STEADY DIECASTING SOLUTIONS
3/154 ARAWALI VIHAR , RHB BHIWADI
301019
EMAIL - STEADYDIECASTINGSOLUTIONS@GMAIL.COM
CONTACT NO – 9549867867

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WE CAN WORK FOR YOU AS A TEAM MEMBER

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DIE CARE AND MAINTENANCE

BY

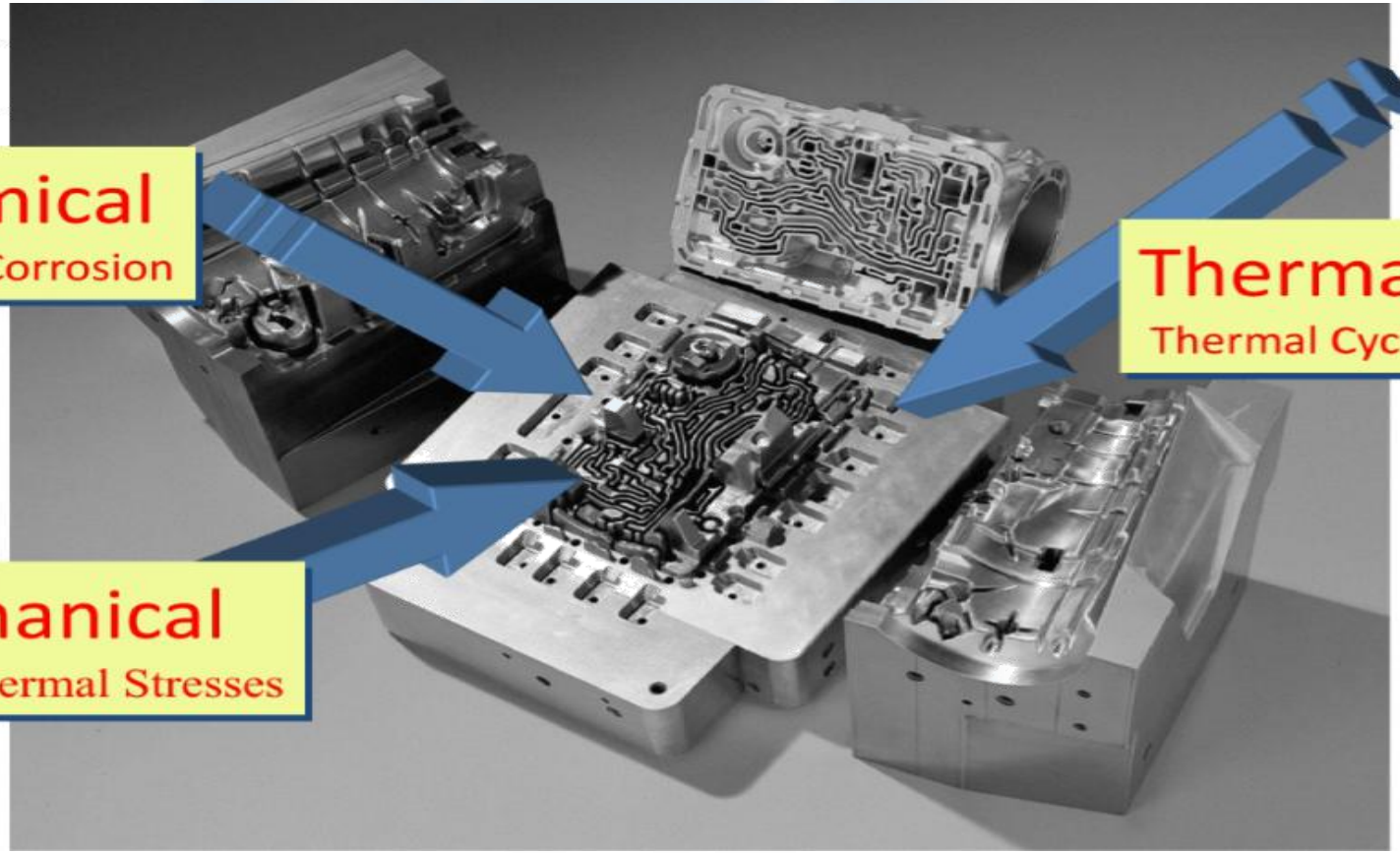
BHARAT SHARMA

Steady Die Casting Solutions

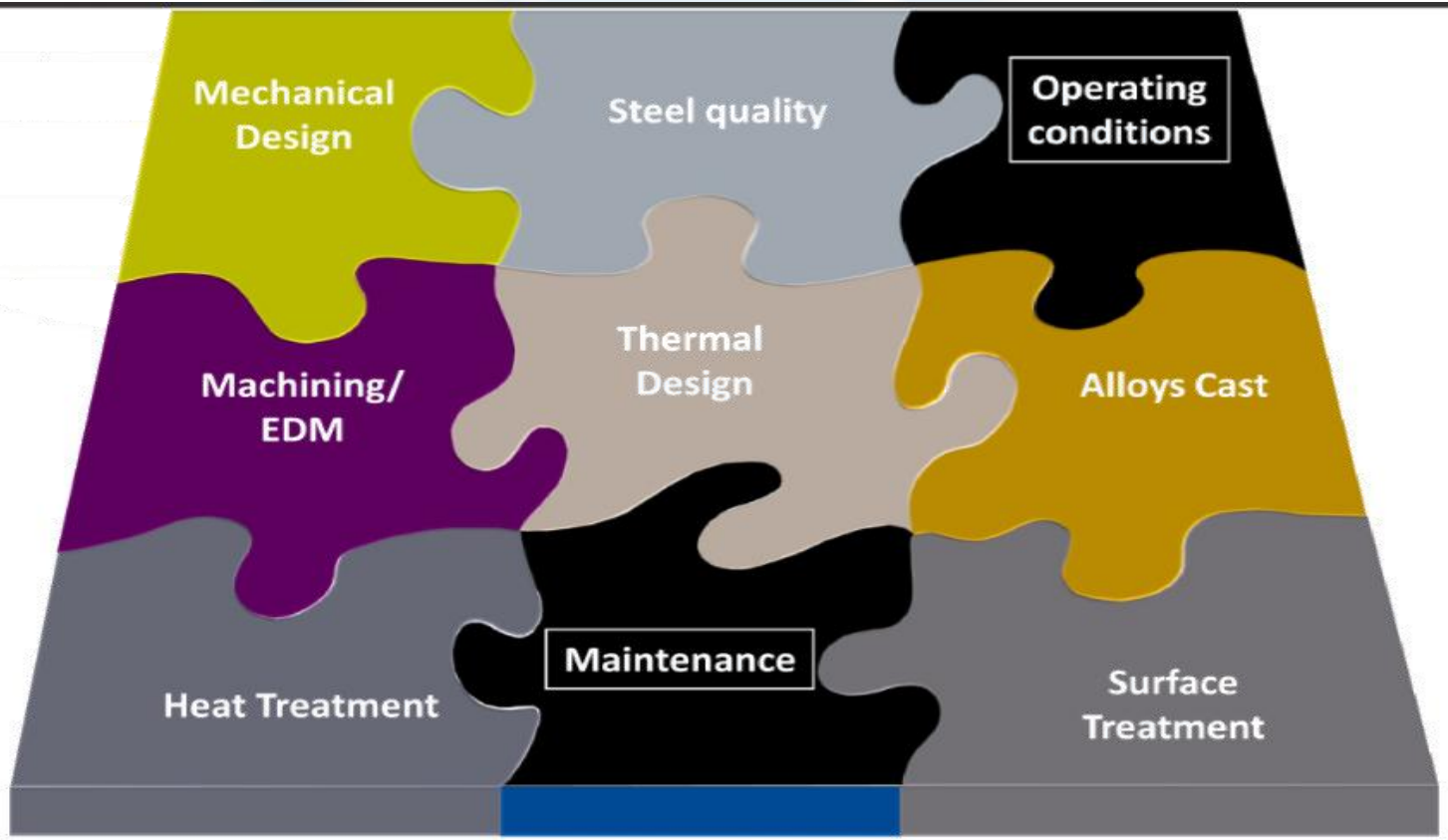
Outline

- Factors that affect die life
- Die failure mechanisms
  - Gross cracking
  - Thermal fatigue (heat checking)
  - Erosion, soldering and cavitation
- Operational Factors
  - Pre-Heating
  - Temperatures and Temperature Control
  - Die Spray & Internal Cooling
  - Minimizing Solder and Scrap
- Die Care and Maintenance
  - Inspection, Handling, Cleaning, Polishing, Welding, Storage

Demands on die casting dies



Factors that affect die life



Contributors to die life

