Rapid Die Manufacturing

High Pressure Casting of Low Volume Non Ferrous Metals Components

Date: 2 November 2006

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Introduction to RPT

- Rapid Prototyping Techniques (RPT) generally used for non functional prototypes
- RPT used for indirect manufacture of functional prototypes by some manufacturers
  - Masters used in sand and centrifugal casting of metallic components
- Explore RPT on direct manufacture of functional prototypes or produce short series of components

Goal?

To use RPT for the Direct manufacture of die components which can produce low volumes parts

Strategy?

Evaluate the performance of two geometrically similar die components manufactured with

- Direct Metal growing method
- Conventional manufacturing

How?

1. Evaluate various RPT platforms and select one that is able to produce die components
2. Design die components
3. Manufacture die component using the selected RPT and conventional manufacturing method
4. Test the component under die casting conditions
5. Capture and analyze data
6. Compare findings

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1. Evaluation and Selection of RPT platforms

Evaluation

Selection criteria

- Fully dense metallic components
- Able to withstand casting process parameters, pressure, melt temperature, heat and cooling.
- Dimensionally accurate, short turn around time and competitively priced
- Single process (no green part)

Literature Survey

- The literature survey indicated that the following platforms could produce Die components able to withstand aluminium high pressure casting conditions.
  - Electron Beam Melting
  - Direct Metal Deposition
  - Direct Metal Laser Sintering

1. Evaluation and Selection of RPT platforms

Selected : Direct Metal Laser Sintering (DMLS)

Deciding factors

- Conforms to selection criteria
- Technology locally available in South Africa at CUT (most deciding factor)
- Further Research to be conducted in collaboration with CUT on the process

2. Design

Specifications

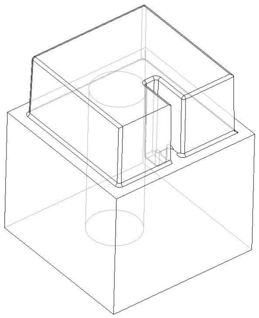
- Design core insert with sharp corners.
- Incorporate detail e.g. thin rib
- Use standard draft angle (1 degree)
- Design die to incorporate 4 similar core inserts using different manufacturing methods and surface treatment

Objectives

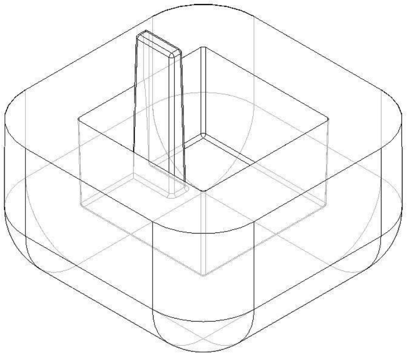
- Sharp corner will accelerate wear
- To pose some manufacturing difficulty
- Detect ease of ejection during surface defects
- To establish most feasible core condition e.g wear resistance, ease of ejection etc.

Models of core, inserts and component

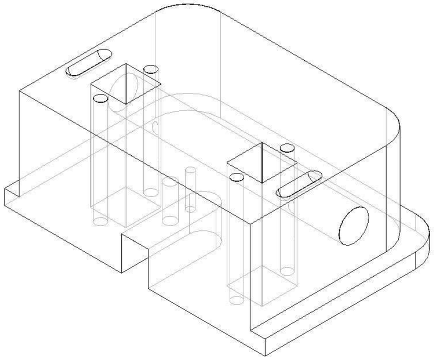
Core



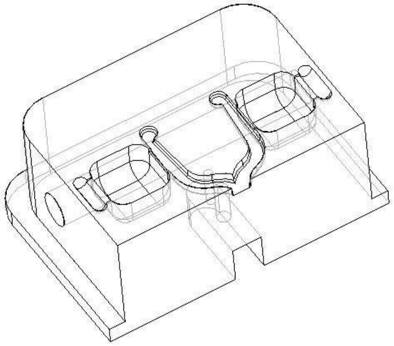
Component



Core holding insert



Cavity insert

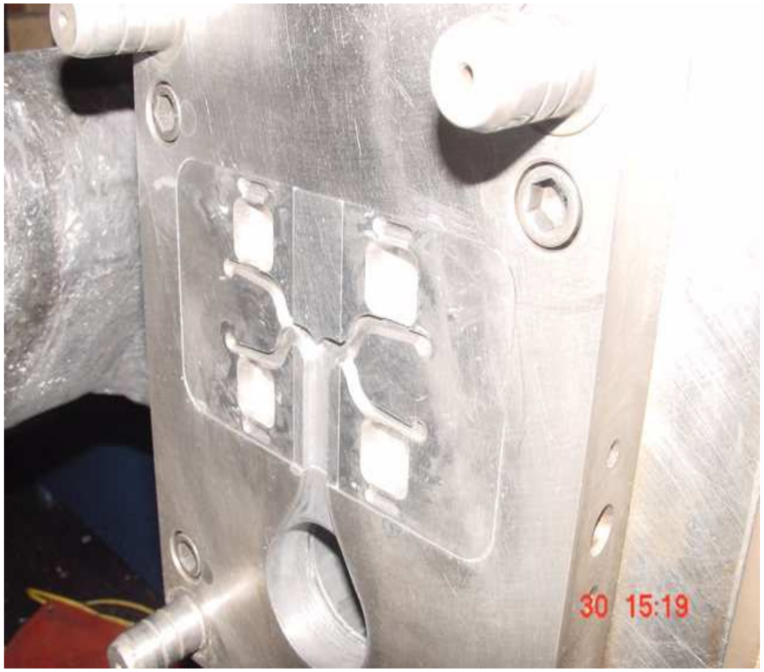


3. Die manufacture, assembly and data capturing

Manufacture 4 core inserts on the following methods:

