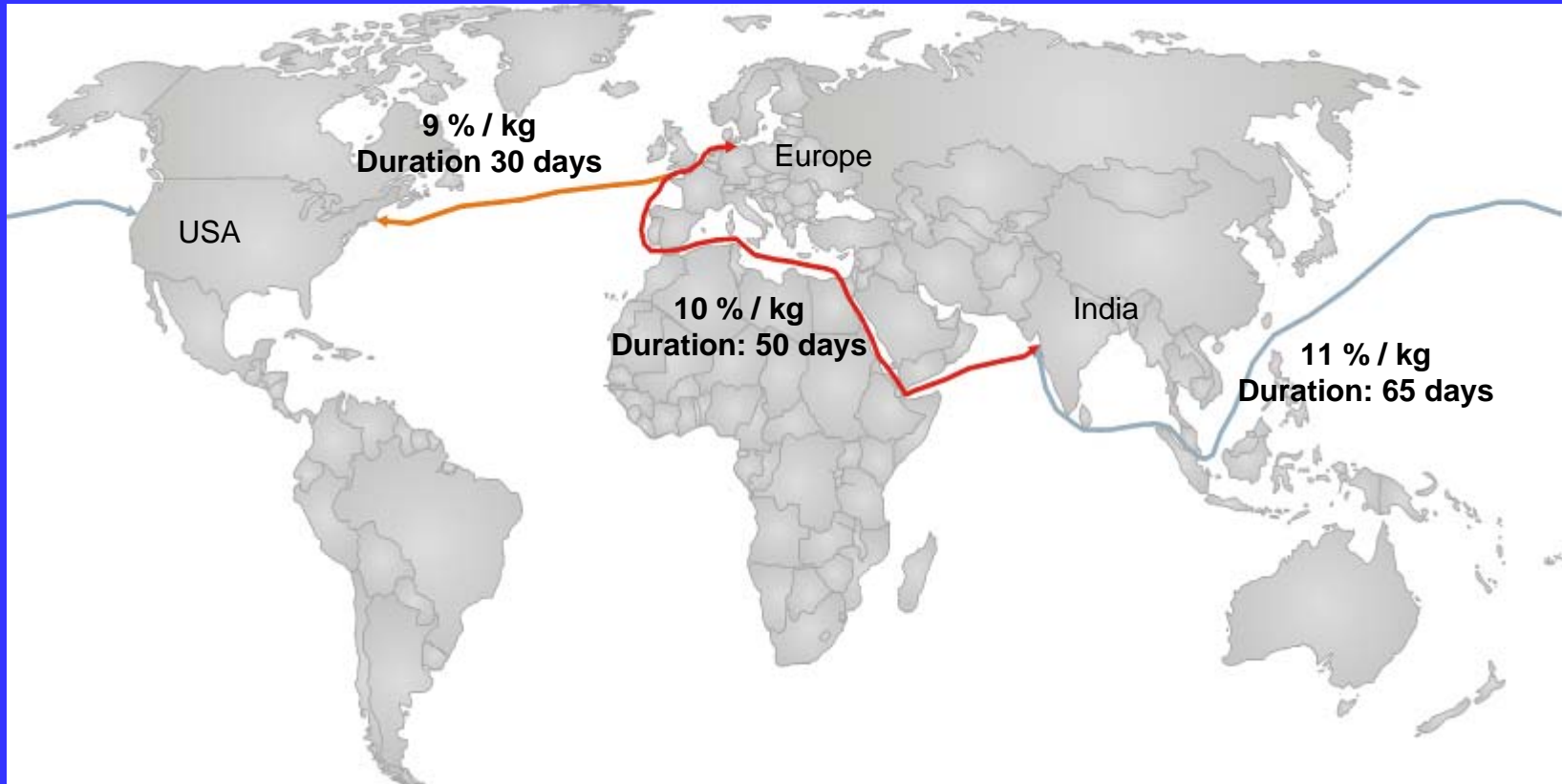
Labour – 32%

Capital costs – 12%

Other – 7%

\* Source: G Wolf, VDG, WTF 2009

# Shipping costs and delivery times



Source: G Wolf, VDG, WTF 2009

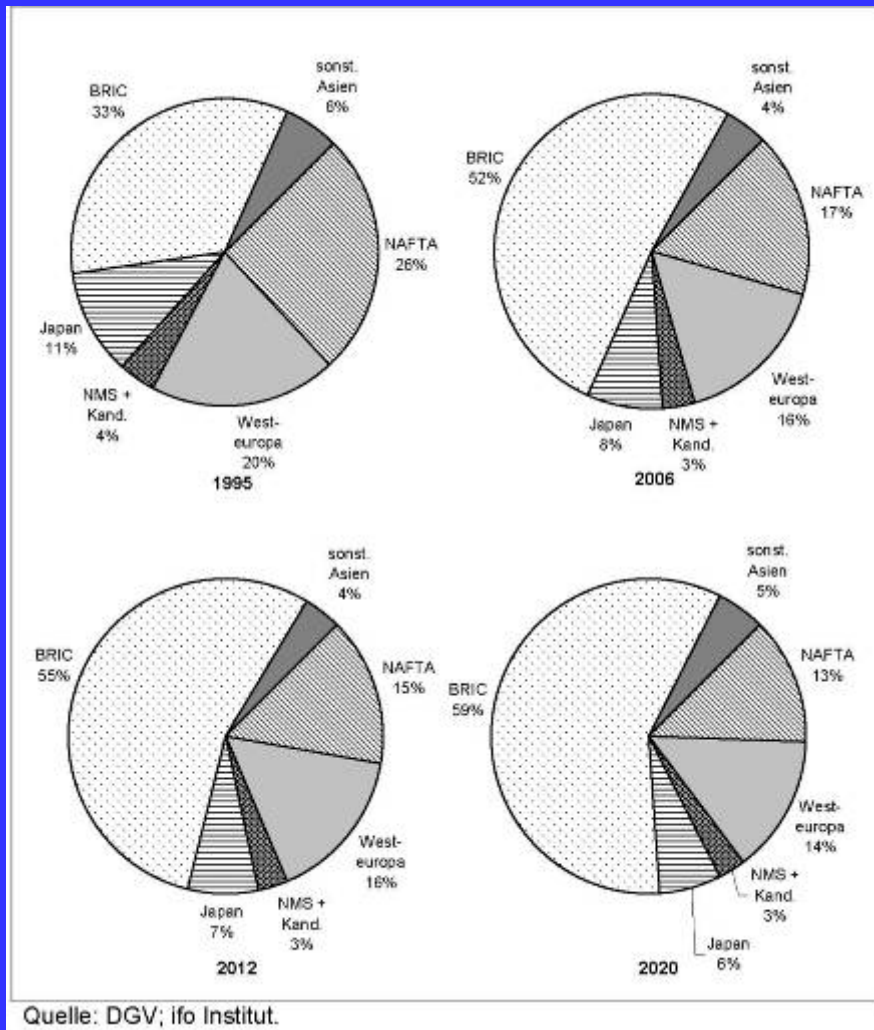
# Global Purchasing policy

Major customer to industry – casting not the most expensive part in the assembly but critical to production process

Purchasing Dept minimised number of castings bought to minimise costs – but multi-million pound projects were being delayed due to defective castings being delivered from the far east

Lack of overview and communication between purchasing and engineering.

# Worldwide movement in consumption of castings



Source: G Wolf, VDG, WTF 2009