Steel Supplier/Heat Treater

Selection of the steel
Heat treatment
Carburizing/Nitriding/Coating

Machining/EDM

Careful machining
Avoid sharp feature
Remove white layer

Design and Construction

Thermal layout
Large radii
Ease of ejection
Layout of cooling system
Optimized gating system

. . . . .

Die Caster

Pre-heating
Minimal spraying
Maintenance
Tempering after welding
Minimal thermal cycles
Alloy used
Documentation

Die failure mechanisms

Gross cracking

- A catastrophic failure in which the die breaks into several pieces or cracks suddenly in a thick section after a limited number of cycles.

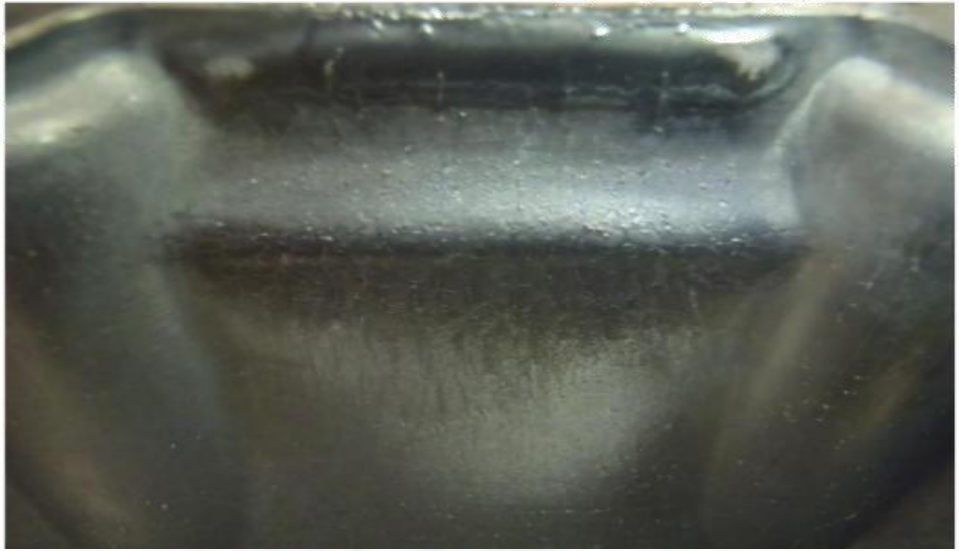
Thermal fatigue cracking

- Also known as Heat Checking
- Most Common Failure Mechanism
- Every cycle, the die surface expands and contracts because of the cyclic heating and cooling. Cracks are initiated at stress concentrations and gradually grow.

