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Introduction

*Die Casting Defects Troubleshooting Guide* is a new tool intended for operator use on the shop floor. It provides die casting operators, supervisors and engineers with quick and easy-to-implement corrections to common die casting defects. Containing casting photographs and photomicrographs for identification of 22 types of defects, the volume then provides brief descriptions of each defect and their causes. The book then guides the user through a step-by-step series of process remedies to help correct the defect.

This publication is part of the NADCA Defects Library. For technical descriptions of the causes and remedies of the defects, the volume entitled *Die Casting Defects: Causes and Solutions* should be consulted. The CD-ROM Defects Library contains all defect photos and photomicrographs, and the texts of both defects volume, on one interactive CD.

The author and NADCA wish to acknowledge the contributions of Bodycote Taussig, Inc. and K&L Engineering, for their invaluable assistance in the preparation of all of the Defects Library materials. They also thank the many die casters who contributed by allowing their castings to be photographed and reproduced in these volumes.
Chapter 1

Basic Procedures for Controlling Defects

You can’t correct and control defects without first measuring and reporting them.

The scrap reporting system must be set up for those who have to make improvements, not just for the bean counters. The scrap report should be available to everyone in the plant. In fact, it should be posted on the bulletin board so everyone can see it.

Daily scrap reports must have the following features as a minimum:

1. It must be available first thing in the morning for the previous day.

2. It must categorize scrap (as a minimum):
   - By defect type
   - By part number
   - By die
   - By shift
   - By operator
   - By machine

The scrap reporting system should show long-term trends and be able to predict customer rejects based on current scrap activity – pareto charts are good ways to show the problems.

The report should include defects that are not detected until the parts are downstream (such as at a machining or plating operation performed later). A system should be developed so these defects can be tracked to the shift and the machine that produced them.

All shots should be reported, even warm-up and scrap that is returned to the furnace at the machine (they cost in die life).

The process is complex, and a continuous reporting system must be set up to provide real time feedback and effective process control if defects are to be controlled.

The two major defects in die casting are surface quality and porosity. Both of these require judgment decisions about severity.

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This means a method of measuring the severity of defects is a requirement and must be devised for many situations.

The rating system is intended to tell you if the defect problems are getting better or worse, or whether changes made in the process are making a difference. What you are looking for is the ability to track any changes or trends, and to know when corrections are needed. This system also allows corrections to be made before the defect level becomes a crisis.

The standards used for the rating system may not coincide with the customer standards or the quality dept. These ratings are for a different purpose and do not need to coincide. For example, you may rank a porosity defect from the worst to the best with rankings from 1 to 5. A capability study could be done as follows:

- **Take 6 sets of samples of 5 sequential castings at intervals of ½ hr. to 2 hr.**
- **Rate each casting and average the total. This gives the average quality level; this should be checked against similar studies to determine if the process is improving or degenerating.**

You also can use this data to estimate the standard deviation, thus obtaining a measure of the stability of the process. This kind of tracking is particularly important.

Note that the person charged with correcting the defect problems might have to set up a rating system for these defects because it will be a requirement to improve defects.

**You can’t improve it if you can’t measure it.**

One of the most difficult problems in developing a rating system is finding a method of reporting and rating porosity. The most typical methods are fluoroscope (x-ray), machining, or sawing.

A cheap and effective method is to use an old lathe to approximately duplicate the customer’s machining.

Always select examples for the rating system and save them. They must not be used for any other purpose.

Bottom line:

- **Defect corrections must start with a good scrap reporting system.**
- **Developing this system starts with defining the names of defects, which means a board with samples and names of defects.**
- **For certain jobs, this may require setting up a rating system just for the purpose of tracking defect causes and corrections.**
Surface Defects:
Cold flow, cold lap, chill, non-fill, swirls, etc.

Cause:
Leading edge of metal flow is too cold, laps together.

