

Compacted Graphite Iron - India



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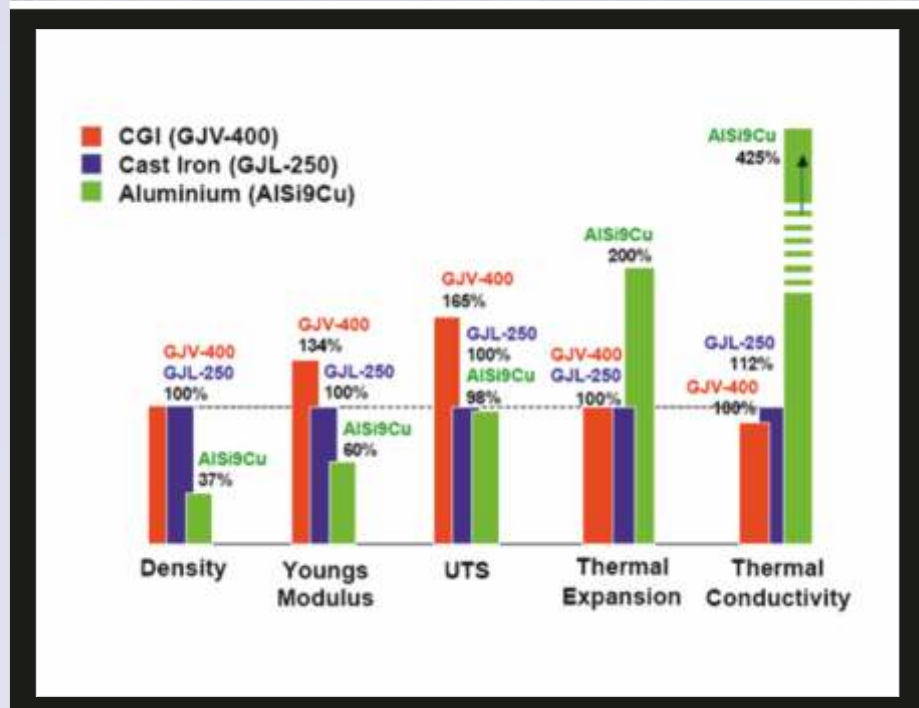
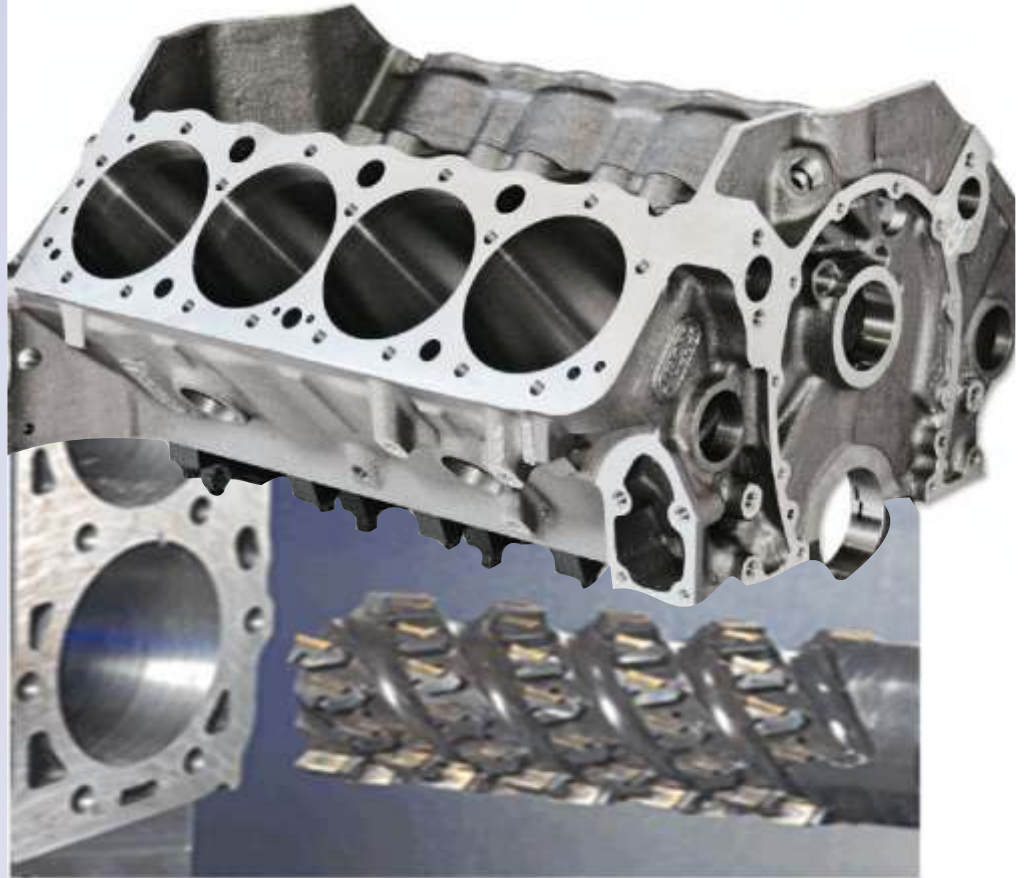
CGI-Compacted Graphite Iron was patented in 1949 almost simultaneously with Ductile Iron. While Ductile Iron received Technical

Acceptance and Commercialization, CGI is still considered as miracle in India. CGI has achieved supreme Technical importance over last One Decade.