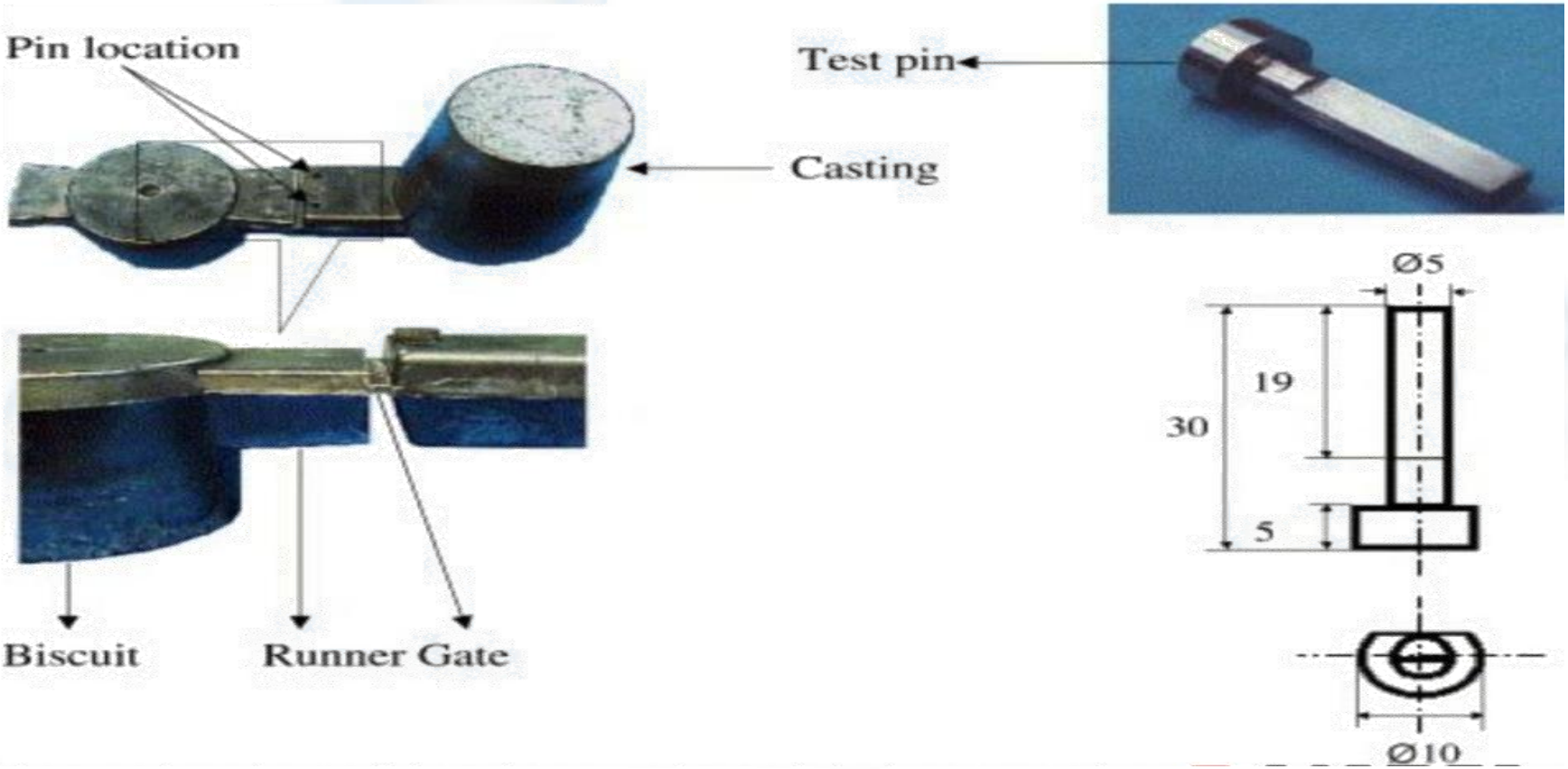
Thermal fatigue cracking

Erosion/Washout

- Metal removal caused by molten metal and abrasive particles passing over the die surface at excessive velocities.