NB: BRIC = Brazil, Russia, India and China, fastest developing economies

# Global vs Local Supply

Arguments: for and against	Global	Regional
Logistics - (JIT / Shipping time / Safety of production)	--	++
Quality costs	-	+
Development partnership	--	++
Cultural differences	-	+
Production costs		
Wages	++	--
Materials	0	0
Energy	0	0
Low value, high volume, continuous supply	+	-

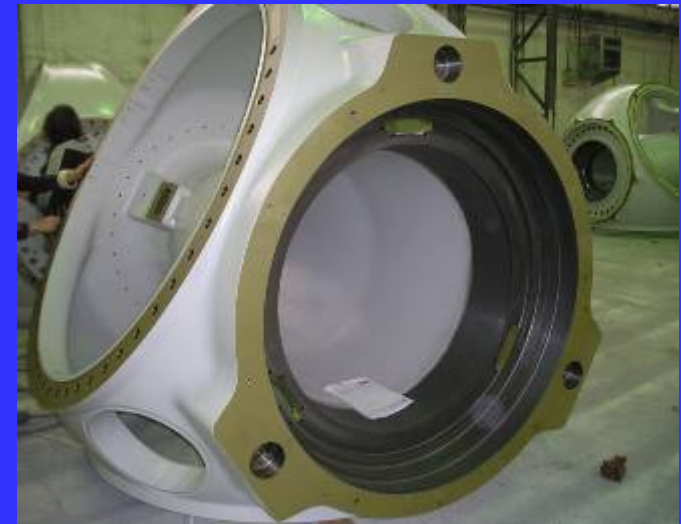
# Simplifying the supply chain

Many foundries are now seeking to offer complete assemblies or components to their customers, offering design services as well as finish machining, painting etc

Clearly, working with one supplier can be an advantage

Example of a finished cast component for the wind energy sector delivered by the foundry.