- Core 0 manufactured on the conventional method from1.2344 material and through hardened
- Core 1 using the DMLS process grown in Direct steel20 material with surface treatment or coating
- Core 2 using the DMLS process grown in Direct steel20 material
- Core 3 using the DMLS process grown in Direct steel20 material and through hardened

Models of assembled Die

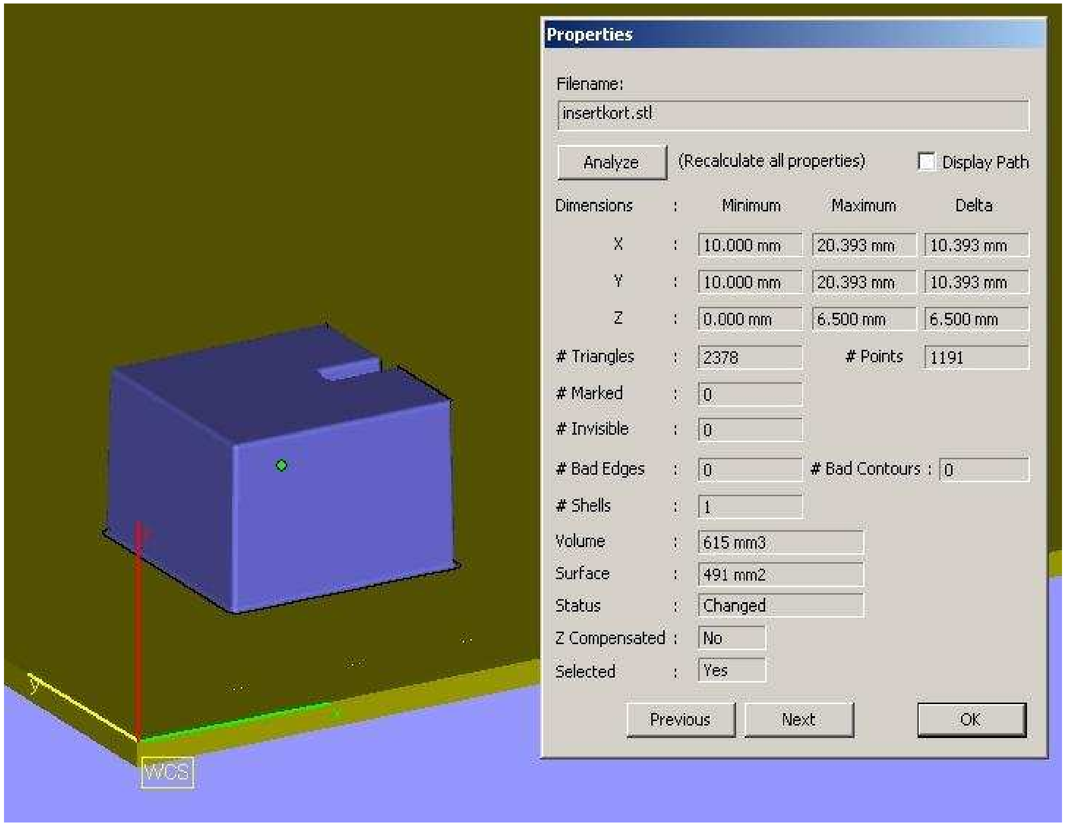


3. Die manufacture, assembly and data capturing

Core 1			Core 2			Core 3			Core 4		
Process	Cost	Hrs	Process	Cost	Hrs	Process	Cost	Hrs	Process	Cost	Hrs
Milling		2.5	DMLS		13.5	DMLS		13.5	DMLS		13.5
Grinding		2	Grinding			Grinding			Grinding		
Jig bore			Jig bore			Jig bore			Jig bore		
Heat tr		1	Heat tr			Heat tr			Heat tr		
F grind		4	F grind		3	F grind		3	F grind		3
SER		7									
Polish		2	Polish		2	Polish		2	Polish		2
Fitting		3	Fitting		3	Fitting		3	Fitting		3
electrode		4									
total		25.5			21.5			21.5			21.5

NB. Times based on a QTY of 3 cores and the DMLS growing time is the worst case scenario