Evaluation of washout resistance



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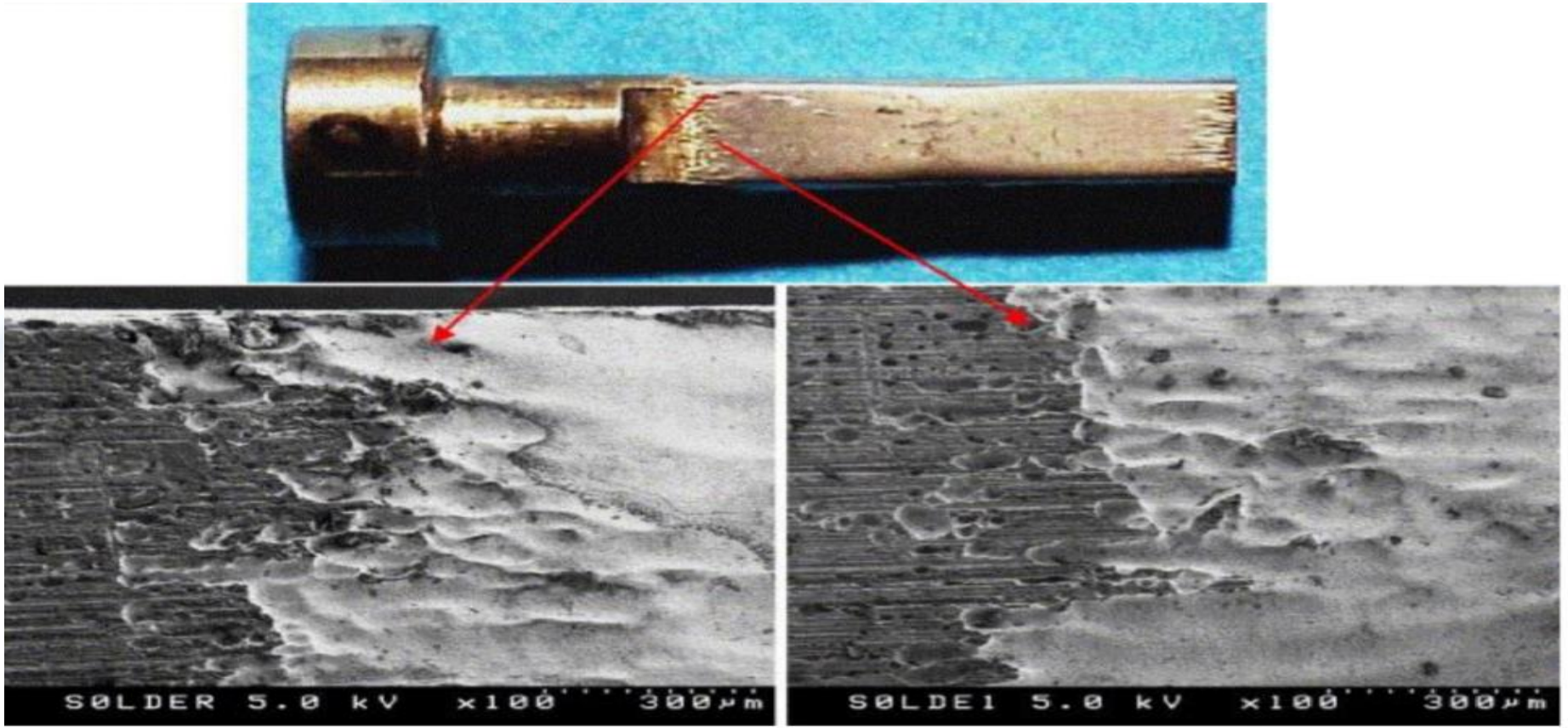
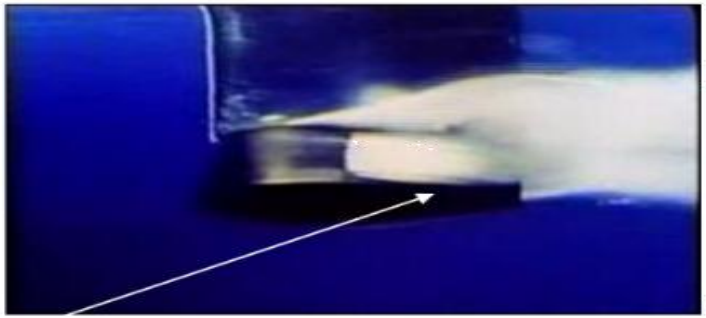


Cavitation

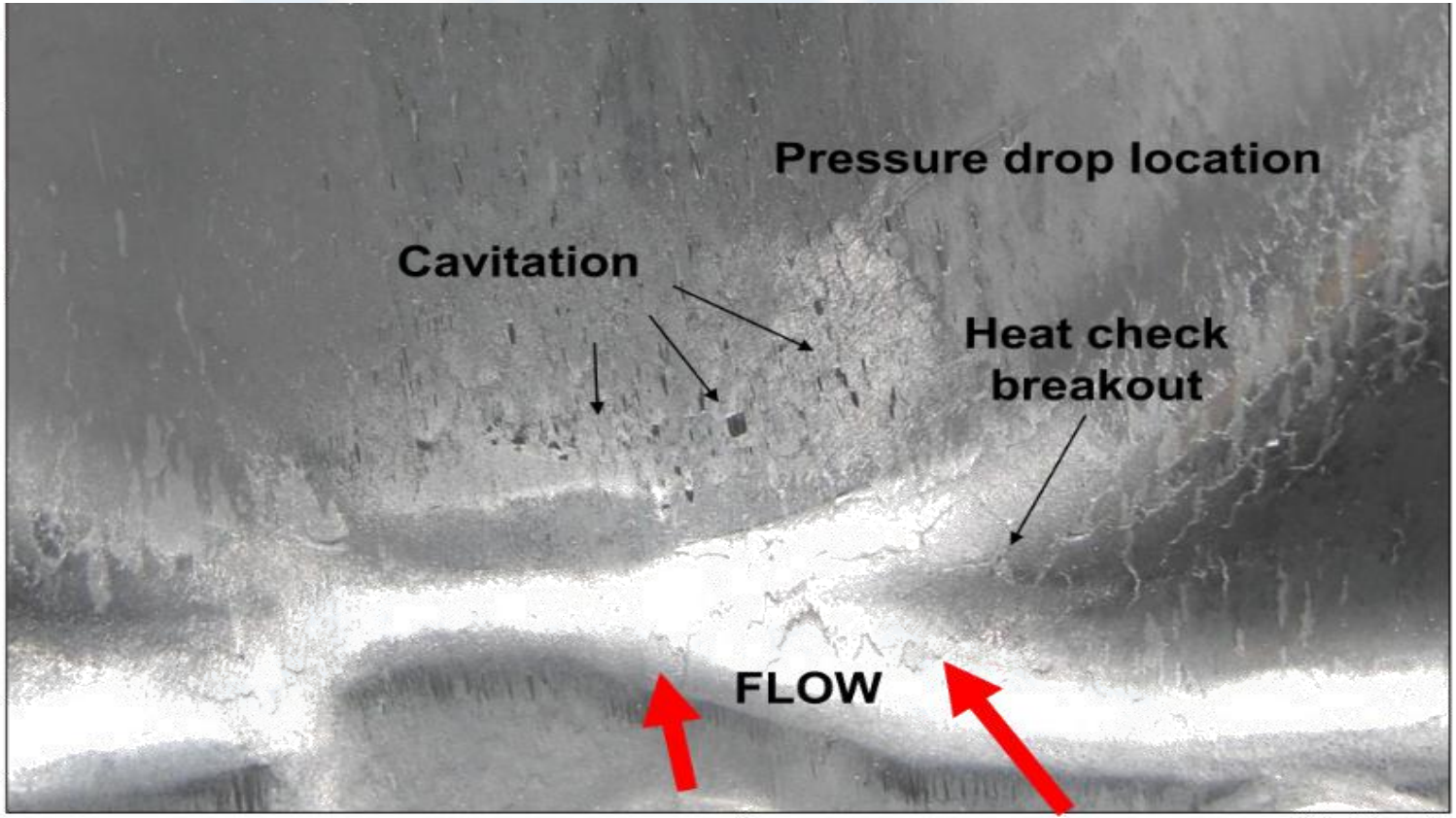
- Damage caused by the bursting of bubbles carried in the liquid metal stream
- Local pressure that falls below saturated vapor pressure causes cavitation to occur
- Resulting vapor cavities (void bubbles) collapse on surface material with high energy and heat
- Occurs at sudden change of flow direction
- Occurs at obstructions to flow that generate pressure variations