Corrections:
1. Increase die temperature, especially at problem location. Check the following causes for cold dies:
   - Slow cycle time
   - Excessive coolant flow for conditions
   - Excessive spray causing cold die
   - Add overflows for more heat
2. Reduce fill time (caution: each action listed affects something else besides fill time; PQ calculations required):
   - Increase plunger speed
   - Increase plunger size
   - Increase gate area
   - Increase hydraulic pressure
3. Change flow pattern (gating):
   - Direct flow at the problem area by moving the gate
   - Change gate design to direct flow in a different direction
   - Change gate velocity (try increase first)
   - Add overflows to capture cold metal
4. Check for low metal temperature:
   - Look for delays that cool metal
   - Look for furnace temperature variations (low temp swings)
   - Increase temperature (carefully, other problems may appear)

5. Low pressure at end of shot-check for:
   - Dragging tips – flash around tip
   - Poor sleeve condition
   - Too little or inconsistent sleeve lubrication
   - White (solder) buildup in shot sleeve

6. Accumulator pre-charge pressure too low or too high

7. Thin biscuit

8. Heavy flashing

9. Bubbling and turbulence in hot chamber – bad rings or poor gooseneck

10. Check also:
    - Alloy—for aluminum alloys:
      - Silicon at high end of range if possible
      - Metal cleanliness
    - Alloy—for zinc alloys:
      - Aluminum content at high end
      - Other constituents in range
    - Vents open, and sized correctly
    - Vacuum working
    - Thin wall section present:
      - Check for minimum wall thickness for the fill time and temperatures being used
      - Design errors, designers not aware of casting problems
      - Tool making errors (dimensions not as expected)
      - Uneven wall section (poor part design)
Typical surface defect (cold flow).

Typical surface defect (cold flow).
Chapter 3
Laminations

Defect:
Laminations: Layers of metal inside or outside of casting.

Cause:
Most common is poor metal flow control, though there are other causes.

Corrections:
1. Check injection parameters:
   - *Fast shot start switch should start fast shot so metal is accelerated before metal gets to gate (start fast shot early)*
   - *Quick fill time – very important, check with calculations*
   - *Proper gate velocity*
2. Gating: good flow patterns – no long flow distance and mixing far from gate.
3. Good die temperature: should be consistent over the trouble area; best if on the high side.
4. Intensifier action proper; and consistent.
5. Die doesn’t flex (die may flex from intensifier pressure) – check for adequate support.
6. Check that the lamination is not from flash left on die (often, die must be cleaned every shot).
7. Examine lamination to see if it is oxide layer.
Laminations from uneven or slow flow, causing splashes with time to solidify as a layer before final fill.

These laminations were caused from the die blowing or flexing.

Flash trapped under the skin.
Chapter 4
Gas Porosity

Defect:
Gas porosity.

Cause:
Gas trapped in the metal flow during die fill.

Corrections:
1. Gas comes from trapped air, steam or die lubricant – Check for sources of trapped air:
   - Consistent pour rates
   - Delay after pour – set right to minimize splashing in shot sleeve (chase the reflected wave)
   - Acceleration to slow shot speed correct (use acceleration as calculated by NADCA data)
   - Use critical slow shot speed
   - Accelerate to fast shot speed as late as possible (this depends on situation)
2. Check runner for smooth flow path:
   - No sharp corners
   - No blind ends, pockets
   - Ever decreasing areas properly used in runner path
3. Check vents:
   - Right size (big enough)
   - Vents kept open (not full of flash)
   - Located at the last point to fill, use short shots or computer predictions to locate last point to fill
   - Vents go to the edge of the die
4. Vacuum working:
   - Vacuum channels big enough
   - Vacuum channels located at last point to fill
   - Filters cleaned and open
   - Vacuum valves working
   - Vacuum level adequate (must be measured and recorded, etc.)

