Zinc Die Casting Process Audit - India

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Introduction

The aim of any zinc die casting process is to manufacture zinc castings that meet the customer’s requirements at the lowest possible cost.

This audit tool provides a step by step method by which an external or internal auditor can assess all of the main zinc die casting process factors that make up the cost of producing zinc die castings and guides actions to improve the process.

• **The first stage audit** combines recording of process data plus a scoring system that enables individual factors to be rated. The scoring system enables identification of the lowest rating factors as well as those that contribute most to increasing cost and therefore enable improvement actions to be prioritised.

• **The second stage audit** focuses on actions that can be taken to improve the process.

• When actions have been taken to improve the process another first stage audit can be done to assess the improvements achieved both at an individual element as well as at groups of levels and overall.
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1. Process Elements

This section is a guide for the audits, outlining the important elements of the zinc die casting process. It is not a detailed technical review. For more detailed information contact IZA. This overview outlines practices that will lead to production cost minimisation and casting quality optimisation, even though at times these practices may incur higher initial costs.

1. Zinc Die Casting Alloy buying, melting and recycling

1.1 Alloy Buying

• While cheap zinc die casting alloy ingot is sometimes available, it is possible that this does not meet the required specifications.
• It is recommended that zinc die casting alloy ingot is always bought against a known international standard for example Indian (IS), USA (ASTM), European (CN), Japanese (JIS).
• It is recommended that, regardless of the quality of castings being made, the alloy ingot supplier be requested to provide analytical details of all shipments delivered.
• It is recommended that regular checks of the composition of purchased ingots be undertaken to ensure that the material does in fact meet specification. If in house analytical equipment is not available this can be done by supplying samples to a qualified external analytical laboratory Note – Proper sampling of ingots is essential to ensure that the analyses are valid. Refer to sampling standards for detail
1. Process Elements

1.1 Zinc Die Casting Alloy buying, melting and recycling (continued)

1.1.2 Ingot Melting and Recycling of Sprues, Runners and Uncoated Recycle (SRR)

• Almost all zinc die casting is now done on hot chamber die casting machines on the basis of it being the most cost efficient method. On this basis the remainder of the discussion here focuses on the hot chamber die casting machine process. **Note – there are special circumstances where cold chamber die casting machines may be necessary (e.g. when casting the high-Al zinc alloys) or are a good choice.**

• While it is common to melt both ingot and SRR in hot chamber die casting machine pots this is not best practice except for operations with only 1 or 2 die casting machines or where floor space is limited.
1. Process Elements

1.1 Zinc Die Casting Alloy buying, melting and recycling (continued)

1.1.2 Ingot Melting and Recycling of Sprues, Runners and Uncoated Recycle (SRR) (continued)

- The preferred method is to use a central melting furnace with automated transfer of molten alloy. The benefits are:
  - Improved capability to blend ingot and SRR in correct proportions
  - Avoidance of significant metal temperature fluctuations in die casting machine melting pots
  - Avoidance of hot spots in die casting machine pots with consequent increases in dross make and reduction of pot life.
  - Removal of ingot and SRR stacking around the die casting machine, that improves access to the machine and reduces OH&S issues
1. Process Elements

1.1 Zinc Die Casting Alloy buying, melting and recycling (continued)

1.1.2 Ingot Melting and Recycling of Sprues, Runners and Uncoated Recycle (SRR) (continued)

• Typically a central melting furnace is designed to provide the molten metal requirement of around 8 to 10 die casting machines. The most common type uses a correctly specified cast iron or stainless steel melting pot that is divided into two sections – one for charging the ingot and SRR and fluxing, the other for ladling clean metal for delivery to the die casting machine pot.

• The most common type of auto metal transfer uses a robotised ladle that will scoop a measured amount of molten alloy from the central melting furnace and then transfer this on demand to a particular machine pot.

• Molten alloy demand is controlled by sensors in each die casting machine pot which signal the ladle when the molten metal level reaches a set minimum level.

• Other methods such as pump operated transfer crucibles and constant height launder systems are also available.

• Central melting requires collection of the SRR at the die casting machines / trimming machines in bins that are then taken to the central melt furnace. Often a simple lift system is used to empty the bins of SRR into the central melt pot. Conveyor systems can also provide an efficient transfer system from the die casting machine to the central melt furnace.

• Shredders might also be considered to make transportation and charging of the SRR easier.

• It is generally recommended that the % of SRR be 50% or less. However if the casting yield (see 1.3.1) is less than 50% it is not possible to achieve this without selling some SRR.
1. Process Elements

1.1 Zinc Die Casting Alloy buying, melting and recycling (continued)

1.1.2 Ingot Melting and Recycling of Sprues, Runners and Uncoated Recycle (SRR)

- Overall die casters typically produce dross at around 3 to 5% of ingot consumption. So a figure of <3% represents a better than typical operation while >5% is worse than typical and so improvement is possible and desirable.
- Dross make is heavily influenced by casting yield which is discussed later (see 1.3.1), but will also be increased by excessive temperatures in melting furnaces, hot spots in crucible walls due to poor burner design, poor skimming practices and dirty material due to failure to store the SRR and ingot in clean and dry conditions.
- Die casting machine potsshould not be skimmed too often as this will expose clean molten metal more regularly to oxidation. Skimming once per shift should be sufficient.

1.1.3 Other Recycling

- Other recycle materials generated include dross skimmings, swarf (machinings), floor sweepings, painted and electroplated reject castings.
- Many die casters sell these components to outside recyclers. This is often the best approach as long as the selling price is reasonable. For dross a typical selling price is 65 to 70% of ingot price, and for electroplated reject around 70 to 75% of ingot price is common.
- If these materials are recycled in house, the recycle process should be assessed in term of a) the yield, b) the quality of the recycled metal (this needs assessment by analyses and also any impact on castings when re used), c) the cost of processing and d) the control of fume.
1. Process Elements

1.2 The Die Casting Machine

The die casting machine provides the energy for high speed injection of molten metal and locking of the die to avoid opening (flashing) during metal injection.

1.2.1 The Injection System

• For all zinc die casting it is recommended that the gate speed should be between 40 and 50 metres/second. For electroplated castings the cavity fill time should be around 0.02 seconds and for other castings no more than 0.04 seconds. Gate speed is the most critical factor in defining casting quality. Whether these conditions are achieved is defined by the metal pressure that the injection system can generate at a certain flow volumes at the gate. These factors can be measured by injection monitoring.