Well known in propellers and rudders



The Navy and Marine industry spend billions on the prevention and cure of cavitation damage to ships' propellers and rudders. Cavitation also affects power requirements for ships to attain their maximum speed.

Cavitation


Pressure drop location
Cavitation
Heat check
breakout
FLOW

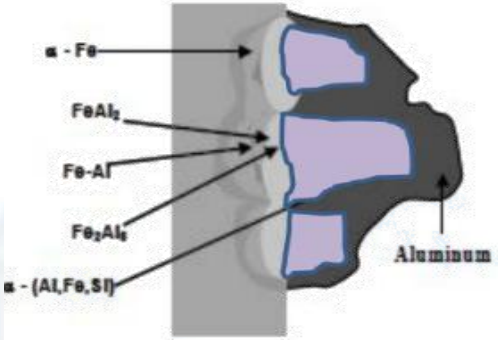
Soldering

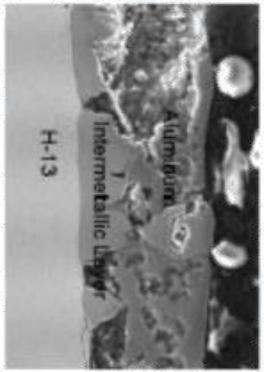
- Reaction between the molten Al and the tool steel that forms a brittle intermetallic on the surface of the die.

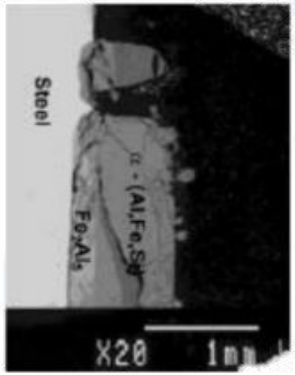
- Results in:
  - Firmly attached area(s) of the casting to the die
  - Down time
  - Die wear or pitting

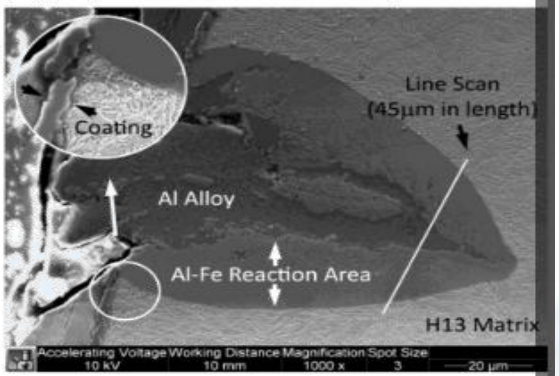
Soldering mechanism

- Molten Al reacts with Die Steel









- Layers of intermetallics are formed
  - 1st layer: higher in Fe, may have 3-4% Cr & no Al
  - Intermediate layers: 55-60% Al and 14–25% Fe
  - Final layer: 64% Al, 28% Si and up to 2% Fe (some possibility of copper if copper is in alloy)

Soldering

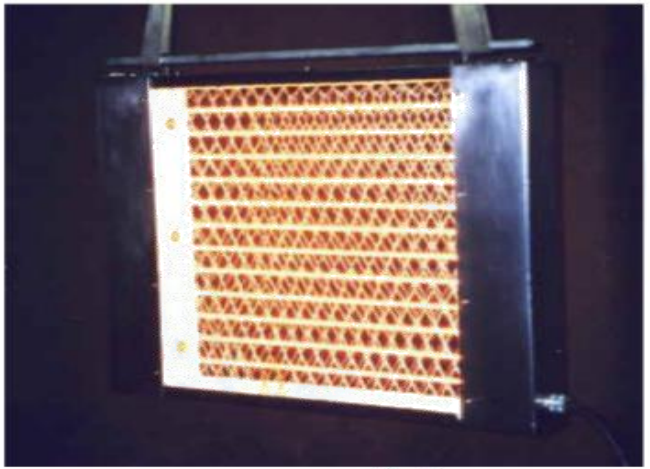
Operational factors

Operational factors

- Operational Factors
  - Pre-Heating
  - Temperatures and Control
  - Die Spray & Internal Cooling
  - Minimizing Solder and Scrap
- Die Care and Maintenance
  - Inspection, Handling, Cleaning, Welding, Storage

Pre heat the die

- Never Cast in a Cold Die
- Preheat the Die Surface to 300°F-600°F
  - Hot oil units
  - Portable heaters (gas fired, infrared)