5. Check for gas from lubricant:
   - Look for excessive plunger lubricant, (discolored castings) – be sure to run the minimum possible amount
   - Try to avoid putting lubricant in front of the tip
   - Look for consistent application procedures
   - Look for excessive die lubricant or anti-solder paste

6. Check for steam (water on die):
   - Check that the die is dry when it closes
   - Use lots of air blow-off, both with manual and automatic systems
   - Put drain holes in die where die lube (water) could accumulate
   - Check for water leaks after die is locked (open die without making a shot, look for moisture)
   - Look for leaks from sprayer, hydraulic cylinders, etc.
Chapter 5
Blisters

Defect:
Blisters.

Cause:
Gas trapped just under the surface in the metal during die fill.

Corrections:
1. Blisters are another version of gas porosity; therefore the same corrections used for gas porosity will apply for blisters, i.e.:
   - Reduce trapped air (see gas porosity corrections)
   - Reduce spray and plunger lubricant
   - Eliminate water on the die
   - Correct venting and vacuum problems

2. The most permanent solution to the blister problem is to correct the gas porosity problem. However, as a short-term solution, blisters can be hidden by the following actions:
   - Cool the die in the immediate area where the blisters occur by:
     - Cooling the blister area with die spray
     - Cool the blister area by adjusting water lines
     - Cool the whole die by slowing the cycle time
     - Adding fountains or baffles to the blister area

3. Cool the casting immediately after ejection by quenching in water (this will keep the skin strong and resist blister formation).

4. Reduce metal temperature (but watch for other problems):
   - Keep process consistent
   - If blister is associated with metal swirls and captured gas from metal flow; try to correct gating or venting problem, or add vacuum

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Typical blister.

Typical blister.
Chapter 6
Flow Porosity

Defect:
Flow porosity.

Cause:
Metal flow is too slow, too cold, or has a poor flow pattern; and leaves space (porosity) between solidified metal flows.

Corrections:
1. This is a metal flow problem, so the same corrections apply as those previously listed for surface defects (see Chapter 2).
2. The spaces between metal flows may appear on the surface (hole) or inside (porosity):
   - The biggest factor by far is the fill time—calculate and measure to be sure it is fast enough—if in doubt, reduce fill time as much as possible
3. Stabilize furnace operation (reduce variation maximum of to +/- 10°F), use the correct metal temperature:
   - Metal temperature at the gate is important, in aluminum, watch for heat loss in ladle and shot sleeve—add more superheat
4. Stabilize die temperature, and run higher die temperature (>400°F).
5. Review and correct metal pressures:
   - Review the static metal pressure, it should be above 2000 psi for zinc, and 3000 psi for aluminum and magnesium
   - Check intensifier operation
   - Consistent (most important)
   - Quick enough (measure and evaluate rise time, best time will vary with casting shape)
   - Pressure setting high enough (final pressure >6000 psi is alright, >9000 psi is best)
Surface from poor flow – caused by stuck plunger once every 10 shots or so.
Chapter 7
Shrinkage Porosity

Defect:
Shrinkage porosity.

Cause:
Cast material takes up less space when solid than when liquid, and this space will appear where there is a hot spot in the casting.

Corrections:
1. Increase pressure on the semi-solid metal (at the porosity location) during solidification.
2. Check for pressure problems:
   - Static metal pressure correct:
     - >3000 min. for Al and Mg
     - >2000 min. for Zn (>1500 may be alright)
   - Intensifier pressure correct:
     - >8000 final metal pressure is very desirable (>6000 may be alright)
   - Check intensifier settings:
     - Use monitor system trace to verify pressures
     - Intensifier accumulator charged correctly, intensifier cylinder not bottoming, etc.
     - Check rise time on monitor (set a desired standard), be sure intensifier is coming in fast enough, check switch settings
     - Shot accumulator pre-charge pressure correct
   - Plunger problems that reduce pressure:
     - Poor tip condition (even if there is no blow by)
     - Poor sleeve condition
     - Soldering at end of sleeve
     - Check for sleeve contraction from heat (sleeve squeezed by die)
Typical shrink porosity shape shown here in a sand casting because the large porosity here shows the structure clearly (1X).

