ARMSTRONG MOLD CORPORATION

GRAPHITE DIE CASTING DIVISION

Getting Started

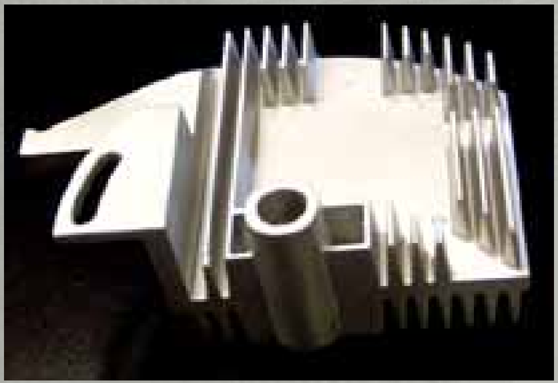
The Evolution of GDC

The GDC technology was developed as a hybrid of traditional permanent mold, graphite mold and the die casting process in response to ongoing demands from Engineers who were looking for a faster less expensive means of developing and testing new products. The main challenge was replicating the mechanical and physical properties of the production intent alloys and having the flexibility to make changes as the designs matured. The initial trials using A380 were carried out in1999, and further development has yielded the process as it stands today. However, given the nature of the process and the diversity of markets served it is in a constant state of development as more challenging geometries are being cast in the GDC process.

It is the intention of Armstrong Mold to support further development to expand the list of alloys and methods within the scope of the Graphite Die-Casting process.

OBJECTIVE

The objective of the ARMSTRONG MOLD GRAPHITE DIE CAST Division is to provide a core prototyping and development process by delivering:



- ***Production Intent Materials***
- ***Reduced Tooling Lead-Time***
- ***Production Like Tolerances***
- ***Increased Production Rate of components***
- ***Reduced Cost***
- ***Reduced Risk***

How can it be done?

- Utilize an alternative mold material that produces a new level of casting
- CNC cavity detail to deliver production die cast tolerances
- Rapid solidification that ensures excellent mechanical and physical properties and cell structure.
- Enable processing of 380 – 390 Aluminum alloys
- Capable of production in excess of 50 to 100 castings per day
- Tooling in Days to Weeks – Not Months
- Provide the capability of supporting bridge to production needs

Process Intent

The GDC process was designed for utilization for both high quality prototyping as well as low volume production applications.

Prototyping

- ***Production tolerances***
- ***Production like properties***
- ***Quantity of parts in short time frame***
- ***Ability to use parts for production machine fixture development***

Low Volume Production

- ***Lower capital investment for tooling***
- ***Able to produce in smaller lot sizes***
- ***Full machining capabilities and assembly***
- ***Full finishing capabilities – painting, plating, impregnation, X-ray and pressure testing***

General Design Data

LINEAR TOLERANCE: +/-.005 first inch add .0015” each additional inch. Across parting line add an additional +/-.005”

SLIDE AREAS: Additional tolerances required on slide pulls are based on projected areas of slide. Up to 5 square inches add +/-.005”, up to 20 square inches add an additional +/-.007”

FLATNESS AND STRAIGHTNESS: As cast +/-.005” square inch add +/-.003” for each inch thereafter.

RADII: Minimum requirement .015”

HOLES: Minimum hole size as cast .125”

ANGLES: Standard tolerance is +/-0.5 deg

SURFACE FINISH: The standard finish is 63 to 90 RMS

DRAFT: Minimum requirement is 1 degree

WALL THICKNESS: Depending on geometry a .120 nominal wall is standard but walls as thin as .09 are possible.

General Design Data

REPRODUCIBILITY: The mold process insures that the castings will be extremely consistent dimensionally, a major consideration for CNC machining.

MAX- MINIMUM SIZE: Current maximum is in the region of 18 inches square to a depth of 6 inches. However, overall geometry will dictate actual capabilities. Castings as small as .5 inch are attainable; again the part geometry will influence overall capabilities.

