



Near Net Shape Forming Using Semi-Solid Metal Forming

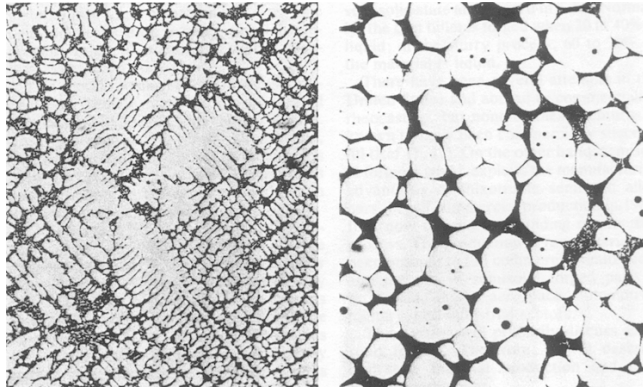
By Dr G. Govender, L Ivanchev

RAPDASA 2005

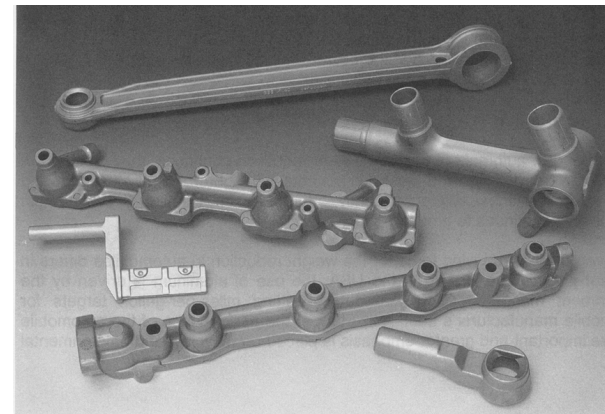
PRESENTATION OUTLINE

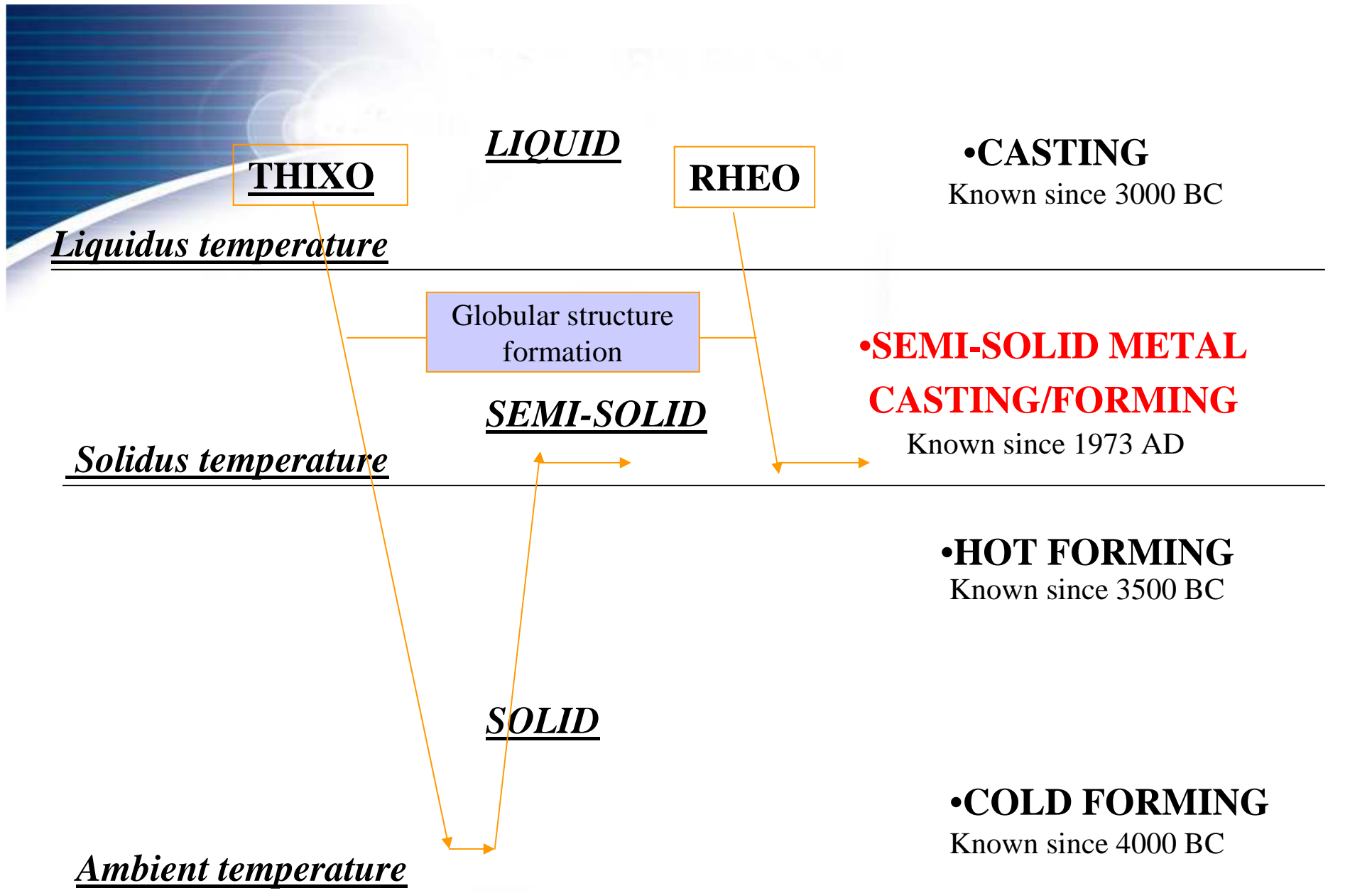
- 1. The Semi-Solid Metal Forming Processes**
- 2. Thixocasting**
- 3. Rheocasting**
- 4. Applications of SSM Forming**
- 5. The CSIR Process**
- 6. Conclusion + Video**