1.2.2 The Locking System

• The locking force that the die casting machine can generate versus the combined effect of the projected area of the shot and the metal pressure at cavity fill is the fundamental determinant of whether the die will flash or not. However other factors such as the mould size versus the area between the platens, the layout of the cavities and the feed system and the condition of the mould and its components will also define whether flashing occurs.

• The actual locking capability of the machine can be measured with suitable monitoring equipment.

1.2.3 Shot Cycle Time

• Shot cycle time is a process setting. It comprise of a number of components that are set individually. It is a significant factor in defining the cost of the casting. Smaller machines tend to have shorter cycle times than larger machines, so it is best to use the smallest possible machine (defined by locking and injection) for the part or use multi cavity dies on larger machines.

• The hold time after casting which usually represents a significant percentage of the cycle time, and is mainly defined by the design of the die (see Section 1.3).
1. Process Elements

1.2 The Die Casting Machine

1.2.4 Observable Factors

These are the factors that can be readily observed during an audit; more detailed measurement requires specialised monitoring equipment.

- **First to second stage change** – Most modern hot chamber die casting machines have two speed injection, a slow first stage and a fast second stage. The change over point from slow to fast speed should be set so that full second stage speed is reached as the metal reaches the gate.

- **Injection pressure and second stage speed** should be set to give optimum casting quality, particularly surface quality.

- If optimised setting of these causes flashing, investigation is required to define why the die is flashing.

- Check that the **maintenance schedule** follows manufacturers specifications.

- **Visible water and oil leaks** give a reasonable guide that the die casting machine may not be well maintained.

- **‘Plunger creep’** is the continued movement after the fast second stage is completed (the plunger should stop at this point). ‘Plunger creep’ will indicate worn piston rings and/or shot sleeve and suggests poor maintenance.

- **Plunger creep** means that the final “squeeze” of molten alloy into the cavity at cavity fill is not happening and may mean less than optimal cavity fill conditions.

- Often plunger creep is associated with bubbling of molten alloy around the top of the injection piston at the end of the injection stroke. This increases dross make.

- **A noisy pump** suggests that the pump vanes are in poor condition and/or the hydraulic fluid is in poor condition

- **Machine cleanliness** and general repair are also indicative of its operational condition.
1. Process Elements

1.3 The Mould/Die

While the whole design and manufacturing of the mould/die play an important role in determining casting quality, operating efficiency and die life (all casting cost determinants), the most critical elements of mould design are feed system design and thermal design.

1.3.1 Feed System Design

• The best method devised for designing the gate and the associated runner system, that brings the molten metal to the gate, is referred to as the tapered runner system, which features continuous and smooth reduction of cross section area of the feed system from the nozzle to the gate.

[Diagram of nozzle outlet and gates with section area bars showing A, B, C, D, E+F+Gate 2, Gate 1+2+3]
1. Process Elements

1.3 The Mould/Die

1.3.1 Feed System Design (continued)

- Feed system design via the tapered runner method begins with defining the best way to fill the casting shape (filling pattern) – that is how the metal flows through the cavity and pushes the air in the cavity out through the vents. This is then achieved by designing a gate and runner that will give the desired cavity filling pattern.

- Good filling pattern - air pushed ahead of uniform metal flow

- Poor filling pattern resulting in flow around the outside of the cavity and air entrapment

Air pushed out through vents

Vents blocked off before cavity fills

Gate

Gate
1. Process Elements

1.3 The Mould/Die

1.3.1 Feed System Design (continued)

- Once the gate and gate runner has been designed, the runner system is designed such that it tapers (reduces in cross section area) continuously and smoothly from the nozzle outlet to the gate. It features large radius bends and runners of ‘modified square’ cross sections. These features will minimise pressure loss, air entrapment, and loss of heat in the metal as it flows through the feed system.
- Typically, gates are long and thin (0.2 to 0.5 mm), however shorter, thicker gates are sometimes preferred for thick castings.
- Sufficient venting should be used. Overflows waste metal and should be minimised e.g. sometimes they are necessary as positions for ejector pins.
- Feed systems can be partly evaluated by simple measurement of cross sections along the length of the runner(s) and gates.
- The feed system should also be matched to the die casting machine injection capability to ensure that optimum filling conditions are achieved.
1. Process Elements

1.3 The Mould/Die

1.3.1 Feed System Design (continued)

- **Casting Yield** – this is the casting weight divided by the shot weight expressed as a percentage. Good tapered runner feed systems will deliver yields of **60 to 70%**. Yields below this level often indicate that the feed system design can be improved. It is quite common to see **levels of 30% or less**. Improving yield can significantly reduce casting cost via less ingot consumption and less recycling.

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Casting Runners

Overflows

Sprue

Total Shot Weight = 200 grams

Casting

Casting Weight = 75 gms

Casting yield % = 75/200 X100 = 37.5%
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1. Process Elements

1.3 The Mould/Die

1.3.1 Feed System Design (continued)

- **Casting Yield** – Example of a high yield and low yield shot

Low yield shot

High yield shot
1. Process Elements

1.3 The Mould/Die

1.3.1 Feed System Design (continued)

- Optimal filling conditions are:
  - High gate speed in the range 40 to 50 metres/second.
  - Cavity fill time of around 0.02 seconds for electroplated castings and <0.04 seconds for other casting types.
  - Of these two factors achieving high gate speed is of primary importance.
  - While machine injection measurements are needed to actually measure these factors, some idea of whether levels are appropriate can be achieved during an audit by observation of casting surface quality and by observation and variation of injection pressure and second stage speed valve setting.
1. Process Elements

1.3 The Mould/Die

1.3.2 Thermal Design and Control

Thermal design is about controlling the temperature of the parts of the die that are in contact with zinc metal (cavities and runners) at optimum levels. Zinc die casting die cavity surfaces are commonly found to be running at less than optimal temperatures.

- **Recommended cavity temperatures**
  - Electroplated castings – 190 to 210°C
  - Painted castings – 170 – 190°C
  - Engineering castings – 150 – 170°C

- Cavity and runner temperatures can be readily measured with hand held surface contact thermocouples and meters, than can be purchased at relatively low price.