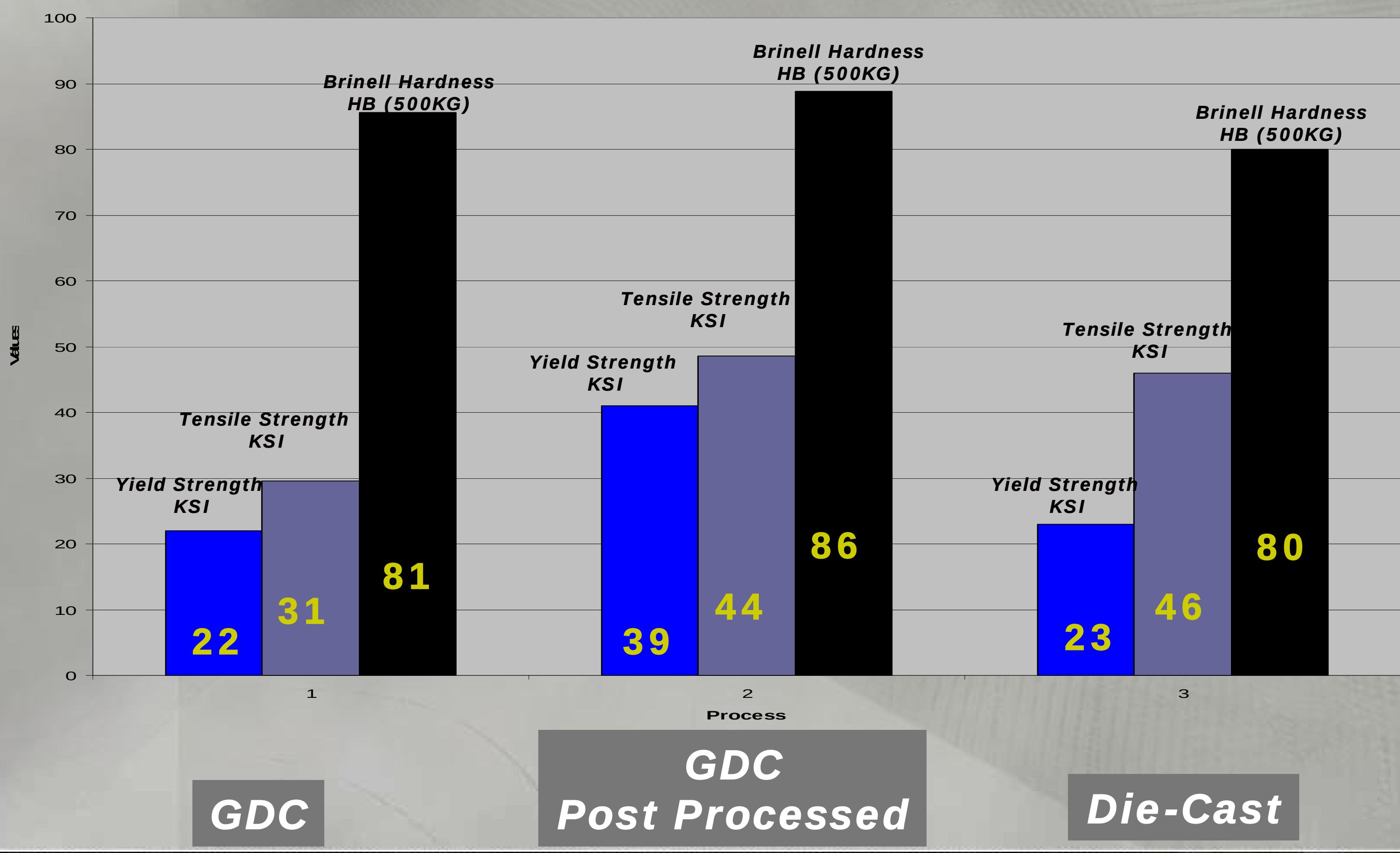
PROCESS CONTROL: Fully automated molds with pneumatic slides and ejection systems