Typical shrink porosity in a die casting. The dendritic structure along the edge of the porosity is barely visible (50X).

Dendritic primary aluminum crystals which formed during solidification of 380 alloy. These unusually large crystals were formed in a partially filled ladle that was left sitting in the dip well of a furnace. The temperature did not fall below the solidus temperature, which permitted the eutectic fraction to drain away (5X).
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— Plunger cooling not working
— Inadequate lubrication
— Poor sleeve cooling
— Hot chamber – check plunger rings
— Hot chamber – if plunger bottoms and rings are good, change gooseneck

3. Feed additional metal to trouble spot:
   • Can squeeze pins be used?
   • Can an additional gate be brought closer to the trouble spot?
   • Can the wall be made thicker between the gate and the trouble spot?

4. Thin biscuit, or biscuit size varies too much.

5. Check temperature difference between site of porosity and surrounding area:
   • Heat up surrounding cold spots
   • Cool hot spot (location of porosity)
   • Check temperature difference between die halves

6. Lower temperature at injection can help, but be careful not to cause other problems.

7. Check alloy constituents (silicon, iron).

8. Check metal temperature fluctuations (watch for large swings, temperatures must be stable).

This photograph shows the rough dendritic structure on the wall of most shrink porosity (20X).
Chapter 8
Heat Sinks

Defect:
Heat sinks (shrinkage porosity).

Cause:
Shrinkage cracks just under surface.

Corrections:
1. See shrinkage porosity, those techniques will work here.
2. Cool hot spot directly where the heat sink occurs – use the following:
   - Fountain (first choice)
   - Die spray
3. Thin biscuits, poor plunger conditions (hot or cold chamber).
4. Heat opposite side of casting:
   - Shut off water
   - Stop spray
5. Check for uneven temperatures between die halves, especially in the area of the heat sink.
6. Use pressure to feed more metal during solidification to area where sink occurs:
   - Adjuster intensifier
   - Move gate
   - Change static pressure
   - Look for dragging tip (low pressure)
   - Check accumulator pre-charge (low pressure)
Heat sink – typical appearance on a smooth surface (1X).

Fracture through a heat sink – the original shrink porosity under the skin is visible (7X).

Heat sink where some eutectic material oozed through the skin to partially fill the sunken area (5X).
Chapter 9
Leakers

Defect:
Leakers (shrinkage porosity).

Cause:
Loose dendritic structure inside casting is exposed by an opening in the casting skin that provides leak path (another version of shrinkage porosity).

Corrections:
1. Look for sharp corners at the spot where the leak occurs, add as much radius as possible.
2. Cool with spray at the spot where the leak occurs-keep cooling even if the spray makes no difference visually.
3. Thin biscuit, or biscuit size varies too much (can be major cause in many shops).
4. Try to keep skin intact in leaker area:
   - Stop drags from solder or other sources
   - Reduce machining if possible, keep skin intact whenever possible
5. Try to keep skin intact in leaker area:
   - Check for problems in plunger – sticking and dragging
   - Poor pressure control – check static and intensified pressure
   - Check intensifier performance
   - Add squeeze pins in area of leakers
   - Move gate closer so more pressure can be applied during solidification by intensifier
6. Change temperature balance, cool area where leakers occur, heat areas surrounding leaker location.
7. Keep metal temperature consistent, and run at minimum.
8. Check constituents in metal, don’t allow variation.

Folds of oxide films, which assist in creating localized shrinkage voids and provides leakage channels through the casting wall (25X).

Typical internal shrinkage in a fracture through a leakage area. Note the continuous irregular paths (black) characteristic of shrinkage voids, which are interconnected through the casting wall. Normally, close inspection will show evidence of internal shrinkage by a frosty appearance or a minor cold shut on the casting surface (25X).
Chapter 10
Cracks and Tears

Defect:
Cracks, tears, hot cracks.