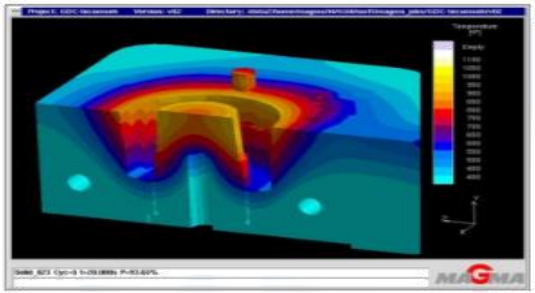


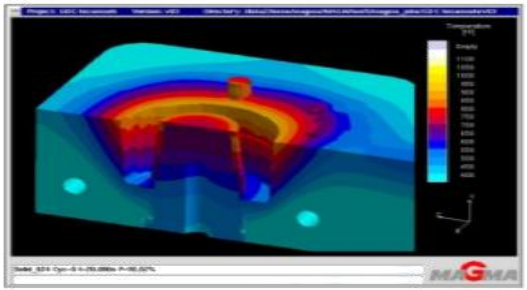
Die temperature

- Suggested Operating Temperatures (°F)

	Good Finish	Average Finish
Al	475 - 600	375 - 600
Zn	450 - 550	375 - 550
Mg	425 - 550	400 - 550

- Minimize Variation Within Die (100°F)





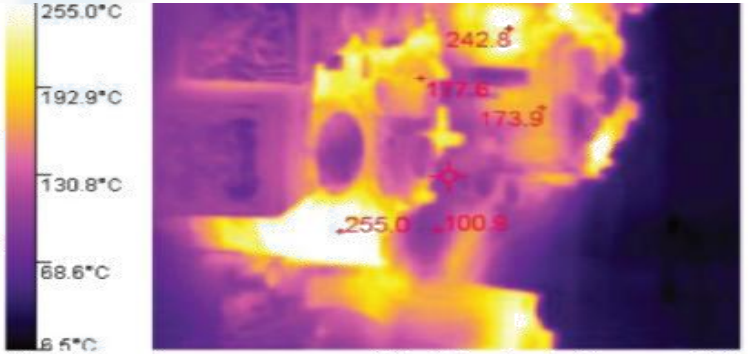
- Higher End of Range is Better

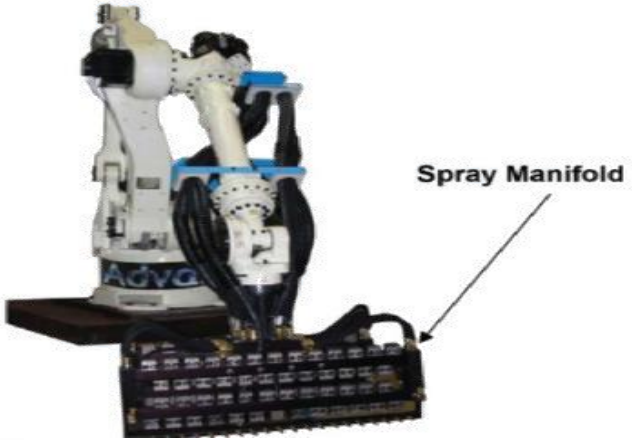
Internal cooling/heating

- Optimize Cooling Channel Design
  - Design Criteria
  - Computer Modeling
- Control Flow Rate
- No Scale in Water Lines
  - Deposits of .005 cut heat transfer by about 40%

Die spray

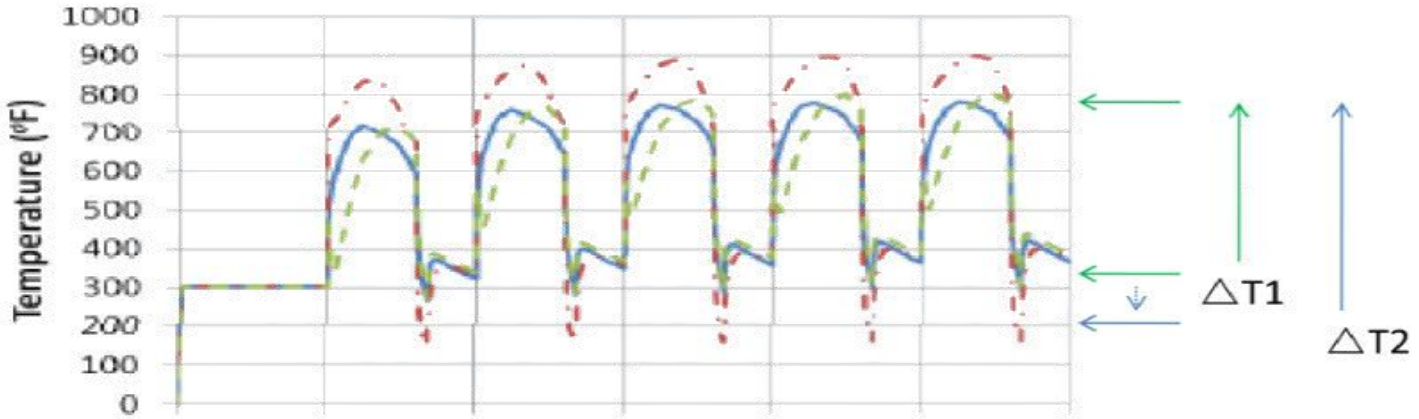
- Function
  - Release casting
  - Thermal control
  - Protect
  - Lubricate
- Know What Die Temp Your Die Spray Is For
- Don't Over Spray
  - Thermal shock decreases die life
  - Residual spray causes gas porosity
- Control!!