3. DMLS growing options versus time



1 off = 1hrs 48 min

3 off = 2hrs 8min

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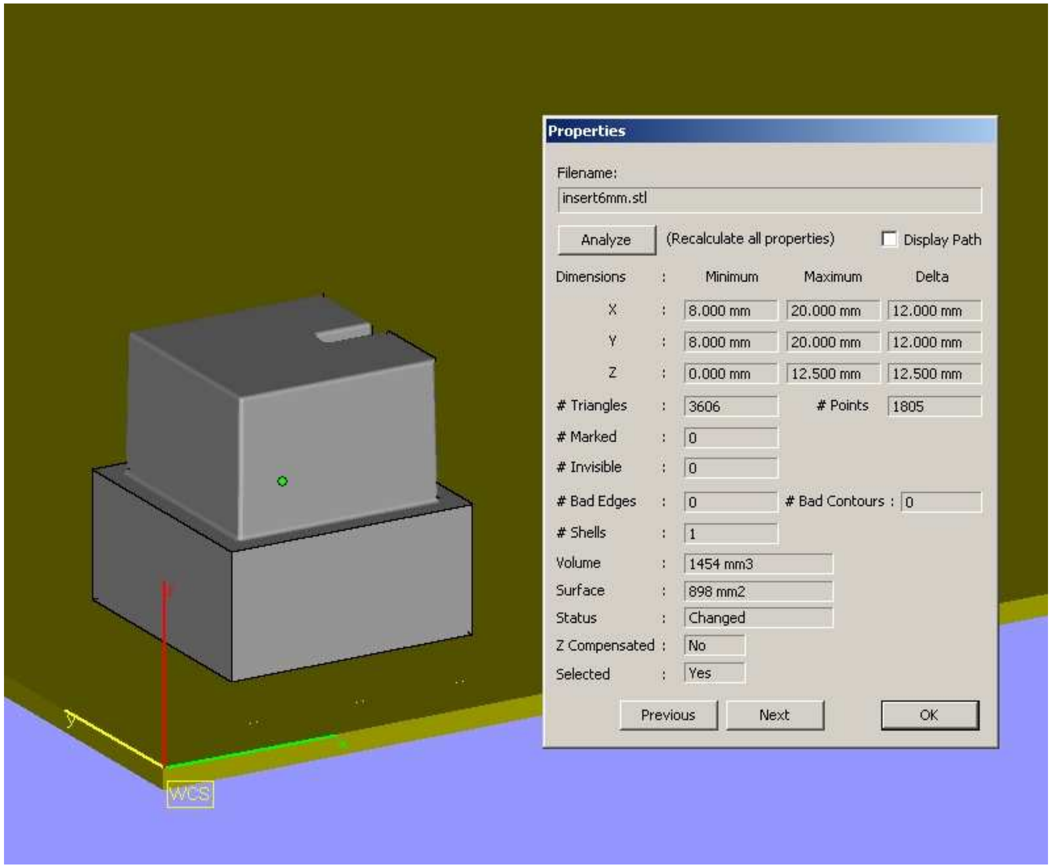
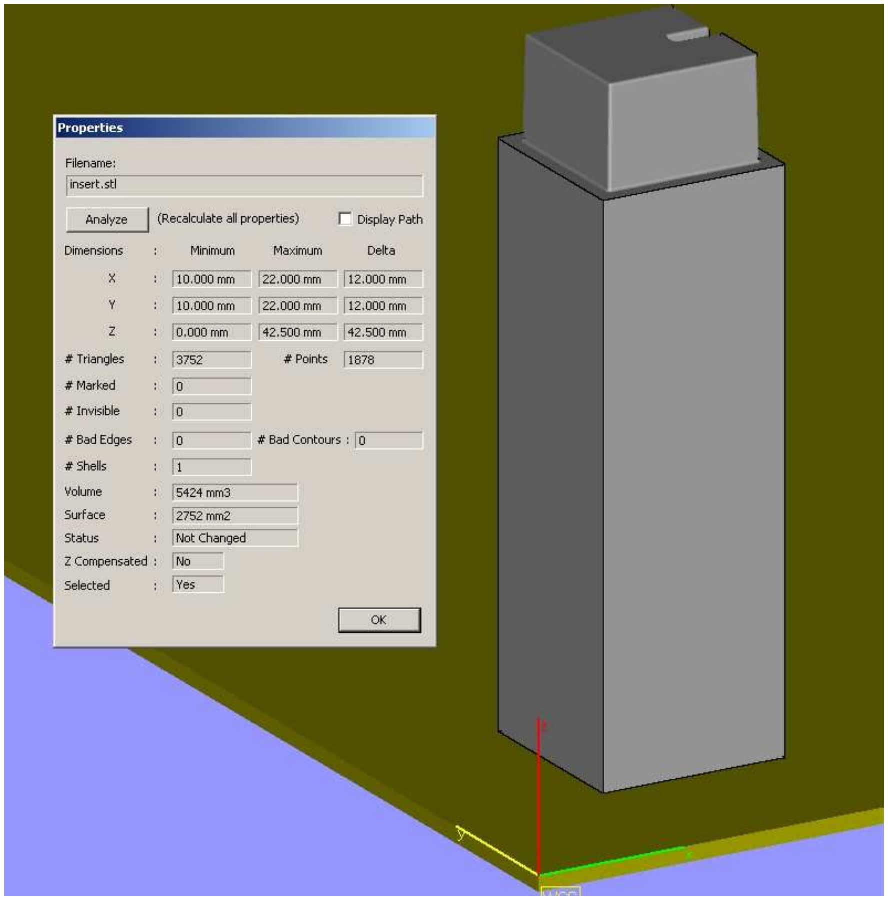
3. DMLS growing options versus time