Some of many components

- Exhaust manifold
- Cylinder heads
- Hydraulic compounds
- Gear pump housings
- Various automotive casings and housings
- Brake disks and drums
- Moulds for steel and alloys
- Engine blocks etc

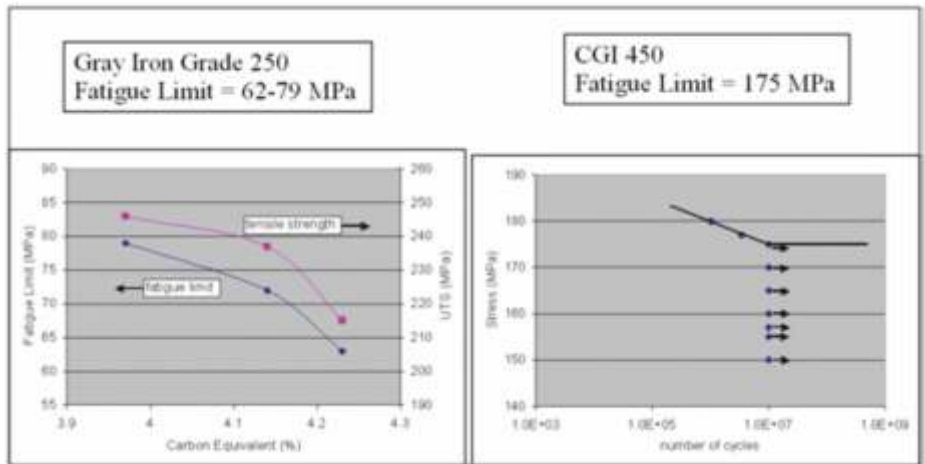
the strength characteristics of CGI compared to Grey Iron allows the manufacturing of Engines for higher pressure operating combustion chambers and more efficient with lower emissions.



Material Properties Comparing CGI 400, FG 250 and Al Si 9 Cu

Property	Units	GJV 450	GJL 250	GJL 300	A 390.0
Ultimate Tensile Strength	MPa	450	250	300	275
Elastic Modulus	GPa	145	105	115	80
Elongation	%	1-2	0	0	1
Rotating-Bending Fatigue (20°C)	MPa	210	110	125	100
Rotating-Bending Fatigue (225°C)	MPa	205	100	120	35
Thermal Conductivity	W/m-K	36	46	39	130
Thermal Expansion	µm-m-K	12	12	12	18
Density	g/cc	7.1	7.1	7.1	2.7
Brinnell Hardness	BHN 10-3000	215-255	190-225	215-255	110-150

The increasing demand for higher specific power and the need for weight reduction and decrease of emissions require the use of stronger material for cylinder Blocks, justifying need for a newer alloy- CGI. The mechanical and physical properties of CGI as a function of Graphite Nodularity, carbon content and influence of Ferrite and Pearlite need careful control.



CGI - Standards

Country or Organization	Company or Standard	Designation	Tensile Strength (MPa)	Yield Strength (MPa)	Elongation (%)	Hardness (HB)	Structure	Fraction Compacted Graphite (Type III, ISO/PGH) (%)
Germany	VDG	GGV-30	min 300	min 230	min 2	max 160	ferritic	>80
		GGV-40	400-500	340-440	min 1	200-280	pearlitic	>80
USA	ASTM	35-28	min 262	min 193	min 2	-	ferritic	>80
		45-40	min 310	min 241	min 1.5	-	ferritic-pearlitic	>80
	60-50	min 414	min 345	min 0.8	-	pearlitic	>80	
	John Deere	V1-A	min 300	-	-	max 255	ferritic-pearlitic	>80
V1-B		min 300	-	-	173-255	ferritic-pearlitic	>80	
V2-B		min 350	-	-	173-255	ferritic-pearlitic	>80	
France	GCV	GCV 320-4	320-360	220-270	4-7	135-165	ferritic	>80
		GCV 360-2	360-420	250-300	2-5	170-230	ferritic-pearlitic	>80
		GCV 420	420-600	350-480	0.5-2.5	240-285	pearlitic	>80
CIATF (1981)			min 280	min 200	min 3	min 120	<20% pearlite	>80
			min 315	min 210	min 1	min 140	ferritic-pearlitic	>80
			min 385	min 280	min 1	min 180	>80% pearlite	>80
CIATF			min 280	min 200	min 3	min 120	<20% pearlite	>80
			min 340	min 240	min 1	min 140	ferritic-pearlitic	>80
			min 400	min 280	min 1	min 180	pearlitic	>80

The decision to proceed from prototype design to batch production of CGI Engines is governed by elemental risk. The production of Compacted Graphite irons requires extremely good process control. Low Sulphur and low Phosphorous containing raw materials are recommended. Control of metal weights, analysis, treatment temperature and use of quality moulds and cores are necessary. Good compacted Graphite structures are obtained with Elkem Process Know How using compactmag in most ladle treatment Processes. Role of Compactmag in production of CGI. CGI manufacture also calls for an extremely reliable thermal analysis based measurement and process control system that prevents flake Graphite formation by simulating Magnesium fade and thereafter conducting an on-line correction of molten Iron. successful commercial production of CGI.