Temperature cycle

- Run as consistently as possible
- Minimize △T between maximum and minumum die temperature

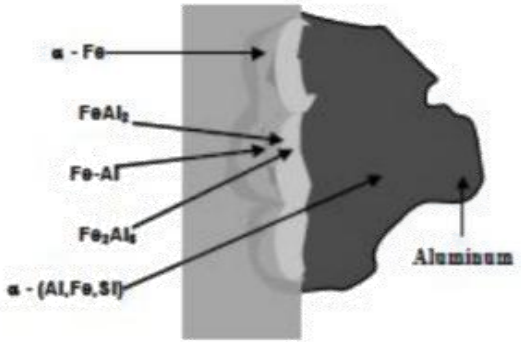


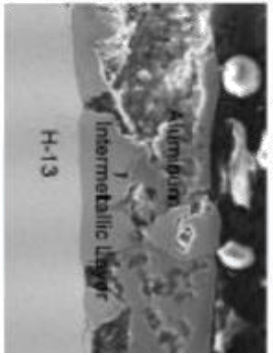
Metal temperature

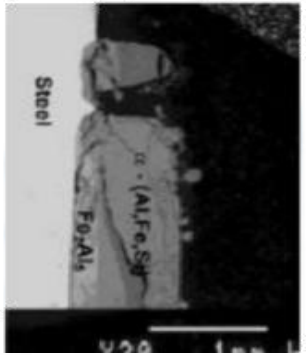
- Keep as Low as Possible
- Maintain Consistent Holding Temperature (+/- 10°F)
- Increase in Metal Temperature Increases Die Temperature and Increases △T

Minimize soldering

- Soldering Penetrates the Die Surface
- Minimize or Eliminate Occurrence
  - Cool areas prone to solder (spray, internally cool, coat)
  - Use higher thermal conductivity die material
  - Keep Fe in Aluminum above 0.8% or add Sr







Minimize scrap

- Every Shot Counts – Good Casting or Bad
- 7% Scrap = 7% of Die's Life
- The Better the Pre-heat, the Lower the Run-in Scrap

Die care & maintenance

Die care and maintenance

- Inspection
- Handling
- Stress Relieving
- Shot Peening
- Polishing
- Die Cleaning
- Weld Repair

Inspection

- Visual and Hardness
  - When?
    - New
    - Periodic Basis
  - Visual For What?
    - Surface finish
    - Cracks
    - Washout
  - Hardness For What?
    - HRC above 38

Handling

- No Clanging or Banging During Transport
- Remove Stuck Castings with Care

Srtress relieve/ temper

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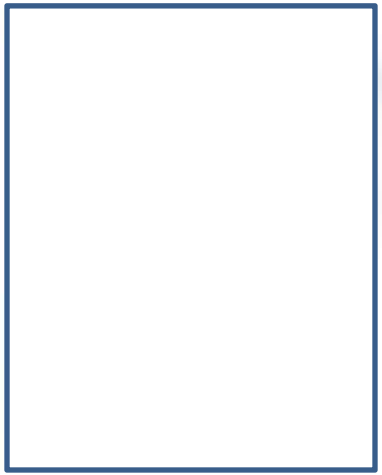
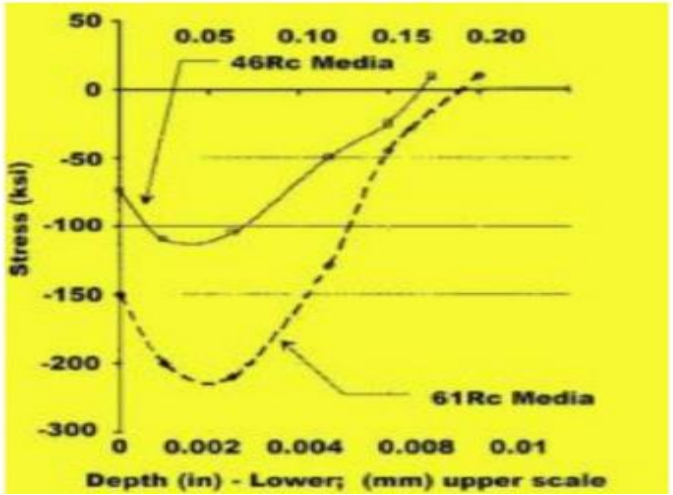
- Residual Tensile Stresses after Heat Treat
- Thermal Treatment Relieves Stress
- When?
  - Regular intervals (25,000 shots)
  - After EDM
  - Temper after welding



Shot peening

- Shot Peening Imparts a Compressive Residual Stress and Texture
- Consider for New Die and Every Other Stress Relief or Die Half-Life



Polishing the cavity

- Fatigue cracks usually initiate at surface defects. Polishing the surface of fatigue test samples is well known to significantly increase the fatigue limit.

- Likewise, heat checking is strongly promoted by imperfections on the surface of the die i.e. machining marks, nicks and dents, engraved features etc.

- There is ample evidence careful polishing of the cavity can delay onset of heat checking and extend die life.

- Texturing the surface of the die, and creating “micro air pockets” may provide other benefits in flow and filling of the cavity. These are well documented in permanent mold coating practices.

Polishing

- The cover cavities for the part in question run more than 400,000 pieces per year.
- The guaranteed cover cavity life was 40,000 pieces (also, actual cavity life was very close to 40,000 pieces).
- There has been scope creep on what is cosmetically acceptable causing tools to be retired earlier then they have been in the past.
- We have worked with the part design, casting process, cavity steel, Metallife, and coatings in an effort to improve the tool life and have gained the improvements we could from those areas. We were looking for other options to extend cavity life. The next progressive step we reviewed was the polishing – or more correctly, the effect of the scratches left by the polishing process.

Polishing

A cavity (cavity 94) for a cosmetic part was run and observed with 20X magnification regularly during its life. At this magnification die fatigue could be seen as early as 1425 shots. These heat checks seemed to be directly related to the polishing scratches left in the die during the tool build.

The heat check was monitored through the life of this cavity.