1 off = 3hrs 32 min
3 off = 4hrs 12min

3. DMLS growing options versus time



1 off = 10hrs 48 min
3 off = 13hrs 49min

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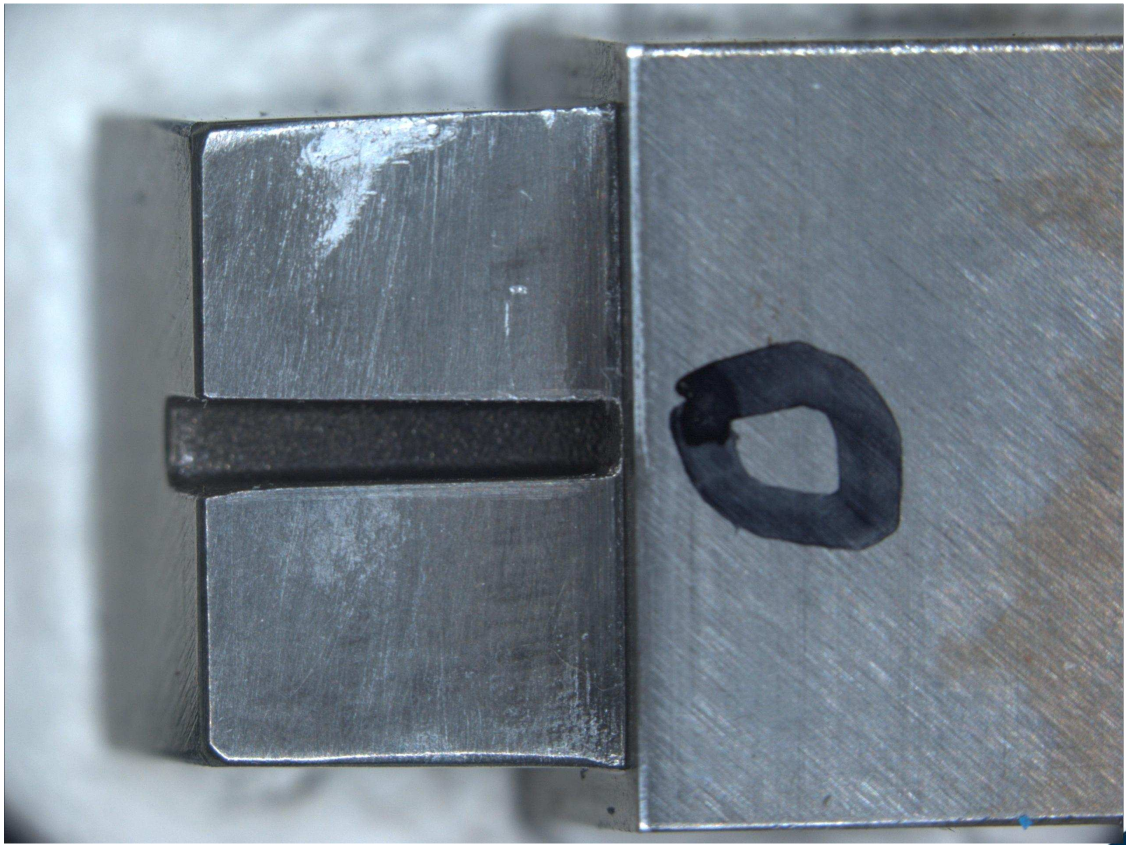
RPT Core 0

Coventional manufactured through hardened (Mat 1.2344)