Cause:
Many causes, from shrinkage cracks on surface, casting being stretched in the die, mechanical stress at die opening, ejection, or from trimming.

Corrections:
Determine the most probable cause first:
1. Shrinkage cracks (surface porosity):
   - Discolored crack
   - Evidence of dendritic structure
2. If shrinkage cracks are the problem:
   - Check for good radii at crack location
   - Cool the hot spot
   - Heat up the adjacent cool spots
   - Add pressure in this area during solidification (see shrinkage porosity, the same corrections apply here)
3. For castings that crack in the die from being stretched during cooling (stress cracks during cooling and after solidifying) as shown by:
   - Cracks at a weak point in the shape
   - Cracks at stress concentration points
   - Crack surface in not oxidized
4. If this stress cracking during cooling is the problem, then:
   - Reduce stress risers (add radius as much as possible)
   - Shorten hold time
   - Look for thin wall castings that cool before runner; in this case cool runner and eject sooner
   - Add wall thickness if possible
   - If biscuit determines hold time, then add cooling to biscuit
   - Change runner shape if necessary to eject sooner

5. Identifying crack problems from mechanical forces or die shift during die opening:
   - Identified by cracks at bottom of deep walls or cores – or cores or walls that stick in the cover half
   - Usually have some evidence of drags
6. Corrections for castings that crack from die shift during die opening:
   - Watch as dies separate, look for evidence of die shift (ejector die drops forward as dies separate)
   - Watch as dies close; If die guide pins carry the load, it is likely there is stress on the casting during opening
   - Add die carrier under ejector die
   - Reset die to re-align the ejector half better
   - Adjust shoes under movable platen as needed
   - Check tie bar stress for even locking
   - Check condition of linkage, repair as necessary
   - Check condition of tie bar bushings, repair as necessary

7. Identifying crack problems that are caused by ejection:
   - Drags usually present
   - Sticking problems present
   - A visual check shows ejection not straight and even
   - Slow down ejection process to clearly see what is happening

8. Corrections for cracks that occur during ejection:
   - Check that ejection movement is straight, guided, and does not wobble during ejection
   - Check for drags, lack of draft, or undercuts
   - Eject slower and smoother
   - Check slides for proper action, (slides not worn out and wobbly)

9. Check metal constituents:
   - In aluminum, check proportion of Fe, Cu, Si; also check for presence of silicon modifiers
Chapter 11

Inclusions

Defect:
Inclusions, hard spots.

Cause:
In aluminum, inclusions are mostly oxides, usually from poor melt-cleaning and furnace cleaning practices; Also can be furnace refractory. In zinc, the iron aluminum inter-metallics can lead to polishing and machining problems.

 Corrections:
 1. Aluminum – the oxides were probably made in the melting furnace; check cleaning procedures:
     • Examine melt line and corners for build up
     • Scrape bottom for excessive corundum material on the bottom of furnace
 2. Check wall cleaning procedures:
     • Proper tools?
     • Operators trained?
     • Is cleaning schedule discipline maintained?
 3. Check for a delay after cleaning and before delivering metal – try to get at least half hour, more is better – very important!
 4. Check fluxing procedures – once/shift?
 5. Check de-gassing procedures – as often as possible
 6. Check filter system:
     • Filters replaces as needed?
     • Filters leaking around the edges?
 7. Review temperature at central melting, is it too high? (probably best between 1350-1400°F). Use one setting; do not allow variations in settings.
8. Check holding furnaces for oxide build up and cleaning procedures:
   - Does temperature vary too much? (look for high temp swings)

9. It is possible that hard spots (or hard areas) will contain sludge, check bottom of furnaces and review holding furnace temperatures for sludge.