- Measurements should be made immediately after the die is opened and the mould spray applied. The temperature will drop rapidly when the die is left open.
1. Process Elements

1.3 The Mould/Die

1.3.2 Thermal Design and Control (continued)

- Any audit of thermal design should begin with measurement and charting of operating temperatures of existing dies to check actual operating temperatures and variation across cavities and from cavities to runners.
1. Process Elements

1.3 The Mould/Die

1.3.2 Thermal Design and Control (continued)

- Die temperatures vary across production runs, particularly being lower when production starts after a break. Sometimes steady operating temperatures are not reached until a relatively large number of shots have been produced. Those castings produced at lower temperatures can be of significantly lower surface quality than those at the steady operating temperature thus impacting on reject and recycle rates.
1. Process Elements

1.3 The Mould/Die

1.3.2 Thermal Design and Control (continued)

- Lower than optimal die temperatures are usually linked to die design and often in zinc die casting due to excessive cooling channels or cooling channels being located where they cool inappropriate parts of the casting.

- **Cycle time** also impacts on die temperature. The longer the cycle time the lower the mould temperature

- **Computer based thermal design packages** are available but significant improvements can often be made by measurement and charting of temperatures, varying the cycle time and water flows and linking the observations of cooling channel positions on existing dies to new dies when they are being designed.

Example of cooling channels that are cooling cavities as well as runners – a typical situation when cavity temperatures are too low
1. Process Elements

1.3 The Mould/Die

1.3.2 Thermal Design and Control (continued)

- Zinc die casters should more often consider the need for **die heating systems** as sometimes additional external die heating will be needed to achieve the desired temperature, particularly for thin wall castings.
1. Process Elements

1.4 The Die Casting Area Layout

- **Central melting and auto ladling of molten alloy** – The benefits of this were discussed in section 1.1.1. If used this will dictate to a significant extent the layout of the die casting area as the die casting machines will need to be lined up so that they are accessible to the auto ladling. However the dictated layout is often also optimal as the basis for good overall layout.

- There should be **sufficient spacing** between the die casting machines for ready access to all parts of the die casting machine.

- Each die casting machine should ideally be located within a “**sump**” that will isolate any liquid leaks – oil, water, die spray and molten alloy that is spilt. This can be part of a raised plinth or in-ground setting. This combination forms a cell for each machine.

- **All services** – gas, electricity cabling, die spray lines, water lines should be routed to the cell in a way that they are sub floor or overhead, that is there are no service pipes that impede operator movement around the machine.

- If gas or oil are used to heat the die casting machine pot **dedicated exhaust systems** that remove the fume/smoke from the die casting machine area should be installed. These usually require forced exhaust – that is a central fan and fume scrubbing system.

- Whether cast shots are manually picked from the die, drop out of the die by gravity or are picked by a robot, the optimal collection system is a **conveyor**. This may be fitted with fans to force cool the shot. Decorative castings should not be dropped out of the die or stacked on top of each other.

- **Robot pick off** can also be set up to directly feed castings to a trimming press. In this case the layout must provide good working space for both the die casting machine the robot and the trimming press.

- A conveyor optimises manual trimming of castings and then stacking both the castings and recycle in suitably designed bins or special containers. Storing either full shots, castings or recycle sprues and runners on the floor is poor practice.

- Conveyors also optimise manual feeding of castings into a trimming press. Locating the trimming press at the end of a conveyor forms a practical manufacturing cell. Trimming adjacent to the die casting machine is recommended.
1. Process Elements

1.4 The Die Casting Area Layout (continued)

- **Sprues, runners and uncoated reject castings (SRR)** should be placed in bins that can then be readily transported by hand truck to the central melt area for remelting. It is also possible to set up conveyors to transport SRR directly back to the central melt furnace.

- One mistake often made with auto ladling is that **the ladle is too far above** the small pouring launder that convey the molten metal back into the die casting machine pot, resulting in splashing and increased dross make.

- **Die spraying** should always be done via a spray gun that has a suitably fine nozzle spray system attached to a central drum of correctly specified die spray that is constantly stirred. Robotic, reciprocating die spray system, with multiple spray heads are recommended over static sprays attached to the edge of the die, as they will enable the correct, small amounts of spray to be delivered to the parts of the die halves where spray (lubrication) is needed. This also minimises excessive spray usage.

- **Manual spraying** is poor practice as it will also result in variable volumes and locations of spray being applied.
1. Process Elements

1.5 Recycling and Waste Handling

1.5.1 Recycle other than Sprues, Runners, Overflows and Uncoated Castings

- Other recycle materials generated include dross skimmings, swarf (machinings), floor sweepings, painted and electroplated reject castings.
- Many die casters sell these components to outside recyclers. This is often the best approach as long as the selling price is reasonable. For dross a typical selling price is 65 to 70% of ingot price, and for electroplated reject around 70 to 75% of ingot price is common.
- If these materials are recycled in house, the recycle process should be assessed in term of a) the yield, b) the quality of the recycled metal (this needs assessment by analyses and also any impact on castings when re used), c) the cost of processing and d) the control of fume.
1. Process Elements

1.5.2 Other Waste

- **Fume**
  - Fume from melting furnaces and die casting machine pots should be collected via canopies above the melt surface and chimneys from the heating chamber when gas or oil are used as a fuel.
  - These should be connected to an exhaust fan on the outside of the die casting factory building and ducted through a suitable scrubbing system that removes particulate matter.

- **Water**
  - Cooling water should be recirculated via a water cooling system and be properly chemically treated to minimise scale build and rust in cooling channels.
1. Process Elements

1.6 Occupational Health and Safety

Safety of workers makes economic sense as well as being ethically positive. Molten zinc alloy can cause serious second degree burns because of its propensity to stick to skin. Following are some basics.

- **A clean, uncluttered workspace** with good lighting, around the die casting machine station is a basic way to prevent many accidents. This is covered in more detail above in Section 1.4.

- All workers should be provided with **eye and hearing protection and gloves**. Clothing should be such that it does not melt or burn if splashed with molten zinc alloy and good footwear with non slip soles and steel toe caps will reduce slipping and impact injuries when handling heavy items such as ingots and dies.

- Around melting furnaces it is recommended that operators wear **full face and head protection** as well as the above items.

- Other factory personnel should not go near the die casting and melting operations unless they are also suitably clothed and protected.

- **Hearing protection** is also very advisable.

- When doing any work on the die casting machine, the workers must be trained and ordered to follow carefully **all safety instructions** provided by the die casting machine manufacturer. The die casting machine environment has many potential dangers such as very hot surfaces, extremely high pressures and potential for major crushing injuries.

- Almost all die casting machines are supplied with basic **safety guards**. At the very least these must be always kept in good operating condition. It can also pay to look at additional guarding that is often available from die casting machine suppliers.