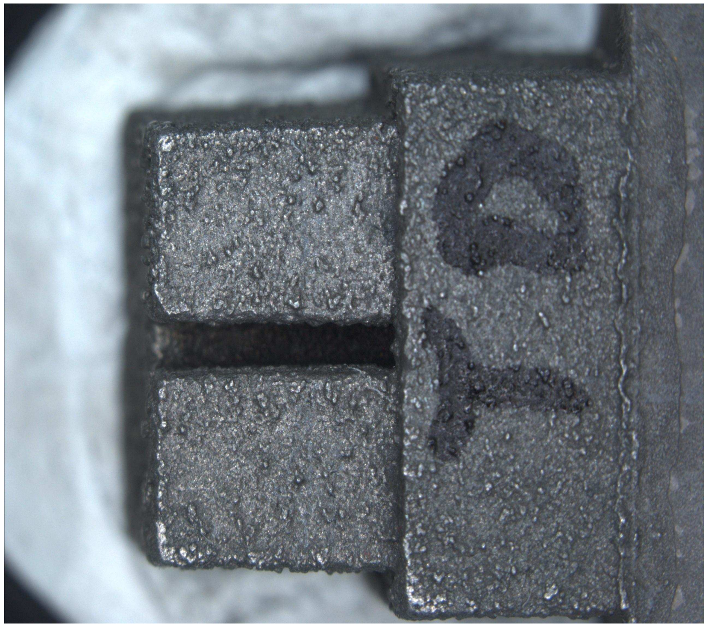
RPT Core 1

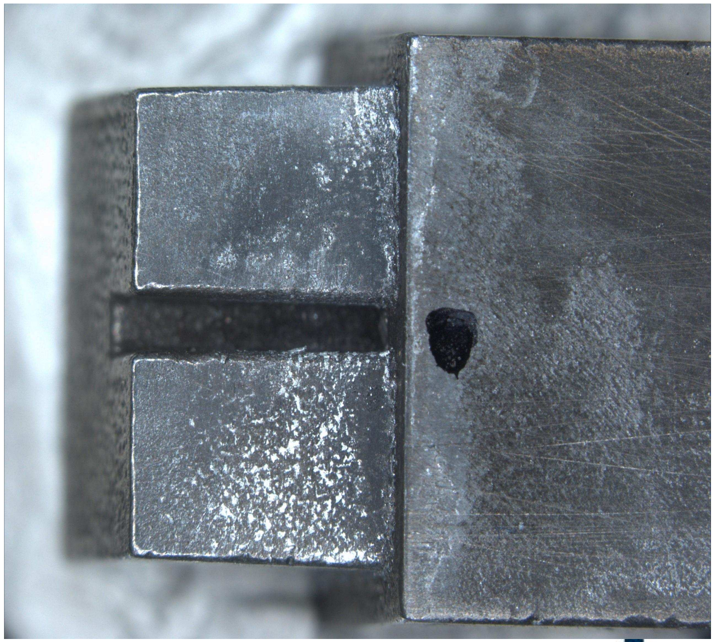
Surface treatment

TD coating bottom right picture

(NB.TD coating was not successful)