Controlled: Mold Temp, Cycle Time, and Metal Temp

STANDARD DELIVERY: <u>Mold and cast samples in 3-5 WEEKS</u>

MATERIAL PROPERTIES

Material Properties – 380 Aluminum



MICROSTRUCTURE

380 Alloy GDC process

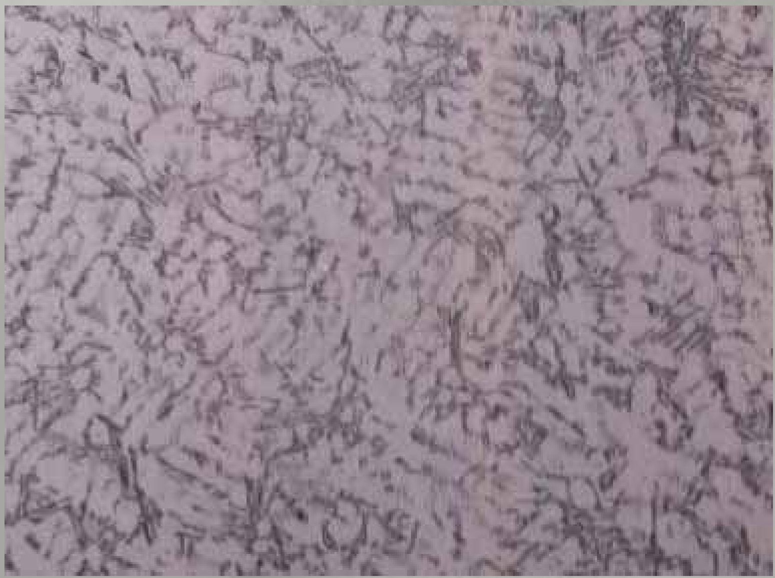


Figure 1

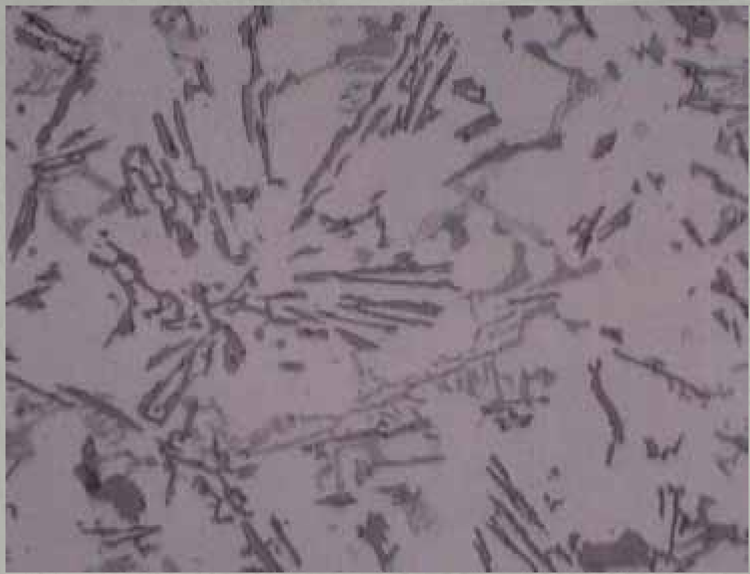


Figure 2

Figure 1: Microstructure of the three sample parts examined (Sample B shown) —predominantly silicon and CuAl2 in an aluminum matrix (100X, 0.5% HF etch).

Figure 2: Microstructure typical of the three sample parts examined (Sample A shown) —predominantly silicon and $CuAl_2$ in an aluminum matrix (400X, 0.5% HF etch).

Process Overview

AVERAGE PROJECT TIME-FRAME

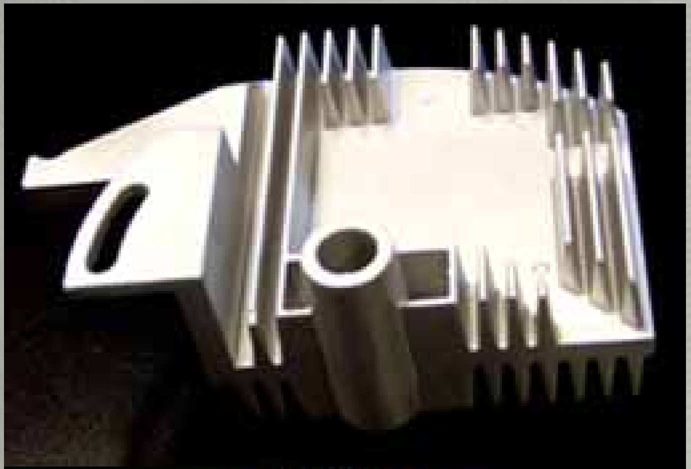
o *3D Cad Files: Customer supplied Cast & Machined, Detailed Prints*	*(1 day)*
o *Logging in of files and data including contract review*	*(1 day)*
o *Job launch including Tooling design review*	*(1 day)*
o *Programming of cutter path's*	*(2-3 days)*
o *CNC machining of cavity, core and slides*	*(2-4 days)*
o *CNC machining of runners and risers*	*(1-2 days)*
o *Installation of vent posts and pins*	*(1-2 days)*
o *Polishing of tool*	*(1-3 days)*
o *Inspection of Cavity, Core and Slides*	*(1 day)*
o *Assembly of tool including ejection*	*(2-3 days)*
o *Sampling of Tooling (as cast part)*	*(1-5 days)*
o *De-gating, Primary Grinding, Secondary Grinding*	*(1 day)*
o *Machining of 1st article*	*(3-7 days)*
Total	***3-5 weeks***