Polishing

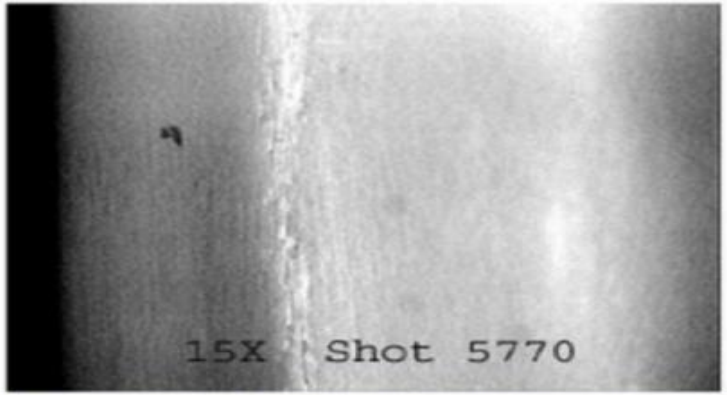
A new process (diamond polishing the fillet radii) was implemented on cavities based on the cavity 94 information, and the tests displayed the positive results. The supplier was confident enough with the results that they have increased the guaranteed tool life by 25%.

Below is a comparison of 2 cavities: 1 with diamond polishing in the fillet radii and 1 with a 300 stone finish.

C102

Cavity 102 (Diamond Polished)
5157 Shots

C98



Cavity 98 (300 Stone Finish)
5770 Shots

Polishing

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The average shot-life on the 10 cavities produced using this diamond polishing technique was 61,588. Before using this process the shot-life was guaranteed (and averaged) 40,000 shots. The supplier's guaranteed shot-life has been raised to 50,000 shots.

Diamond polishing has been implemented on all of our cosmetic casting, cover cavities at this supplier.

Diamond polishing is also being pursued on non-cosmetic castings to extend the cavity shot-life.

With diamond polishing additional care must be taken through out the life of the cavity. If the diamond polish is removed while removing carbon or solder it must be reinstalled or the benefits will be removed.

Die cleaning

Die cleaning

- Solder
- Flash
- Carbon Build-Up
- Rust/Corrosion
- Techniques
  - Abrasive techniques
  - Chemical cleaning
  - Mechanical processes
  - Water-based techniques
  - Ultrasonic cleaning

Ultrasonic cleaning

Ultrasonic cleaning

Part	Qty.	Contaminant	Part Material
Cavity Insert	1	Solders, Build-up, Grease	
Core Pins	14	Solders, Build-up, Grease	
Core Pins	2	Build-up, Grease	
Core Pin	1	Build-up, Grease	

Machine Set-up				
	Tank #	Chemical	% Concentration	Temperature
Washing with U/S	1	M5	20%	90°C
Rinsing	2	Tap Water	Tap Water	Ambient
Rust Inhibition	3	M8	5 to 10 g/l	55°C

Test	Die cast Components	
Stage	Time	Comments
Washing with M5, tank 1	1 hour	General Condition: Solders, build-up and grease. We feel that the results that we have seen in our lab were very conclusive. The contaminants were removed leaving the parts clean.
Rinsing, tank 2	00:05	
Rust Inhibition M8, tank 3	00:05	

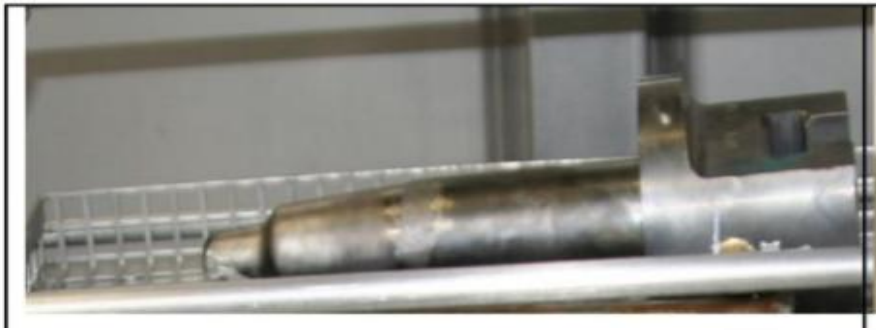
Ultrasonic cleaning

Before

After

Ultrasonic cleaning

Ultrasonic cleaning



Ultrasonic cleaning

Conclusion:

Our labor-free process effectively cleaned the cracks and the contaminants from the parts provided to us. We feel that the results that we have seen in our lab can be duplicated without issue at your facility, utilizing the same process and set-up parameters. Sizing parameters will be discussed based on your tools sizes and overall needs for your operation.

Weld repair

Die Steel & Heat Treatment Acceptance Criteria for Die Casting Dies (Publication #229)

- Defines:
  - Preparation of die for welding
  - Weld materials
  - Pre-heat
  - Welding
  - Post-heat

Storage

- Clean Dry Location
- Corrosion Protection

Summary

- Die Design Features
  - Eliminate high thermal loads, hot spots and stress concentrations
  - Internal thermal control is a high priority
- Operational Factors
  - Minimize $\triangle T$
  - Pre-heat
  - Control spray, temperature extremes
  - Reduce soldering and scrap rate
- Treat Dies with Care
- Stress Relieve Periodically. Temper after welding.

FOR

DIE CASTING SUPPORT

CONTACT US

STEADY DIE CASTING SOLUTIONS

BHARAT SHARMA

9549867867

steadydiecastingsolutions@gmail.com

- ON SITE TRAINING
- CONSULTING
- TRAINING TO EMPLOYEES
- PROBLEM SOLVING
- PROCESS CONTROL IMPLEMENTATION AND TRAINING
- PROCESS IMPROVEMENT BY USING LATEST TECHNOLOGY OR EQUIPMENT
- CASTING DESIGN FOR YOU AND YOUR CUSTOMER
- DIE CAST GATING
- PROCESS CONTROL
- DIE CASTING DEFECT
- METAL MELTING AND HANDLING
- MACHINE TONNAGE CALCULATION