10. Some hard spots are refractory material; this came from cleaning and then tapping the furnace too soon.

11. For zinc and ZA alloys, reduce hot spots in the pot and reduce excessive fluctuations in furnace temperature.

12. Most of the harder material will rise to the surface as dross and can be skimmed off (if allowed to form).

13. For ZA alloys, keep the iron content below 0.75%.
Chapter 12
Solder

Defect:
Solder.

Cause:
Aluminum or magnesium and die steel combine and cast metal sticks to die surface; in zinc, the zinc forms a layer on top of the steel.

Corrections:
1. Aluminum:
   — Check temperature in solder area, reduce if at all possible – this is the best solution
   — Add fountain (bubbler) in solder area (even a 1/8” diameter fountain will do a good job)
   — In solder area to high heat transfer material (TZM, ANVIL-LOY, MITECH)
   — Be sure water lines are functioning (clean of deposits)
   — Increase spray on the solder area
   — Reduce speed, increase cycle time

- Reduce fill time
  — Lower the length of time the metal impacts on the solder area

- Check the metal velocity – is it too high?
  — Velocity above atomization, but not much (about 1000 to 1400 ips)
  — Check PQ² for proper process settings, find best plunger size, speed, pressure, etc.
  — Check actual plunger size and speed – are desired conditions really being met?

- Check Draft angle at solder point
- Check for undercuts or rough surface on die at solder point
Solder on a core pin.

- Check iron content of alloy – above 0.75%
- Use lower pressure if possible

1. Zinc (build up):
   - Lower die temperature (if it can be done, this is the best action)
   - Improve die surface finish – reduce surface roughness
   - Increase draft angle
   - Coatings – smooth surface, i.e., tin, crc
   - Polish die (use inhibited acid to keep die damage to minimum, polish with 600 grit)
Chapter 13
Carbon Buildup

Defect:
Carbon Buildup.

Cause:
Build-up of deposits, usually from lubricant, or water mixed with lubricant.

Corrections:
1. Check lubricant application:
   - Spray volume is at minimum
   - Increase die temperature with cycle time decreases, water flow adjustments, or spray adjustments
   - Even out the die temperature, get rid of cold or hot areas
   - Spray mixture and amount applied should not be varied arbitrarily, especially from shift to shift
   - Use the proper lubricant to match the die temperature, especially when using a cold die (measure die temperature, verify with the supplier that the lubricant will work at the die temperature)
   - Do not spray into blind fins and cores and other cold areas
   - Extra spray should be carefully removed with air blow-off
2. Do not use hard water for mixing with lubricant.
Scale buildup. Rough casting surface caused by scale or carbon buildup on the die surface (1X).
Chapter 14
Die Erosion

Defect:
Die erosion, cavitation, burn out. Die has worn spots causing raised spots on the casting; can be small deep cavities (cavitation), or larger erosion areas at the gate.

Cause:
High metal velocity, bubbles in incoming metal, high oxide or silicon content in metal.

Corrections:
1. Check gate velocities:
   - *Aluminum metal velocities should be about 1000 ips to 16000 ips*
   - *For zinc, gate velocity should be about 1200 ips to 2000 ips*
   - *For magnesium, gate velocity should be about 1200 ips to 3000 ips (Less damage occurs from higher velocities in magnesium)*

2. Check metal temperature, should not be high.
3. Check die temperature in the gate area, reduce with spray if possible.
4. Check metal cleanliness, oxide cleaning procedures should be in place (see hard spots).
5. Check fill times – long fill times accelerate gate erosion.
6. Check alloy – hyper-eutectic (high silicon) alloys require smaller process window (lower gate velocities).
7. In zinc, trapped air bubbles cause cavitation and “burn out” (see gas porosity corrections):
   - Check gate design – small design mistakes that do not follow NADCA guidelines can cause cavitation
   - Change gate locations, try to find a location where gate doesn’t impinge on die steel
   - Use slow shot speed on plunger to reduce trapped gases – set it so plunger moves slowly up to sprue

Cavitation (10X).
Chapter 15
Outgassing

Defect:
Outgassing: Defective surface finish occurring when bubbles appear during a painting or finishing operation.