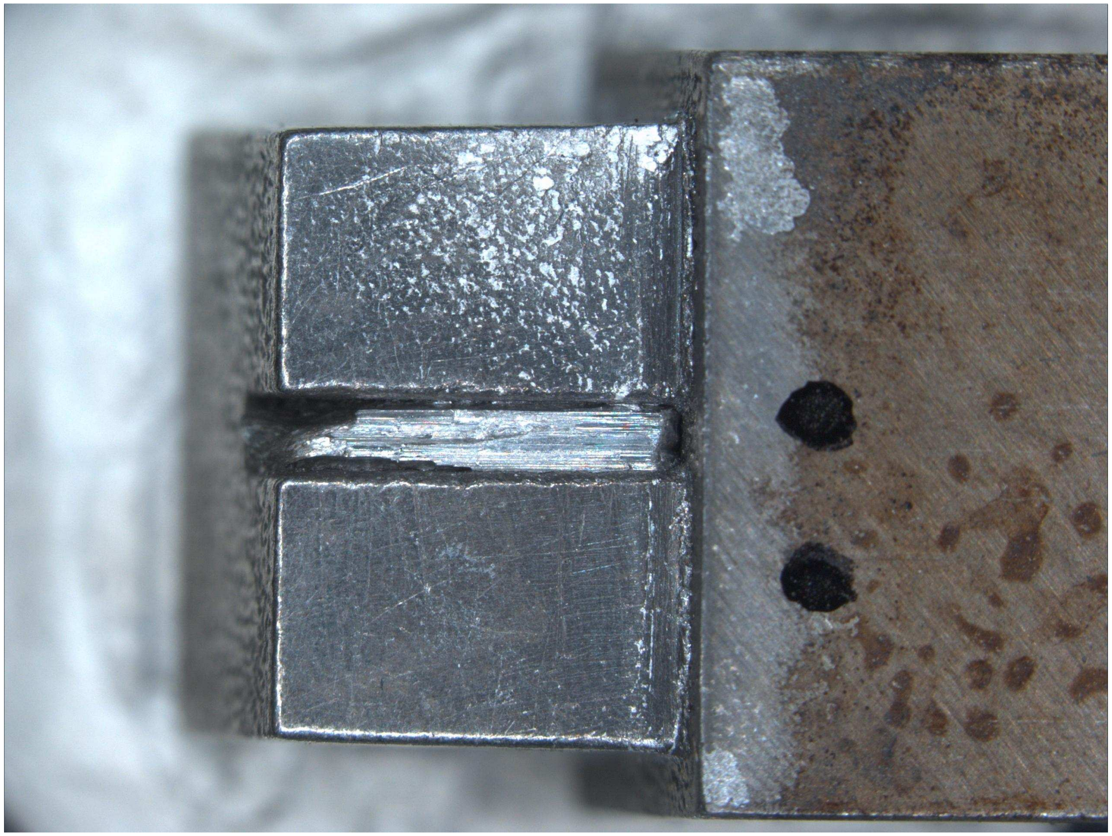
- **Plasma nitriding**





RPT Core 2

- Direct steel 20 untreated



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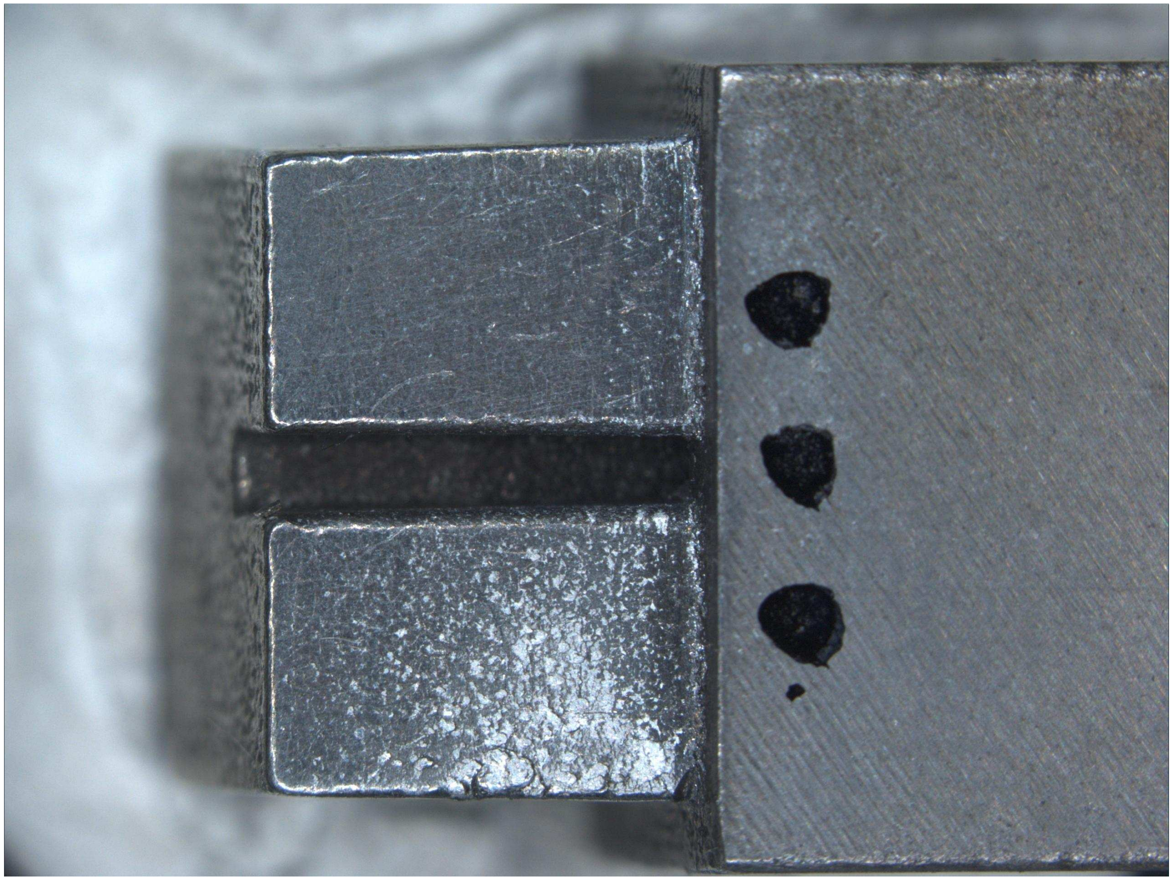
RPT Core 3

- Direct steel 20 through hardened



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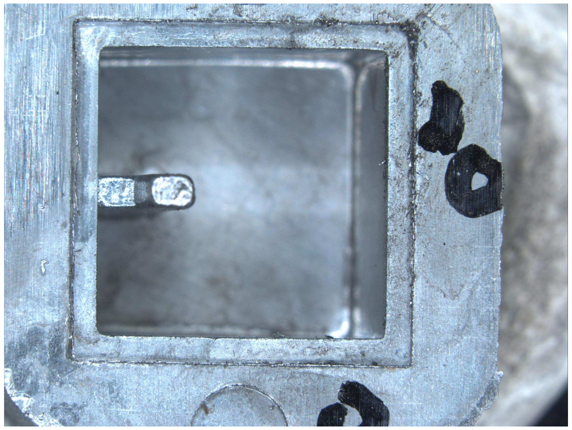
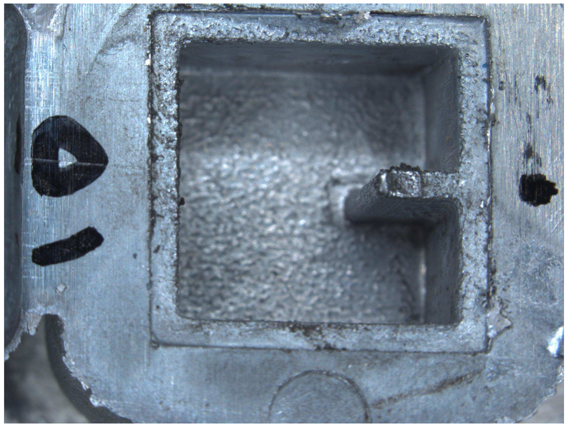
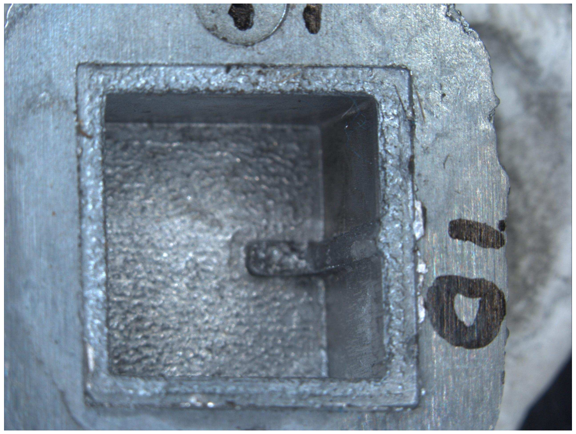
First test series (100 shots)