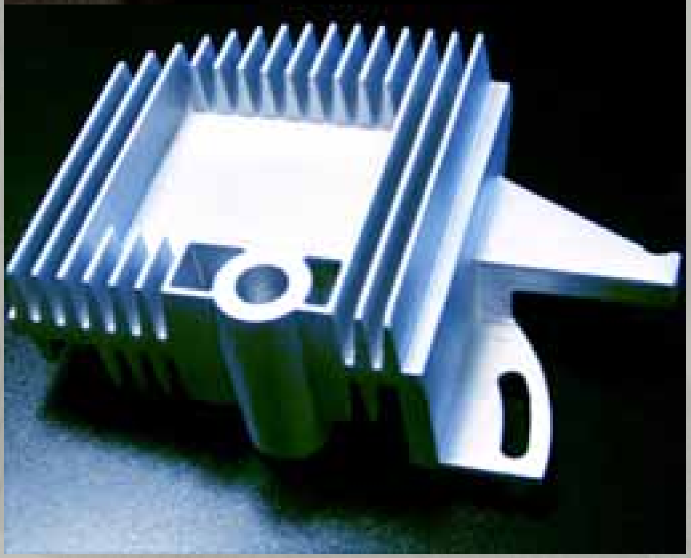
Prototype Parts

Part Name:	Heat Sink
Part Size:	7.5” x 5.25” x 2.75”
Material:	A380 Aluminum
Quantity:	70 pcs
Tooling Cost:	$10,307.00
Fixturing Cost:	$715.00
Part Cost:	$99.36
Delivery:	4 weeks (as cast) 5 weeks (machined)

Notes: Structural and thermal testing

(second order 70 pcs)





Prototype Parts

Part Name:	*End Bell*
Part Size:	*6.5” Dia. x 5.5”*
Material:	*A380 Aluminum, ZA 12*
Quantity:	*70 pcs*
Tooling Cost:	*$7,978.00*
Fixturing Cost:	*$1,480.00*
Part Cost:	*$109.23*
Delivery:	*4 weeks (as cast)* *5 weeks (machined)*

Notes: This part was first developed in A380 and later Produced in ZA12 because of failure in life testing. Today the part is produced in ZA27 in a high pressure die casting process.

(second order 140 pcs)

Production Parts

Low Volume Production /Beta testing

Part Name:	3 Part Assembly (Front & Back Plate And Step Tank)	Part Name:	4 part Assembly (Front, Back and Weir Plates & Step Tank)
Part Size:	2.5” x 5.25”x 1.35”	Part Size:	2.5” x 5.25” x 1.45”
Material:	A380 Aluminum	Material:	A380 Aluminum
Quantity:	1400 sets (80 sets per week)	Quantity:	2100 sets (100 sets per week)
Tooling Cost:	$19,790.00	Tooling Cost:	$25,215.00
Fixturing Cost:	$5,425.00	Fixturing Cost:	$7,250.00
Part Cost:	$231.26 per set	Part Cost:	$312.00 per set
Delivery:	3 1/2 weeks (as cast) 4 1/2 Weeks (machined)	Delivery:	3 ½ weeks (as cast) 4 weeks (machined)

Notes: Full functionality and thermal testing. Cost reduction from CNC parts
**6 major rev changes during 1400 sets.

Notes: Ongoing engineering and process development project. Beta testing of working assemblies prior to production tooling release.