- Suitably **interlocked barriers** should be provided around any robotic equipment, and robot ladles should be equipped with suitable warning devices (bell, flashing light)
1. Process Elements

1.7 Casting Defects

Following is a brief overview of the main casting defects.

1.7.1 Porosity

- This is due to air entrapped in the casting either due to poor cavity filling pattern that does not allow cavity air to be vented during cavity fill or being entrapped due to turbulent flow of metal in the feed system between the shot sleeve and the gate.
- It is almost always caused by poor feed system design, but its effects can be exacerbated by low gate speeds.
- It is very often sub surface and will not be seen until machining, polishing or after coating, or will be show up as reduced mechanical properties.
1. Process Elements

1.7 Casting Defects (continued)

1.7.2 Cold Shuts or Flow Marks

• Caused by metal starting to solidify before the cavity is filled.
• It is caused by low die temperatures, long fill time, low gate speed or poor cavity filling pattern, or a combination of these.
• It will usually be visible at casting, but very fine flow marks can be very difficult to see and will only show up as defects after coating.
• Cold shuts and porosity are the two most common causes of casting defects and often show up together.

Cold shuts / flow marks
1. Process Elements

1.7 Casting Defects (continued)

1.7.3 Intergranular Corrosion

- Caused by contamination of the zinc alloy with either lead, tin or cadmium, with levels that are higher than the specified limits for each of these elements.
- Often caused by purchasing alloy contaminated with high levels of these elements, but can also be caused by contamination of the recycle material by one of these elements.
1. Process Elements

1.7 Casting Defects (continued)

1.7.3 Intergranular Corrosion (continued)

• Very often castings contaminated in this way will show no signs of any problem until some time after casting (months to years). This can be very dangerous to die caster’s and the industry’s reputation because failure due to intergranular corrosion often means that the casting will fall apart and because of the time involved this can be a long time after the casting is put into service.

• Sometimes intergranular corrosion will show up after electroplating or painting as large blisters.

1.7.4 Other Defects – more detail on these can be provide by IZA

– Shrinkage porosity.
– Shrinkage Tearing
– Laking
– Die soldering
– Die erosion

1.7.5 Defect Identification – Sometimes defects can be readily identified by simple observation. However often, and particularly after coating, the defect type is more difficult to identify. Then metallographic (microscopic) examination can be very valuable to fast track defect identification which then enables identification of process parts that cause the defect. Metallography can also assist in identifying if, in fact, the defect is caused by the casting process, for example on coated casting or the finishing process itself. If this assistance is required contact IZA.
2. First Stage Audit

Introduction

- The first stage audit provides a relatively speedy assessment of the die casting process. It consists of questioning of relevant managers, engineers, technicians and die making staff who together can provide a detailed insight into the operation based on a specific set of questions, plus a tour of the die casting area and die making facility to observe the other factors.
- Some of the factors are rated by a scoring system, others by comment only and some by both.
- The scoring system ranges from 0 or 1, to a possible maximum score for each process element.
- 0/1 means that the particular process element is rated as poor. The maximum score that the particular process element matches best possible industry practice.
- Not all process elements have the same maximum score. A higher possible maximum means that the process element involved is of greater importance for making good quality and lowest cost die castings.
- The audit is divided into the same seven sections as the process overview (Section 1 above). For each section a total score is calculated. The first six are also combined to give an overall process score. The seventh (casting defects) is separated because casting defects are the outcome of problems in one or more of the other six sections.
- Therefore it is possible to rank:
  - 1) individual process elements against industry practice, for example a 5 out of 10 score (50%) indicates significant improvement could be made versus best industry practice.
  - 2) Individual sections can be assessed, for example a score of 40% in the section on alloy purchasing, melting and recycling indicates that significant improvement can be made in this area. Then this section of the process can be examined in more detail to define the low scoring process elements that give this low score, and these problem elements can be ranked and tackled in order of importance.
  - 3) The sections can be compared with each other so that the most important section that is lowest scoring can be tackled as a matter of priority, with other sections and/or elements tagged for later work.
- The total overall score as a percentage is also useful as it gives a guide to where the audited process ranks versus best industry practice.
- Each of the following sections contains an Excel spreadsheet table. By double clicking on this table data can be added.
2. First Stage Audit

2.1 Basic Company Data

- **Double click the table below** to reveal relevant part of scoring spread sheet in Excel, to enable data insertion
- **Company Name** – useful for external auditor
- **Product Type** – a summary list of the type of products made by the company
- **Company Size**
  - small = ingot consumption of 50 tonnes per month or less
  - medium = ingot consumption of 50 to 100 tonnes per month
  - Large = ingot consumption of greater than 100 tonnes per month

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<th>Company Name</th>
<th>Product Type</th>
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Company Size
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</table>
2. First Stage Audit

2.1 Ingot purchase, Melting and Recycling

Following are guidelines for ranking individual process parameters that are scored:

- List ingot brands that are used
- Overall alloy control – high score if:
  - supplier certificate of analysis provided and used
  - check analyses of ingot done
  - melting furnace and die casting machine pots samples taken and analysed on a planned basis
- Central melting
  - score = 0 if not used
  - score = 3 if used and includes good mechanisms for metal charging
- Auto metal transfer
  - score = 0 if not used
  - score = 1 if used but metal splashes as delivered to machine pot
  - score = 2 if used and metal transfer is splash free
- Dross make
  - Score = 0 if 10% or greater
  - Score = 1 if 7 to 10%
  - Score = 2 if 5 to 6%
  - Score = 3 if 3 to 5%
  - Score = 4 if 2 to 3%
  - Score = 5 if < 2%
- Recycle collection
  - Score = 0 if left on the floor
  - Score = 1 if collected in bins but bins are not purpose built and/or bins contain tramp material
  - Score = 2 or 3 if collected purpose designed bins and recycle material is clean
- Ingot storage
  - Score = 0 if stored outside and open to environment
  - Score = 1 if stored inside but conditions are damp and dirty.
  - Score = 2 if stored inside and conditions are damp or dirty
  - Score = 3 if stored inside and conditions are dry and clean
2. First Stage Audit

2.1 Ingot purchase, Melting and Recycling  (guideline scoring continued)

- **Fuel type used**
  - Score = 0 if using coal gas
  - Score = 1 if oil used, but economical supply of gas or electricity is available
  - Score = 2 if oil used because no economic alternative available
  - Score = 3 if gas or electricity is economically available and is used

- **Fuel consumption**
  - Score = 0 if coal gas used
  - Score = 1
  - Score = 2
  - Score = 3
  - Score = 4

Go to next page to fill in the table
2. First Stage Audit

2.1 Ingot purchase, Melting and Recycling

- **Double click the table** below to reveal relevant part of scoring spread sheet in Excel, to enable data insertion.
- Fill in the table below as per guidelines on the previous pages
- For scoring change the number given to red
- When completed add the total number of the red scores, % achieved then shown automatically.