*J Leceta et al WTF 2009*



# Global Sourcing

- Foundries in the UK have had many pressures on them - raw material prices, legislation - env and H&S.
- Countries like China are now having to consider environmental pressures too, as well as having to cope with restrictions on energy usage and availability, but also there will be efficiencies
- China is also experiencing the same sorts of skills issues that the UK industry has experienced for many years

# Range of Materials and Properties

Non Ferrous - Aluminum, Zinc, Copper base alloys,  
Magnesium, Titanium

Ferrous – Steel, cast irons.

Growth over the last 20 years: in Ductile Iron and also  
Aluminium.

Also Magnesium in last 15 years

Aluminium – use in auto is still relatively low,  
particularly in structural parts

# Cast Irons

Grey irons (soft, 150 to 350 N/mm<sup>2</sup>) with very good damping and noise reduction properties, also very good in compression

SG (spheroidal graphite, nodular or ductile irons)

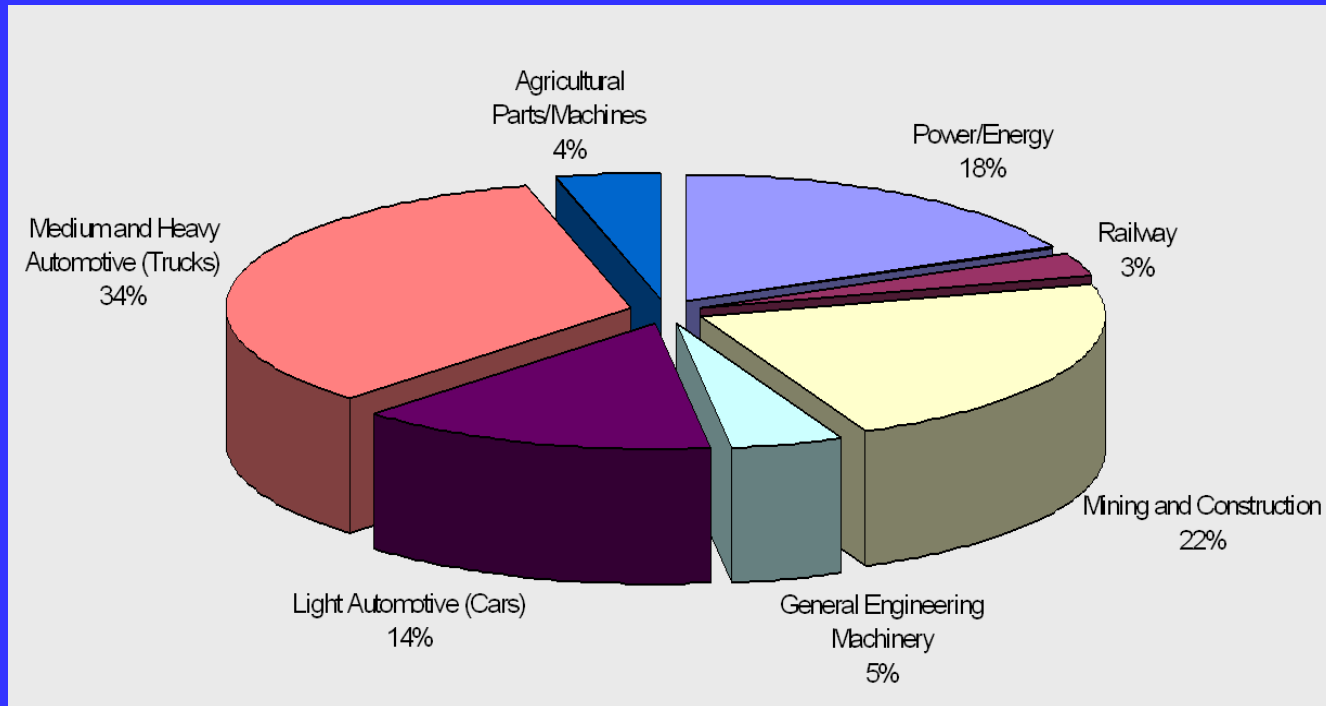
Austempered ductile iron, ADI - strength and ductility of steels (1000 to 1200N/mm<sup>2</sup> with 1 to 4% ductility) – issue is heat treatment.