Possible Production Routes

- By Magnesium
- By (Mg, RE)-Alloy
- By Cerium
- By Nitrogen
- By Titanium

Production by high RE-MgFeSi recommended by Elkem, Why?

Rare earth's are reported to have beneficial effects on section sensitivity

- High rare earth is easier to control than Magnesium
- Various RE vs. Mg ratio's can easily be made
- The entire treatment is done in one go - treatment alloy with balanced total composition
- Rare earth's may be an attractive alternative to the use of Titanium

Some Important Considerations for CGI are

- Base iron composition
- Preconditioning
- Alloy addition rate
- Process recoveries
- Inoculation
- Final CGI composition
- Microstructure
- Mechanical properties

Typical Base Iron Composition –Elkem suggestions

C.E	4.3 – 4.5%
C	3.7 – 3.9%
Si	1.5 – 2.0%
S	0.005 – 0.010%
P	Max 0.03%

Example of CGI Composition (Final) Elkem Recommendations

C	3.8	%
Si	2.5	%
Mn	0.20	%
P	0.02	%
S	0.007	%
Ti	0.012	%
La	0.008	%
Ce	0.015	%
Mg	0.010	%

CompactMag® →

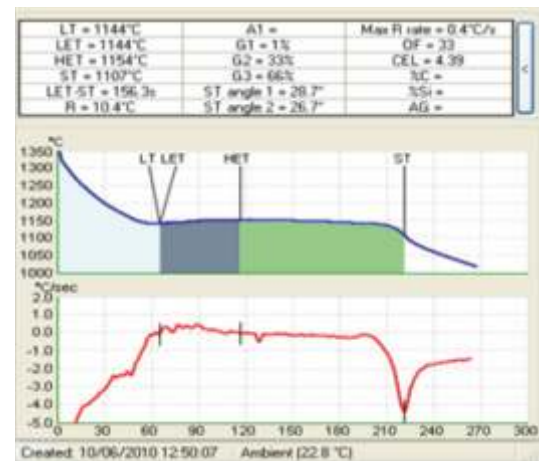
CGI Production -Base

Stage 1 – Base furnace Charge

This foundry uses a balanced charge of 33% Pig iron, 33% Steel and 33% returns.

In this case, base nucleation is very high due to the rusty nature of the scrap and pig iron.

Preseed™ preconditioner is used to precondition the furnace in order to lock the nuclei in place ready for treatment and subsequent inoculation.

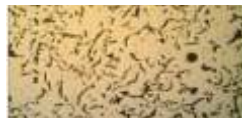


Base Furnace Curve

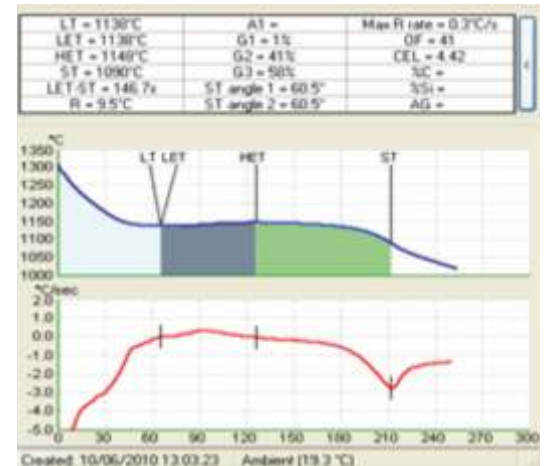
CGI Production -Final

CompactMag™ alloy is added at 0.3% addition and Foundrisil® inoculant is used as a cover at 0.25% addition. The metal is tapped out at 1520°C and poured at 1420°C. There is a short period of 2 minutes to stabilise the iron prior to pouring.

The Mg to S balance is maintained at 1:1. Final Mg and S levels are 0.01%



Final Microstructure x25



Treated & Inoculated Iron EPIC Thermal Curve

Conclusion : US Market is ready and have commercialized greatly on CGI Castings for Value Add components and Customers. India can view CGI Production of critical components as future-ready market. There are 3 players in India with minimal production of CGI Castings in India. The Question is how the Indian Foundry Industry interfaces with Potential Users , especially in Heavy and Medium Auto Segment , to transform to CGI Usage for Qualitative Benefits .

(Contributions : Elkem Research Centre, Kristiansand, Norway.)