Cause:
Leak path develops through casting skin when casting is heated during finishing, allowing the heated and expanding trapped gas to escape.

Corrections:
1. If problem is in overflow gates, then minimize or combine number or overflow gates used, reduce size of overflows.
2. Keep overflows away from edge of castings to minimize heat build up next to casting.
3. Make main gate thinner while still maintaining appropriate gate area for casting quality needs.
4. Reduce metal temperature, but stay above 790°F for zinc, and above about 1200°F for aluminum.
5. Reduce die temperature at gate.
6. Reduce trapped gas (see gas porosity corrections):
   - Use slow shot speed on plunger (hot chamber)
   - Reduce spray to absolute minimum
7. Make sure there is pressure at the end of the stroke:
   - No thin biscuits or leaking plunger rings
   - Change or correct problems before plunger starts to stick or drag
   - Check for proper metal pressure, both static pressure and intensified (right size plunger)
   - Accumulator pre-charge correct
A blister and a hole (in the paint) at the gate from outgassing (4X).
Chapter 16

Edge Porosity

Defect:

Edge porosity – porosity at the gates.

Cause:

Either shrink or gas porosity.

Corrections:

1. Shrink porosity correction:
   - The path for the gas is formed by the loose dendritic structure near the gate; this can be reduced by cooling this area more (can overcool for thin gates)
   - Use long, flat gate ramps to avoid the hot steel next to the gate
   - Make the gate thinner and wider to spread the heat more (don’t exceed the proper gate velocity)
   - Move the gate to the other half of the die if it would be cooler there
   - Reduce fill time as much as possible – this reduces heat left at the gate by the metal stream

2. Gas porosity:
   - Gas porosity will contribute to outgassing, but not nearly as much as shrink porosity
   - Use the techniques described in gas porosity corrections to reduce this problem (Chapter 4)
Edge porosity (6.5X).
Chapter 17

Bending, Warping

Defect:
Bending, warping, out of flatness.

Cause:
Many operational and design issues.

Corrections:
1. Design issues:
   - Too much tolerance allowance for tool construction (save most of the available tolerance for process variations)
   - Incorrect shrinkage (one value for all dimensions may not be accurate enough)
   - Incorrect estimate of process capabilities
2. Operational corrections:
   - The most important factor is a consistent ejection temperature; The casting and the die must be at the same temperature each time a casting is ejected
   - Control hold time with a thermocouple instead of a timer
   - Maintain a very consistent process to keep temperatures consistent:
     — Consistent die spray
     — Consistent cycle time
     — Consistent cooling water flow rates
Uneven ejection forces:
- Poor ejector system design, or worn ejector guide mechanism
- Uneven length of bumper pins
- Incorrect ejector pin locations
- Drags from worn or heat checked die, or undercuts in the die
- Stress on casting during die opening
  - Worn machine linkage
  - Worn tie bar bushings
  - Worn platen shoes
  - No die support
  - Worn guide pins

- Not enough draft allowance, especially on short walls and internal cores
- Ejection too early
- If variation is eliminated, and the casting shape is stable, then change the die dimensions so the casting comes out within specifications
Chapter 18

Flash

Defect:
Flash – Excessive cast material often accompanied by dimensional deviation.

Cause:
High metal temperature and either poor die fit or poor machine locking when high pressure is applied.