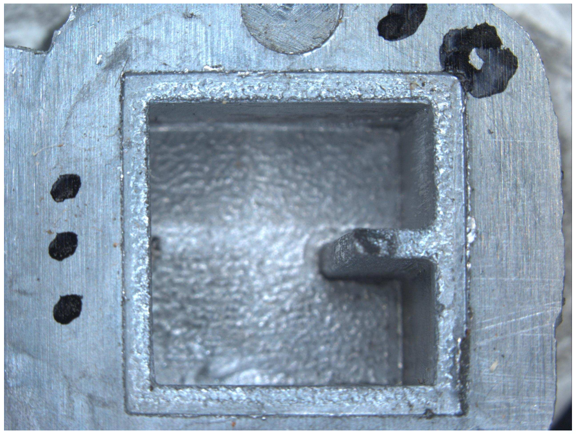
- Melt aluminium alloy A356
- Melt temperature 650-680°C
- Plunger speed 1m/s
- Cycle time ~30 seconds
- Shot weight average 300gs

First test series (After 10 shots)

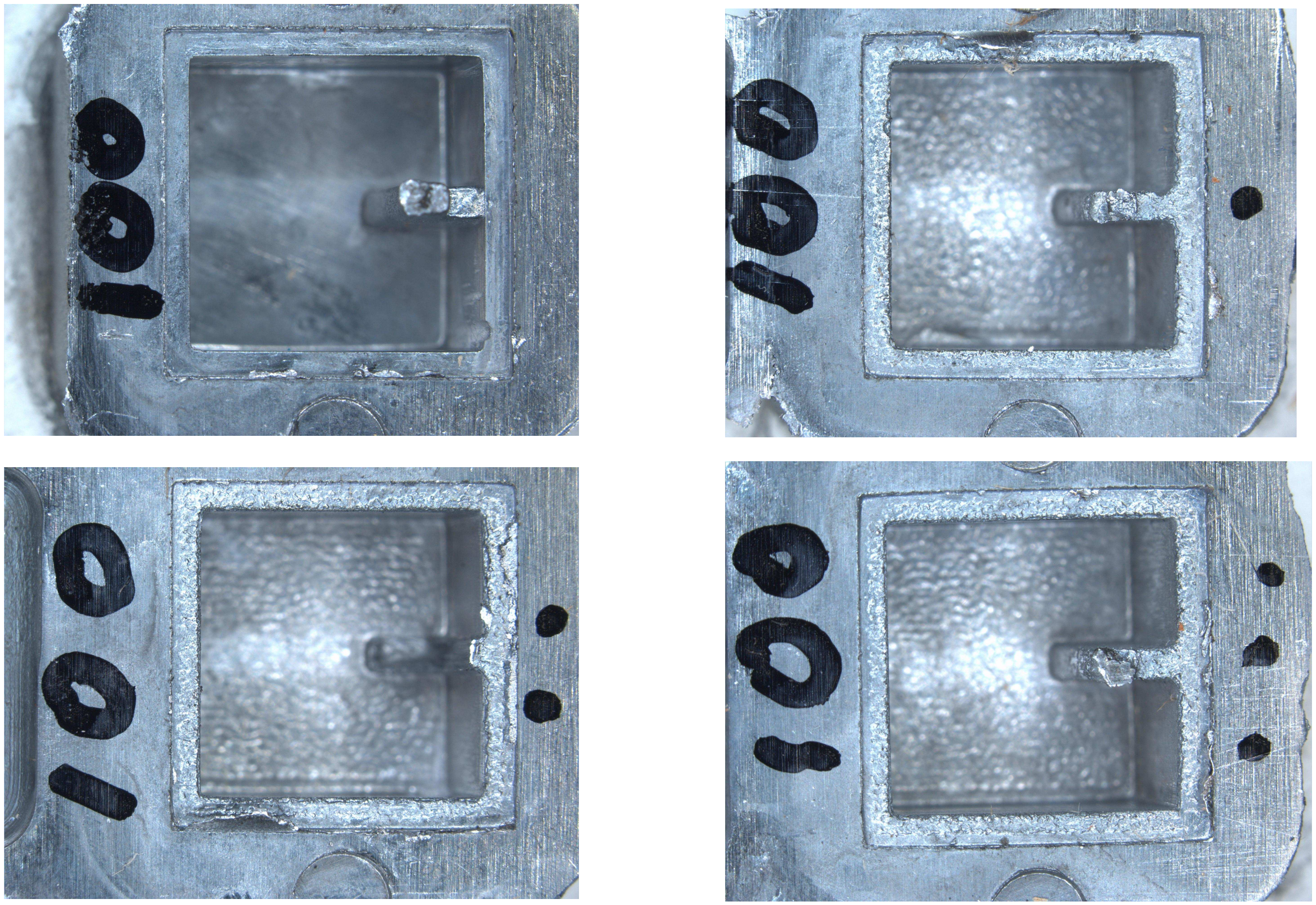








First test series (After 100 shots)