<table>
<thead>
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<th>Metal melting</th>
<th>Value - if applicable - circle or add data</th>
<th>Scoring Range</th>
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<td>Ingot brand(s) and alloy grade used</td>
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<td>1.5</td>
<td>dross make % (of ingot use)</td>
<td>%</td>
<td>Between 0 and 2</td>
<td>2</td>
</tr>
<tr>
<td>1.6</td>
<td>recycle collection method</td>
<td></td>
<td>Between 0 and 5</td>
<td>5</td>
</tr>
<tr>
<td>1.7</td>
<td>recycle storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>Ingot storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>fuel type used</td>
<td>oil</td>
<td>Between 0 and 3</td>
<td>3</td>
</tr>
<tr>
<td>1.10</td>
<td>fuel consumption</td>
<td>unit/tonne</td>
<td>Between 0 and 3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Actual Score - Total** 26

**Maximum possible score** 34

**% scored for this section** 76%
2. First Stage Audit

2.2 Die Design and Manufacture

*Following are guidelines for ranking individual process parameters that are scored*

- The first three items are general data only
- **Die design technology used**
  - Score low if all done by manual methods.
  - Score middle if some CAD methods used but understanding not great.
  - Score high if up to date CAD systems used and well understood by design engineers.
- **Die maintenance**
  - Score low if maintenance facilities are poor, die condition seems poor, die storage is poor.
  - Score middle if reasonable maintenance facilities, die condition seems OK and die storage is OK.
  - Score high if maintenance facilities well laid out and equipped and clean, dies are well stored and identified and dies appear in very good condition.
- **Die Manufacturing Technology**
  - Score low if much is manual, limited measuring equipment, facilities are in poor condition.
  - Score medium if some CAM equipment, better measuring equipment and facilities are in reasonable condition.
  - Score high where state of the art CAM equipment used, facilities are clean, well lit and well laid out, and very good measuring equipment is used.
- **Feed System Design – understanding and application**
  - Score low when feed systems do not followed tapered runner method, are heavy relative to casting size, feature excessive overflows, poor cavity filling pattern and limited or no venting.
  - Score medium when some understanding of tapered runner method is show on dies, feed systems are reasonable sizes, use of overflows is moderate, cavity fill patterns are reasonable and use of venting is better.
  - Score high when feed systems follow tapered runner method closely, are light weight, feature only overflows for specific purposes, achieve good cavity fill patterns and excellent use of venting.
2. First Stage Audit

2.2 Die Design and Manufacture (continued)

• Casting Yield
  - Score ‘0’ if not measured and is below 30%
  - Score ‘3’ if measured and is between 45 and 60%
  - Score ‘6’ if measured and is 70% or above

• Thermal design and die temperature control
  - Score low when no idea of die operating temperatures or importance.
  - Score medium when reasonable data on mould temperatures in production, die temperatures are within 30 C of recommended levels, but still with variation across metal contact surfaces, and some attempt is made to design for correct operating temperatures.
  - Score high when mould temperatures are controlled at recommended levels are even across the metal contact areas.

• Die or insert change time (depends to an extent on size and complexity of die or insert)
  - Score low if > 60 minutes
  - Score medium if 30 to 40 minutes
  - Score high if < 10 minutes

• Cavity(ies) Layout
  - Score low if poorly laid out making even cavity (ies) operating temperatures unlikely, poor location of cavity relative to sprue and layout makes good gate location difficult
  - Score high if well laid out to ensure even cavity(ies) operating temperatures and allows optimum location of gate(s) and minimum length of runners

Go to next page to fill in the table
2. First Stage Audit

2.2 Die Design and Manufacture

- Double click the table below to reveal relevant part of scoring spread sheet in Excel, to enable data insertion.
- Fill in the table below as per guide lines on the previous pages
- For scoring change the number given to red
- When completed add the total number of the red scores, % achieved then shown automatically.

<table>
<thead>
<tr>
<th>2</th>
<th>Mould / Die</th>
<th>Value - if applicable - circle or add data</th>
<th>Scoring Range</th>
<th>Actual Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Type</td>
<td>dedicated</td>
<td>Unit / inserted</td>
<td>both</td>
</tr>
<tr>
<td>2.2</td>
<td>Mould making</td>
<td>In house</td>
<td>external</td>
<td>both</td>
</tr>
<tr>
<td>2.3</td>
<td>mould design</td>
<td>In house</td>
<td>external</td>
<td>both</td>
</tr>
<tr>
<td>2.4</td>
<td>die design technology used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>die manufacturing technology used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>Feed system design - depth of understanding and application</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>Casting yield</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.9</td>
<td>Thermal design and mould temperature control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.10</td>
<td>Mould or insert change time</td>
<td>minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.11</td>
<td>cavity layout</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Actual Score 44

Maximum Possible Score 44

% scored for this section 100%
2. First Stage Audit

2.3 Die Casting Machines

• Machine Type
  • While hot chamber die casting machines are almost universally used for zinc die casting the use of cold chamber machines is sometimes necessary or a good choice.
  • Therefore ascertain the reasons why cold chamber machines have been selected and how the machine is utilised and score according

• Machine Origins
  • As a general guide die casting machines from China are the lowest cost and lowest in terms of reliability and life, Taiwanese are next best, followed by Japanese and then European.
  • However die casting machine choice is also driven by economic reasons, so the most expensive/highest performing machine may not always be or might rarely be the best choice. Therefore ascertain the rationale behind machine choice and base the score on this.

• Machine Operating Conditions
  • Generally a dirty machine with loose wires, leaking water and oil and general poor condition will be in poor operating condition (score low), while clean machines with all associated equipment in good condition and no water or oil leaks is indicative of a machine in good operating condition (score high).

• Metal Temperatures
  • All melting pots should have a functioning thermocouple and temperature controller. If this is not the case score very low
  • Hot chamber machines have either cast iron or stainless steel metal holding pots. These should not be operated above 440C. If they are at or above this temperature, score low.
  • Optimum operating metal temperature should be around 415 to 425C
2. First Stage Audit

2.3 Die Casting Machines (continued)

- **Machine Pot Life** (time from new to replacement)
  - Less than 6 months score low
  - More than 2 years score high.