Corrections:

1. Die fit:
   - Check die fit at operating temperature – use bluing or other means to check fit with die at operating temperature
   - Review castings for evidence of die deflection (look for differences with high and low pressures); review die design for proper robustness

2. Machine locking conditions:
   - Strain tie bars for equal load
   - Check condition of machine:
     - Linkage not worn
     - Tie bar bushings and movable platen shoes in proper condition
     - Platens flat, not bent
     - Die set up correct
     - Tie bar nuts not loose

3. Die opening force centered on machine:
   - Center of load calculated, and load on each tie bar calculated

4. Metal pressure considerations:
   - Static metal pressure in the 3000 to 6000 psi range
   - Intensified metal pressure in the 7000 to 12,000 psi range
   - Impact spike high because of accumulator in back or other considerations
   - Intensifier control not consistent, comes in fast one time, slow the next
5. Die and casting thermal conditions:

- Uneven heating, hot spot in casting and/or in the die – this causes the die to expand unevenly
- Be sure the hotter areas (such as the biscuit block or the area around the sprue or sleeve) have cooling – these hotter areas can expand and hold the die open
- Heavy section of the casting on parting line in a hot section of the die
- Die temperature fluctuate from unstable operating conditions
- Metal temperatures at the gate fluctuate from unstable holding furnace or operating conditions
Chapter 19
Stained Castings

Defect:
Stained castings, discolored casting.

Cause:
Foreign material in the metal, almost always die lubricant, but can be other material.

Corrections:
1. Review lubricant practices:
   - Check amount of plunger lubricant
   - Consistency of application (this is a major factor in many plants)
   - Check amount of die lubricant used
   - Check mixture ratio
   - Possible look for a different lubricant material
2. Look for other material in liquid metal – possible from scrap.
Staining from die lubrication (0.5X).
Chapter 20
Waves and Lakes

Defect:
Waves, lake.

Cause:
Usually seen in decorative zinc castings, caused by early metal flows that solidify quickly leaving a separate skin that is not remelted; the surface of this area is more fine grained than the rest and has a slightly different appearance.

Corrections:
1. Correct metal flow:
   - Much quicker fill time
   - Change flow pattern to minimize splashing and jetting in the area

Lake seen when a section of the casting was polished; this would have caused a defect if the casting had been plated.
Chapter 21

Drags

Defect:
Drags.

Cause:
Deformation of the casting by undercuts encountered during ejection. Undercuts may be caused by buildup on the die or by die erosion of solder.

Corrections:
1. See corrections for build-up, solder and erosion (Chapter 12 and 14).
2. Make sure die surface is smooth, machining marks have been completely polished out.
3. Check draft angles.
4. Reduce the temperature of the steel that has the drag – this can be done with spray or with high heat transfer die materials.
5. Check metal temperature.

Drag starting in a hot corner close to the gate.

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Chapter 22

Deformation from Ejector Pins

Defect:
Deformation from ejector pins.

Cause:
Caused when the casting is still soft and sticks in the die; consequently the ejector pins bend the casting trying to eject.

Corrections:
Check the following

1. Undercuts, drags.

2. Casting stays in the die too long or too short (hold or dwell time not correct for casting).
   - Short dwell time means the casting may be too soft at ejector pin location and may deform
   - Long dwell time for certain shapes may mean that the part has contracted onto the die steel, and thus requires extra ejector force to remove

3. Machine ejection system is “jerky,” with high impact on the casting.

4. Poor die design, check for:
   - Too few ejector pins
   - Pins in the wrong locations (must be balanced force around cores and other ejection resistant features)
   - Use ribs under ejector pins to spread the load
   - Ejector pins too small
   - Ejection guidance system inadequate or worn out (ejector plate wobbles during ejection)
   - Ejection system load not balanced, or if unbalanced ejection load is required, the ejector plate guidance system design was not adequate for the off center loading
Deformation from ejector pins.
Chapter 23
Excessive Flux

Defect:
Excessive flux.

Cause:
Too much flux causes an increase in porosity and surface corrosion; this is determined by putting casting in clean water overnight or examining a fracture through the porosity area for white spots.

Corrections:
Reduce flux usage:
1. Review procedures with experts, determine the correct amount to use, and the correct application procedures.
2. Write down procedures.
3. Train operators carefully about how much flux to use and how to apply it.

Flux inclusion in the shape of an egg shell, which broke when a fracture was made for examination (15X).