Compacted Graphite Cast Irons, now being used for automotive applications (half way house between grey and ductile)

# ADI Properties

Norm ASTM 897-06 / 897M-06					
Grade	$R_m$ min.	$R_{p0,2}$ min.	E min. (%)	Impact test (Joules) <i>(without notch)</i>	Brinell HBW 10/3000/30
750-500-11	750	500	11	110	241-302
900-650-09	900	650	9	100	269-341
1050-750-07	1050	750	7	80	302-375
1200-850-04	1200	850	4	60	341-444
1400-1100-02	1400	1100	2	35	388-477
1600-1300-01	1600	1300	1	15	402-512

# Range of Materials and Properties



ADI market 2007 (Source. ADI Treatments Ltd, UK).

# Good Casting Design - *The Ten Rules*\*

1. Use the minimum wall thickness necessary to meet the performance criteria
2. Use gradual and progressive blends at section changes
3. Avoid isolated heavy sections
4. Avoid sharp corners and sharp re-entrant angles
5. Avoid heavy mass concentrations
6. Identify critical or special areas of the component
7. Identify key dimensions and tolerances
8. Identify any jigging or fixture points
9. Quantify the quality and material specification consistent with optimum economy and fitness for performance
10. Liaise with a castings expert at an early stage of the design process

\* List reproduced with permission of Castings Technology International

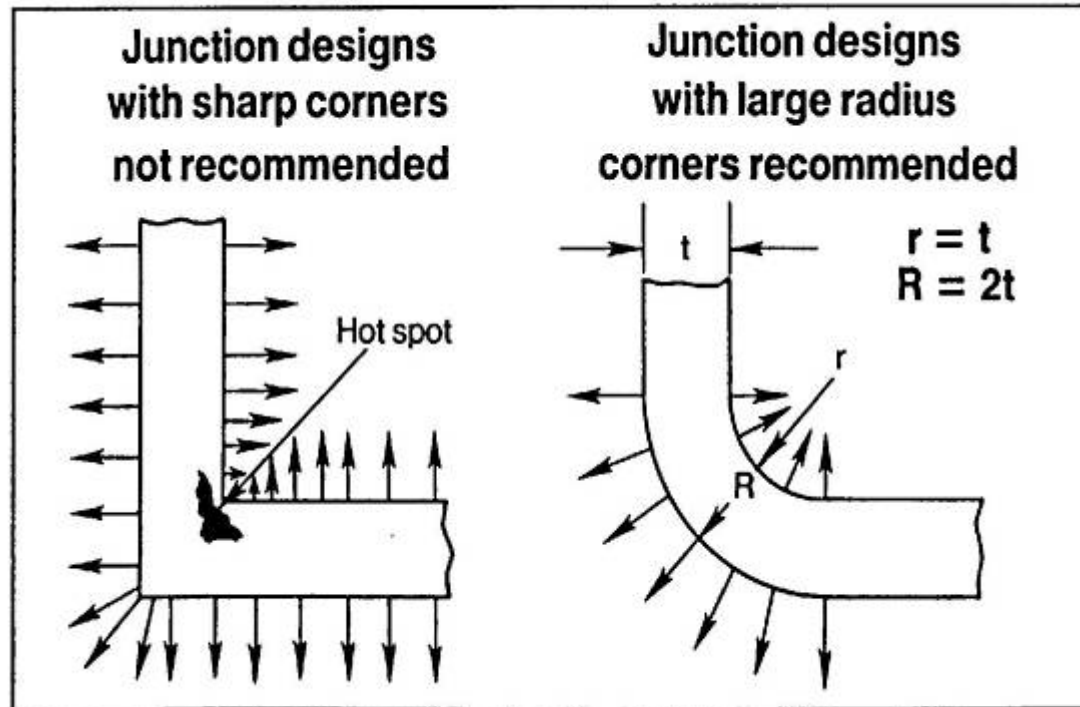
# 1. Use the minimum wall thickness necessary to meet the performance criteria

One way to reduce weight is to reduce wall thickness.

Overdesigning (over-engineering) the casting gives it both a weight penalty and a cost penalty, due to increased material and processing costs, which may make the casting superficially less attractive compared to another process route.

But be realistic! Thin-walled castings can result in mis-run (short-run) and relative dimensional accuracy.