- **Plunger Creep**
  - If all or more than 50% machines exhibiting creep score low
  - If less than 10 to 20% of machines showing creep score medium.
  - If no creep evident score high

Go to next page to fill in the table
# 2. First Stage Audit

## Die Casting Machines

- **Double click the table** below, to reveal relevant part of scoring spread sheet in Excel, to enable data insertion.
- Fill in the table below as per guidelines on the previous pages
- For scoring change the number given to red
- When completed add the total number of the red scores, % achieved then shown automatically.

<table>
<thead>
<tr>
<th></th>
<th>Die casting machines</th>
<th>Value - if applicable - circle or add data</th>
<th>Scoring Range</th>
<th>Actual Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Type (hot chamber = 5, cold chamber = 1 unless very large castings being made)</td>
<td>hot chamber</td>
<td>cold chamber</td>
<td>multi slide</td>
</tr>
<tr>
<td>3.2</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>Machine sizes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>Machine country(s) of origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>machine operating condition - visual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>metal temperature</td>
<td>OK</td>
<td>high</td>
<td>not measured</td>
</tr>
<tr>
<td>3.7</td>
<td>machine pot life</td>
<td>months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>plunger creep</td>
<td>yes</td>
<td>no</td>
<td>some</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Actual Score</th>
<th>Maximum Possible Score</th>
<th>% scored for this section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26</td>
<td>26</td>
<td>100%</td>
</tr>
</tbody>
</table>
2. First Stage Audit

2.4 Die Casting Area

- **Layout and Cleanliness**
  - Poor access to process elements, machines too close together, poorly lit, floor dirty, tools, working materials rubbish (any non process required material) strewn on floor - score low
  - Good access to process elements, machines well spaced, floor clean, well lit, tools in racks, working materials stored in bins score high.

Go to next page to fill in the table
2. First Stage Audit

2.4 Layout and Cleanliness

• Double click the table below, to reveal relevant part of scoring spreadsheet in Excel, to enable data insertion.
• Fill in the table below as per guidelines on the previous pages
• For scoring change the number given to red
• When completed add the total number of the red scores, % achieved then shown automatically.

<table>
<thead>
<tr>
<th></th>
<th>Die casting area</th>
<th>Value - if applicable - circle or add data</th>
<th>Scoring Range</th>
<th>Actual Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>layout</td>
<td></td>
<td>Between 1 and 5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Cleanliness, tidiness (5 S's)</td>
<td></td>
<td>Between 1 and 5</td>
<td>3</td>
</tr>
</tbody>
</table>

| Actual Score | 6 |
| Maximum Possible Score | 10 |
| % scored for this section | 60% |
2. First Stage Audit

2.5 Recycle and Waste Handling

**Process recycle material**
- Sprue, runner, reject castings (uncoated), overflows, swarf, dross, coated reject castings, floor sweepings sold, but price is low, score 1 or 2.
- Sprue, runner, reject castings (uncoated), overflows, swarf, dross, coated reject castings, floor sweepings sold, price at industry average score 3
- Sprue, runner, reject castings (uncoated), overflows, swarf, dross, coated reject castings, floor sweepings sold, price above industry average score 4 or 5
- Sprue, runner, reject castings (uncoated), overflows recycled in house but recoveries below industry averages and/or problems with quality of recycled alloy score 1,2
- Swarf, dross, coated reject castings, floor sweepings reprocessed but yield below expected averages and/or problems with recovered alloy quality score 1,2.
- Swarf, dross, coated reject castings, floor sweepings reprocessed but yield above expected averages and recovered alloy quality good score 4,5

**Waste Cooling Water**
- If cooled, treated and reused score 4.
- If dumped, score 0

**Waste Heat and Fume** (from diesel or gas fired melt furnaces)
- If exhausted into factory area score 0
- If directly exhausted outside factory score 1
- If fume and heat collected by exhaust fan and scrubber system score 2 or 3
- If waste heat also recycled e.g. to burners or to a device to preheat ingot or recycle score up to 4

Go to next page to fill in the table
2. First Stage Audit

2.5 Recycle and Waste Handling

- **Double click the table** below, to reveal relevant part of scoring spread sheet in Excel, to enable data insertion.
- Fill in the table below as per guidelines on the previous pages
- For scoring change the number given to red
- When completed add the total number of the red scores and input number to *Actual Score*. % achieved then shown automatically.

<table>
<thead>
<tr>
<th>Recycle and Waste handling</th>
<th>Value - if applicable - circle or add data</th>
<th>Scoring Range</th>
<th>Actual Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Sprue, Runner, Reject castings, overflows</td>
<td>sell, reprocess</td>
<td>Between 1 and 4</td>
<td>4</td>
</tr>
<tr>
<td>5.2 dross</td>
<td>sell, reprocess</td>
<td>Between 0 and 4</td>
<td>4</td>
</tr>
<tr>
<td>5.3 coated reject</td>
<td>sell, reprocess</td>
<td>Either 0 OR 4</td>
<td>4</td>
</tr>
<tr>
<td>5.4 swarf</td>
<td>sell, reprocess</td>
<td>Between 0 and 4</td>
<td>4</td>
</tr>
<tr>
<td>5.5 waste water</td>
<td>recycle, dump</td>
<td>Either 0 OR 4</td>
<td>4</td>
</tr>
<tr>
<td>5.6 waste heat</td>
<td>recycle, emit</td>
<td>Between 0 and 4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Actual Score** 4

**Maximum Possible Score** 12

**% scored for this section** 33%
2. First Stage Audit

2.6 O, H and S

*Note - Work area layout and cleanliness is also important for O,H and S, however this is covered in 2.5 above*

• Worker Safety equipment and clothing
  • workers wearing eye and ear protection, suitable gloves for hot metal, safety shoes and non flammable clothing score high
  • Workers not wearing any of above score 0.
• Safety Guards on Machinery
  • Any safety guards non operational score low
  • Basic safety guards as provided by manufacturer are operational score medium
  • As above plus additional optional guards installed and operational score high
• Safety Procedures during machine maintenance and mould change
  • Machine not properly locked out during any work score 0
  • All manufacturers safety procedures followed score high

Go to next page to fill in the table
2. First Stage Audit

O, H and S

• **Double click the table** below, to reveal relevant part of scoring spread sheet in Excel, to enable data insertion.
• Fill in the table below as per guide lines on the previous pages
• For scoring change the number given to red
• When completed add the total number of the red scores, % achieved then shown automatically.