Production Parts

Low Volume Production

- **Part Name:** *5 parts – 2 housings, 3 covers*
- **Part Size:** *4.65” x 4.76” x 1.89”*
- **Material:** *390 Aluminum*
- **Quantity:** *200 - 450 pcs of each part*
- **Tooling Cost:** *Housings- $7,600.00 each*
Covers- $8,550.00 each
- **Fixturing Cost:** *Housing- $875.00*
Covers- $1,125.00
- **Part Cost:** *Housing- $128.03*
Covers - $140.58
- **Delivery:** *3 ½ weeks (as cast) 4 weeks (machined)*

***Notes:* All parts were impregnated and pressure tested @ 100psi . Parts were used as bridge to production after initial prototyping and design changes were made.**

PROCESS COMPARISONS

GRAPHITE DIE CAST

PART NAME:	‘C’ COVER
DIMENSIONS:	4.00” X 4.30” X .200”
TOOLING COST :	$5,720.00
CASTING QTY:	300 ($15.22)
LEAD TIME:	2 WEEKS
PRODUCTION RATE:	100 PER DAY CAST

RPM

PART NAME:	‘C’ COVER
DIMENSIONS:	4.00” X 4.30” X .200”
TOOLING COST:	$3,200.00
CASTING QTY:	300 ($24.00)
LEAD TIME :	4 WEEKS
PRODUCTION RATE:	40 PER WEEK

PROCESS COMPARISONS

GRAPHITE DIE CAST		RPM	
PART NAME:	‘A’ COVER	PART NAME:	‘A’ COVER
DIMENSIONS:	16.00” X 12.00” X 1.50”	DIMENSIONS:	16.00” X 12.00” X 1.50”
TOOLING COST:	$16,713.00	TOOLING COST:	$7,250.00
CASTING QTY:	300 ($94.00)	CASTING QTY:	300 ($142.00)
LEAD TIME:	2 WEEKS	LEAD TIME:	4 WEEKS
PRODUCTION RATE:	60 PER DAY CAST	PRODUCTION RATE:	30 PER WEEK

Process

After machining the mold is polished to remove cutter marks and to obtain the fine surface finish on the castings.

Process

Prior to pouring we apply our proprietary surface coating which extends the life of the mold and enables us to control the solidification and flow characteristics of the alloys.

The ejection system is similar to that found on a permanent mold tool.

Process

Cycle times are controlled using our PLC equipped control panels. We have full control over the ejection of the main core and cavity, plus 2 additional slides, if required.

Process

Our mold presses are custom made to our own specifications, and we are currently in the process of designing the next generation that we intend to be able to tilt pour.

TO SUMMARIZE

Features of the Graphite Die Casting Process

- CNC cut tooling
- Ability to cast thin walls
- Flexibility for use as prototype or low volume production option
- Rapid solidification cycles
- Complete in-house mold design and construction.
- High part to part repeatability
- Castings can be used to prove out assembly fixtures, trim dies or machining fixtures.

Benefits of the Graphite Die Casting Process

- **Aluminum and zinc parts in 3 - 5 weeks**
- **Semi-permanent mold will make hundreds of parts from one tool**
- **Ideal for 100-2000 parts**
  - **Short run production**
  - **Bridge from prototype process to production**
  - **Cost effective**
- **Able to cast spec die-cast alloys-380, 390**
  - **More accurate test results for tensile, yield, hardness**

REAL WORLD EXAMPLE

Hello All,

In a conversation with IBM, we agreed in principle that it could be very beneficial to convert the parts slated for die casting to the Graphite Die Casting process from Armstrong Mold Corp.

The benefits we see at this time are:

Excerpt from an e-mail received from John Wood, Talbot Associates.

REAL WORLD EXAMPLE

A. Faster tool build- 4-6 weeks as opposed to 14 week for Tool Steel Dies.

B. Ability to make changes to the parts faster (while in the design stage of development) and at a much lower cost than changing a Tool Steel Die; all without compromising the integrity of the final part die due to welding/re-machining of the tool steel.

C. The development parts would be cast in the Graphite Mold Process in the same material (A380 Al) that will be used in the Die Cast Production parts. This eliminates the need to re-evaluate the parts when switched from hog outs in wrought material (i.e.. 6061). Also, the Graphite Mold parts would have the draft and radius requirements to further qualify the cast parts for interference and clearance before production release.

D. The ability to make development and initial production quantities to support builds at POK with a lower cost than hog outs.

Contact

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