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Results

Thermal properties:

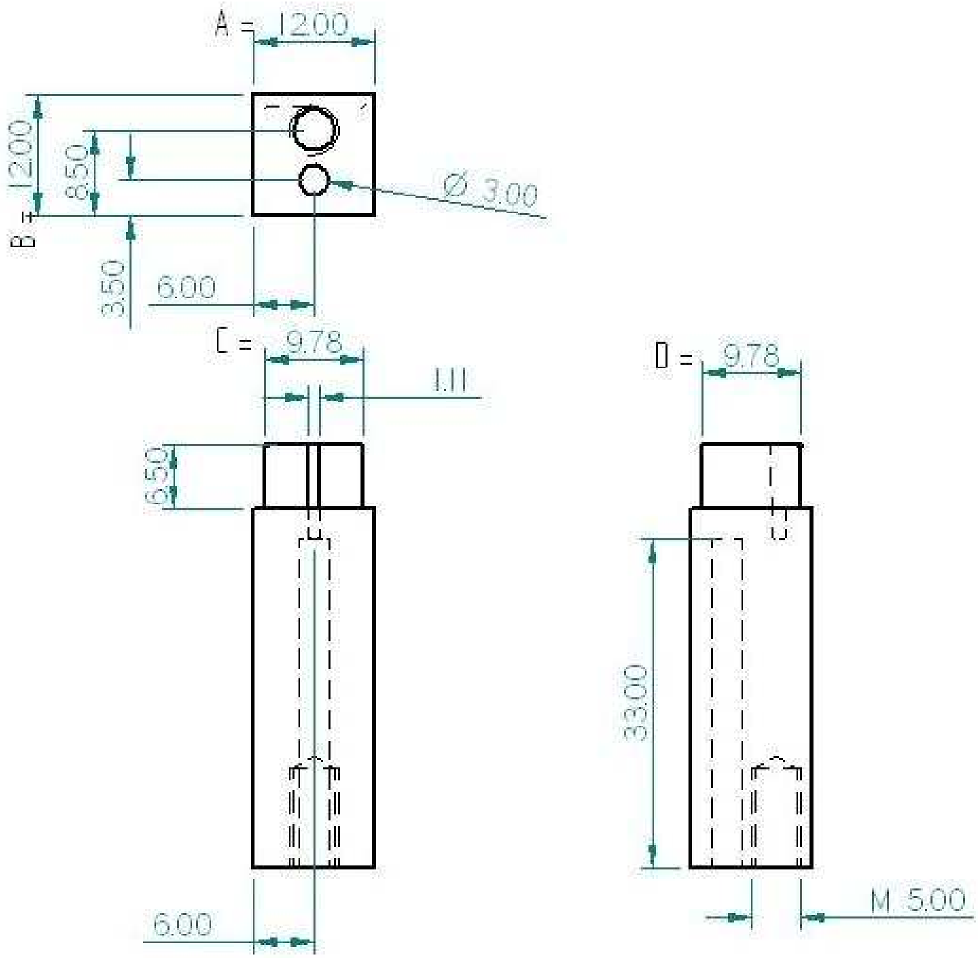
- **Direct steel cores dissipate heat faster 7-10° when compared with conventional one.**

Wash out properties:

- **Aluminium melt sticks more to the direct steel cores**
- **Direct steel core 1 (surface treatment plasma nitriding) shows crack initiation in corner where aluminium melt welded to the surface**

Results

Dimensional check



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Results

Dimensional check after 100 shots

Core 0			Core 1			Core 2			Core 3		
Dim	Pre	Post	Dim	Pre	Post	Dim	Pre	Post	Dim	Pre	Post
A	12.005	12.005	A	12.01	12.01	A	12.005	12.005	A	12.008	12.008
B	12.00	12.00	B	12.005	12.005	B	12.00	12.00	B	12.00	12.005
C	10.075	10.075	C	9.90	9.895	C	9.9	9.81	C	9.95	9.825
D	10.07	10.075	D	9.90	9.875	D	9.90	9.80	D	9.96	9.80

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Conclusion

Encouraging results

Advantages

- Conformal cooling
- Good heat dissipation
- Shorter turn around time
- Minimal manufacturing operation hence less equipment required

Disadvantages

- Limited resources
- Restriction on size
- Raw material development

Good Possibilities for further development of rapid die design and manufacturing selection tool and methodology

Thank You

Any questions?