<table>
<thead>
<tr>
<th></th>
<th>2.7 O, H and S</th>
<th>Value - if applicable - circle or add data</th>
<th>Scoring Range</th>
<th>Actual Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Worker safety clothing and equipment</td>
<td>0</td>
<td>Between 0 and 5</td>
<td>0</td>
</tr>
<tr>
<td>6.2</td>
<td>Safety guards on machinery</td>
<td>15</td>
<td>Between 0 and 5</td>
<td>15</td>
</tr>
<tr>
<td>6.3</td>
<td>Safety procedures during machine maintenance, mould change etc.</td>
<td>0</td>
<td>Between 0 and 5</td>
<td>0</td>
</tr>
</tbody>
</table>

*Actual Score 0
Maximum Possible Score 15
% scored for this section 0%
2. First Stage Audit

Total Score Achieved

- This is valuable as an overall number of where the operation is compared with best practice.
- A best practice factory will score 80% or more
- So if the score is 50% or less it can be seen immediately that there is much scope for process improvement.

OVERALL SCORE ACHIEVED FOR AUDIT  71%
2. First Stage Audit

2.7 Casting Reject Rates (Casting Defects)

*Important Note* - Auditing of casting reject rates is an important and fast indicator of the “health” of any zinc die casting process. However as casting rejects are an outcome of problems in one or more process elements the score is treated separately from all other scores above

- **As cast**
  - Above 5% score low
  - 3 to 4% score medium
  - Less than 1% score high

- **After Finishing**
  - Above 10% score low
  - 4 to 6% score medium
  - Less than 2% score high

Go to next page to fill in the table
### 2. First Stage Audit

#### 2.7 Casting Reject Rate (Casting Defects)

- **Double click the table** below, to reveal relevant part of scoring spreadsheet in Excel, to enable data insertion.
- Fill in the table below as per guidelines on the previous pages
- For scoring change the number given to red
- When completed add the total number of the red scores, % achieved then shown automatically.

---

**NOTE - Casting Quality is an important measure on its own, but it is not included in the overall audit score because it is a function of all the other process elements**

<table>
<thead>
<tr>
<th></th>
<th>Value - if applicable</th>
<th>Scoring Range</th>
<th>Actual Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Casting quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Product Classification</td>
<td>engineering</td>
<td>Between 1 and 5</td>
</tr>
<tr>
<td>7.2</td>
<td>Quality level required</td>
<td>low end</td>
<td>Between 1 and 5</td>
</tr>
<tr>
<td>7.3</td>
<td>Reject rate as cast</td>
<td>%</td>
<td>Between 1 and 5</td>
</tr>
<tr>
<td>7.4</td>
<td>Reject rate finishing</td>
<td>%</td>
<td>Between 1 and 5</td>
</tr>
<tr>
<td>7.5</td>
<td>main reject causes</td>
<td>surface quality</td>
<td>mechanical</td>
</tr>
</tbody>
</table>

**Actual Score** 6
**Maximum Possible Score** 10
**% scored for this section** 60%
3. Second Stage Audit

Introduction

• The first stage audit provides a relatively quick process assessment of 1) the overall zinc die casting process, 2) the main elements of the process ranked by importance to casting production cost and 3) performance of each individual aspect of the process.
• The second stage audit enables a more detailed assessment of the process aspects that impact directly on casting quality. It focuses on specific data measurement, observation and actual process change.
• Parts of it require a specific die and die casting machine combination to be chosen for detailed performance assessment. This combination will often either be a casting that is identified as causing problems, with the aim of identifying why the problems are occurring and working out ways to make improvements, or a new die that has been designed with optimised features.
• The audit is done via tables, split into process elements. Some guidance is provided in the tables and linkages back to relevant sections in Part 1 (Process Elements). For more detailed, specific information the auditor can contact IZA.
3. Second Stage Audit

Casting Defects
- *This is the optimum starting point for the second stage audit if the audit is linked specifically or mainly to casting defects*
- *It can be applied to a number or group of castings or a selected casting/die/die casting machine combination*

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Item</th>
<th>Detail</th>
<th>Comment (IZA can provide more background technical detail if required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casting defects</td>
<td>All castings, a group of castings or a single casting/die/ die casting machine combination</td>
<td>Selected casting(s), after casting - define defect types and %</td>
<td>define visually or use metallographic examination if defect type not obvious</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected casting(s) after polishing / machining - define defect types and %</td>
<td>define visually or use metallographic examination if defect type not obvious</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected casting(s) after electroplating, painting, - define defect types and %</td>
<td>define visually or use metallographic examination if defect type not obvious</td>
</tr>
<tr>
<td>Next Step</td>
<td>Link defects to possible process causes</td>
<td></td>
<td>Refer to defect definition literature</td>
</tr>
</tbody>
</table>
## 3. Second Stage Audit

### Melting and Recycling

*Applied broadly to the whole process*

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Item</th>
<th>Detail</th>
<th>Comment (IZA can provide more background technical detail if required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting and Recycling</td>
<td>Check metal composition</td>
<td>Take die casting machine pot samples</td>
<td>Use OES sample mould</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* One from each machine pot if 5 die casting machines or less</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Total of 5 samples if more than 5 machines</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Two samples from central melt furnace</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Send to qualified analytical laboratory</td>
<td>qualified = set up for zn alloy analyses, preferably a registered lab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assess results</td>
<td>Investigate causes if out of spec - ingot source or process</td>
</tr>
<tr>
<td></td>
<td>Check pot temperature</td>
<td>Check molten alloy composition on die casting machine pots and central melt furnace.</td>
<td>Use portable temperature meter and immersion thermocouple</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assess results</td>
<td>Adjust to correct range and replace faulty fixed t/c/s and meters</td>
</tr>
<tr>
<td></td>
<td>Handling of recycle</td>
<td>Use of appropriate bins, baskets, pallets</td>
<td>Provide information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure no tramp material included</td>
<td>Instruct on potential problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment for easy transporting within the factory</td>
<td>Provide information e.g., hand lift trucks</td>
</tr>
<tr>
<td></td>
<td>Recycling processes used - yield</td>
<td>Recycling processes used - yield and quality of recycle metal, use of flux, fume control</td>
<td>Provide information on optimum methods and need to ensure quality of metal recycled. Assess economics of recycling vs selling</td>
</tr>
<tr>
<td></td>
<td>and quality of recycle metal, use</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>of flux, fume control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ingot brand - meeting spec.</td>
<td>Sample ingot and analyse</td>
<td>Ingot sampling standard must be used</td>
</tr>
<tr>
<td></td>
<td>Central melting and auto ladling</td>
<td>Identify benefits if not being used</td>
<td>Economics and process control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify usable space to instal</td>
<td>Provide information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sketch possible layout</td>
<td>Provide information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide supplier information</td>
<td>Provide information</td>
</tr>
</tbody>
</table>
3. Second Stage Audit