## 4. Design optimisation



Heat from both faces in the corner heats up the adjacent sand mould, delaying the solidification of the adjacent part of the casting, leading to the formation of shrinkage.

Courtesy of Castings Technology International

## 6. Identify critical or special areas of the component

- Design criteria and analysis data
- Highly stressed areas
- Critical surfaces
- Machined surfaces
- Areas of high quality
- Cosmetic areas

## 6. Identify critical or special areas of the component

There will be areas of the casting where shrinkage or defects of any size would be unacceptable.

However, in general, this will not be the case for the whole casting.

Take advantage of this.

## 6. Identify critical or special areas of the component

Use gauges, templates and diagrams to assist with inspection.

For example a marked up sheet of Perspex or a colour-coded diagram that operators can use during inspection:

red = no defects

orange = level one defects (specify a max limit)

green = larger defects may be tolerated

## 9. Quantify the quality and material specification consistent with optimum economy and fitness for performance

- Material properties to suit cast parts
- Take advantage of cast materials
- Specify surface quality
- Specify internal quality
- Apply fitness for purpose
- Do not over specify

## 9. Quantify the quality and material specification consistent with optimum economy and fitness for performance

### Set realistic criteria

It is possible, of course, to produce castings to very high levels of quality, for example single crystal turbine blades, castings for aerospace, nuclear, automotive applications.

But also machine beds, non safety critical parts, non-load bearing areas ...

The earlier design changes are incorporated, the cheaper the design change will be.

Design changes at a late stage are much more expensive in terms of design revalidation, rework to patterns or tooling.

Communication with supplier at an early stage - at the design stage.

There will be many opportunities to make savings by taking advantage of the versatility of the casting process.

Set realistic and applicable criteria particularly with regard to quality control.

The simpler the process, the more cost effective it is likely to be.

Don't over specify!

Quality = fit-for-purpose NOT perfect.

# Materials specifications

Grey iron microstructure

# Consider Grey Cast Iron

Cooling rate affects structure and properties of grey irons to a greater extent than other alloys

Cooling rate affected by:

- pouring temperature
- volume or mass of casting
- thermal properties of mould/core.

Thin sections, rapid cooling – fine structure

Heavy sections, slow cooling – coarser structure

# Grey Cast Iron

Because grey iron is section sensitive grades are often defined by separately cast test bars

Clearly then different parts of a casting, with different section thicknesses, are likely to have different properties, and certainly properties that are different from those obtained in the test bar unless they have the same cooling rate.

Some users therefore request test bars to be taken from particular positions in the casting to ensure the correct mechanical properties in the casting are met.

This example, using grey cast iron, serves to illustrate how an understanding of the particular metal or alloy will help ensure that the correct specification is laid down.

Separately cast test bars will be cheaper, test bars taken from the casting will be more expensive but more representative.

Early communication with the foundry will help.

# Good Practice in Specifying

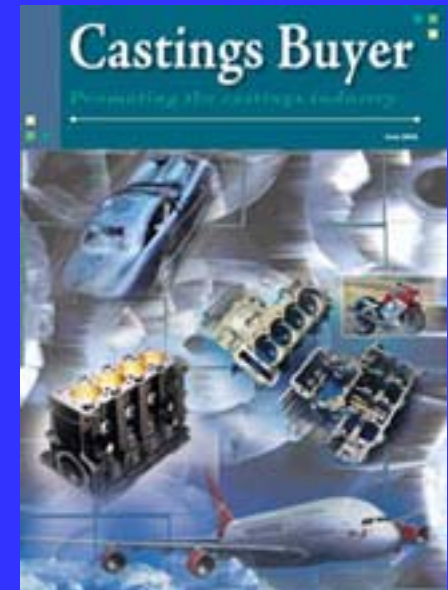
- Communication with supplier at an early stage - at the design stage
- There will be many opportunities to make savings by taking advantage of the castings process
- Set realistic and applicable criteria particularly wrt quality control.

# Where to get extra help or advice

1. Foundry Yearbook and Casting Buyers Directory
2. Castings Buyer - free journal aimed at end-users

From ICME, [www.icme.org.uk](http://www.icme.org.uk)

**Cast Metals Federation** – Industry Trade body - free on-line casting sourcing directory: [www.castmetalsfederation.com](http://www.castmetalsfederation.com)



# Training

Short courses include:

Casting Metallurgy, Introduction to Processes

plus

New Foundation Degree in Casting Technology

plus

Casting Design training courses

[www.icme.org.uk](http://www.icme.org.uk)



Thank-you

Institute of Cast Metals Engineers