Die Casting Machine

*Other than plunger creep, focuses on a particular die / die casting machine combination with the view to applying beneficial outcomes across the process, where possible.*

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Item</th>
<th>Detail</th>
<th>Comment (IZA can provide more background technical detail if required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die casting machine</td>
<td>Machine monitoring</td>
<td>Injection, locking, matching machine and die performance</td>
<td>Only real way to properly define die casting machine but specialised monitoring equipment is needed</td>
</tr>
<tr>
<td>Plunger creep</td>
<td></td>
<td>list % of machines affected</td>
<td>Observe each die casting machine in production</td>
</tr>
<tr>
<td>Setting of 1st to 2nd stage</td>
<td></td>
<td>check effect of altering on selected machine-die combination or optimise on a new product</td>
<td>Fixing means new piston rings and/or new shot sleeve</td>
</tr>
<tr>
<td>Setting of 1st to 2nd stage</td>
<td></td>
<td>check effect of altering on selected machine-die combination or optimise on a new product</td>
<td>Set so that change over is at just before the metal reaches the gate which is calculated from the shot volume and the metal plunger diameter</td>
</tr>
<tr>
<td>Pressure setting</td>
<td></td>
<td>Is it varied as per requirements of each die or is it at a fixed level for all dies</td>
<td>% of maximum used - check via pressure control valve</td>
</tr>
<tr>
<td>1st stage speed setting</td>
<td></td>
<td>Is it varied as per requirements of each die or is it at a fixed level for all dies</td>
<td>% of maximum used - check via control valve</td>
</tr>
<tr>
<td>2nd stage speed setting</td>
<td></td>
<td>Is it varied as per requirements of each die or is it at a fixed level for all dies</td>
<td>% of maximum used - check via control valve</td>
</tr>
<tr>
<td>Locking force</td>
<td></td>
<td>Is it varied as per requirements of each die or is it at a fixed level for all dies</td>
<td>% of maximum used</td>
</tr>
<tr>
<td>Pump</td>
<td></td>
<td>Noisy -</td>
<td>check vanes, oil condition</td>
</tr>
<tr>
<td>Die Spray</td>
<td></td>
<td>Lubricant type used and adherence to formulation</td>
<td>Use proprietary spray designed for zinc die casting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delivery to machine</td>
<td>Central mixer with distribution system is advisable for best control of formulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Method of application - Use robot sprayer with multiple nozzles, fixed heads or manual</td>
<td></td>
</tr>
</tbody>
</table>
3. Second Stage Audit

Die

- Can be applied to a number of die/die casting machine combinations or a single selected combination.

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Item</th>
<th>Detail</th>
<th>Comment (IZA can provide more background technical detail if required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die</td>
<td>Mould temperature</td>
<td>Check and record on a number of dies - 3 points - runner, cavity near gate, cavity remote from gate</td>
<td>Use hand held temperature meter and surface thermocouple</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check on the selected problem die - multi points, cavity and runners</td>
<td>Use hand held temperature meter and surface thermocouple</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check effect of altering water flow and cycle time</td>
<td>Reduce flow or turning water off can increase temperature and improve surface quality but may impede die operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Redesign cooling on selected problem die or assist design on die for new product</td>
<td>Redesign can be done by knowledge of existing mould temperatures and assessment of cooling line placement, but full redesign may require more detailed thermal assessment,</td>
</tr>
<tr>
<td></td>
<td>Mold heating versus cooling</td>
<td></td>
<td>Mold heating sometimes necessary. Provide information</td>
</tr>
<tr>
<td>Feed system design</td>
<td>Casing yield % - measure on dies currently in production</td>
<td>If low provide broad advice on how to increase</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casing yield % - measure on selected problem die - measure 98 and overflows separately</td>
<td>If low assess whether due to sprue and runner design, amount of overflows or both</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Existing design - selected problem die - assess filling pattern and gate and runner design</td>
<td>Simple, beneficial modifications may be possible and worth trying</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redesign for selected problem die or design for a replacement die</td>
<td>After assessing number of cavities, cavity orientation and number of cavities (see below), follow tapered runner method. Focus on venting rather than overflows.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other die features</td>
<td>mould steel, heat treatment, ejector pin placement</td>
<td>Provides machine pumping requirements vs available machines</td>
</tr>
<tr>
<td>Cavity layout and mould size</td>
<td>Existing design - selected die</td>
<td>If too small for die casting machine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If too small for die casting machine and number of cavities being used</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If cavity orientation and position optimised</td>
<td></td>
</tr>
<tr>
<td>Die changing</td>
<td>Assess current mould change times</td>
<td>If too long:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* pre preparation of new mould</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* equipment for removing and inserting dies - hoists, trolleys</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* ready availability of proper tools to make change</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Use of quick change fittings</td>
<td></td>
</tr>
</tbody>
</table>
### 3. Second Stage Audit

**Other Process Factors (Miscellaneous)**

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Item</th>
<th>Detail</th>
<th>Comment (IZA can provide more background technical detail if required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous</td>
<td>Handling of shots</td>
<td>use of proper containers or conveyors</td>
<td>provide information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>use of robots</td>
<td>provide information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>care in handling castings</td>
<td>provide information</td>
</tr>
<tr>
<td>Trimming</td>
<td>press vs manual</td>
<td></td>
<td>can trimming presses give improved productivity, economically</td>
</tr>
<tr>
<td></td>
<td></td>
<td>care in handling castings</td>
<td>stacking in containers with protective interleaves</td>
</tr>
<tr>
<td>Polishing</td>
<td>hand or automated</td>
<td></td>
<td>can automation provide economic (productivity) benefits on some shapes</td>
</tr>
<tr>
<td></td>
<td>machine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>care in handling castings</td>
<td>stacking in containers with protective interleaves</td>
</tr>
<tr>
<td>Electroplating</td>
<td>manual or auto</td>
<td></td>
<td>can automation give improved productivity, economically</td>
</tr>
<tr>
<td></td>
<td>electroplating line</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>in house or external</td>
<td>can “in house” improve economics and quality control</td>
</tr>
</tbody>
</table>
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