INTRODUCTION

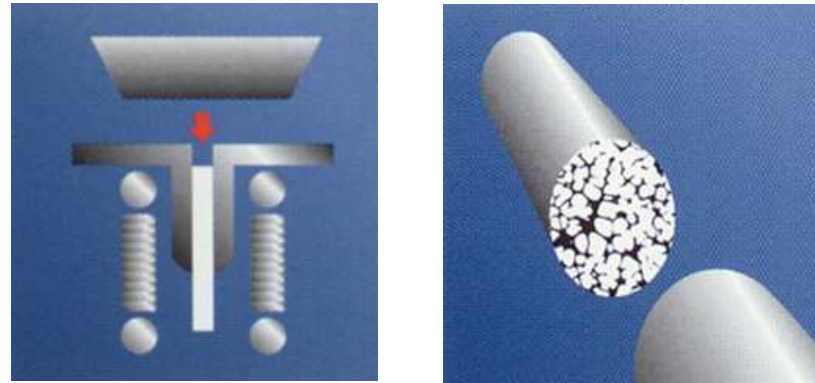


1. THIXOFORMING
2. RHEOCASTING

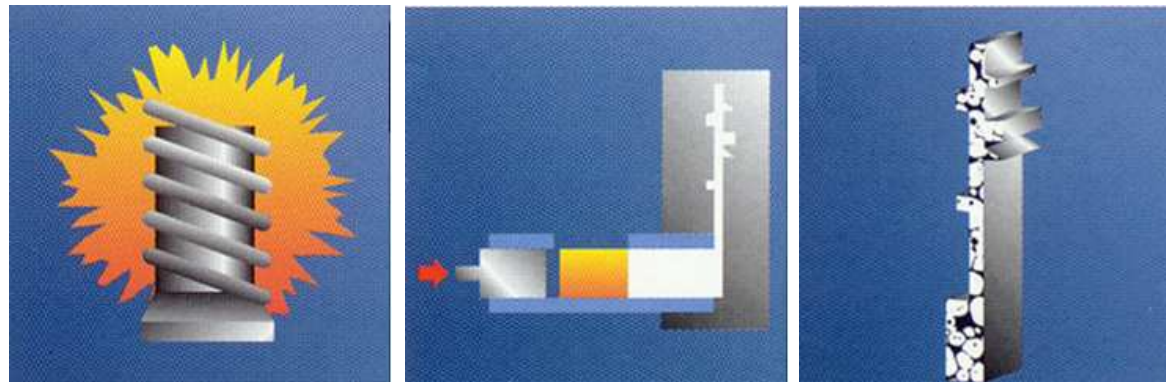




Thixocasting



SSM FEEDSTOCK



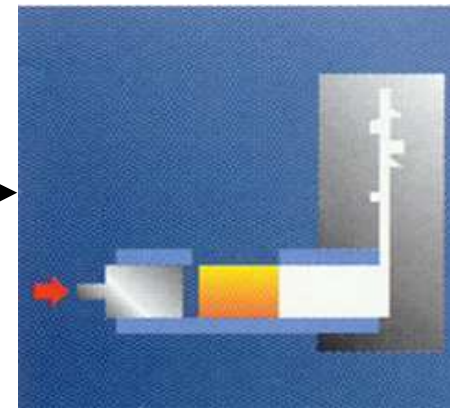
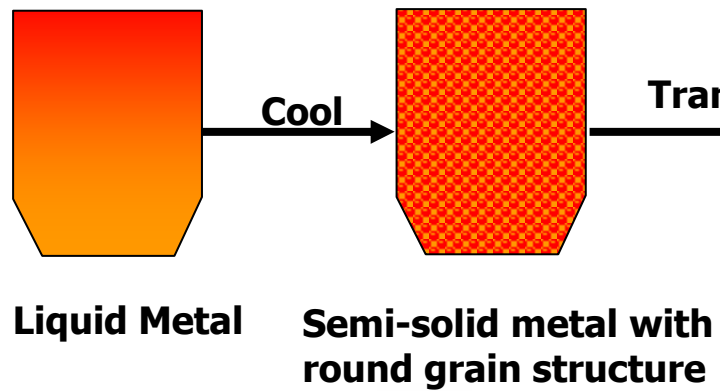
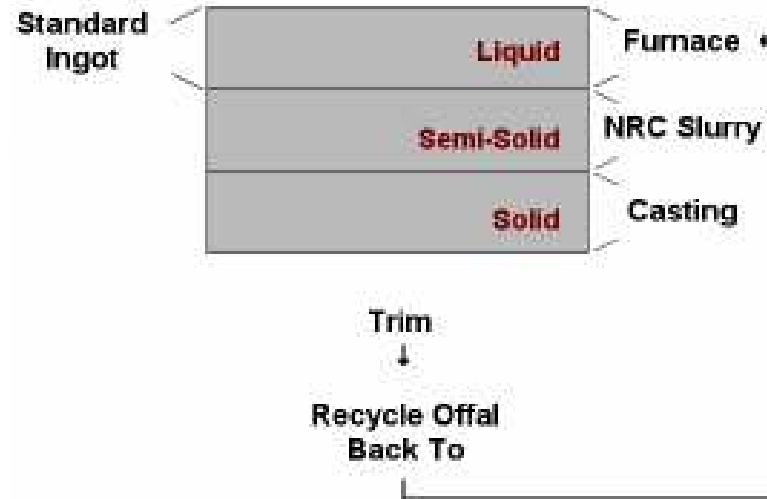
SSM FORMING PROCESS

Disadvantages of the Thixocasting Process

Disadvantages

- High cost of feedstock material compared to normal foundry alloys
- In order to meet production rates multiple induction heating stations are required which requires high capital expenditure
- The scrap produced cannot be recycled on site and is also devalued significantly
- The feedstock is supplied in specific lengths, which means there would be additional scrap created by off cuts.
- During reheating oxidation of the billet surface occurs therefore dies have to be designed to remove oxides during the forming process.
- During reheating there are liquid metal losses from the billet prior to casting.

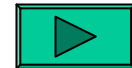
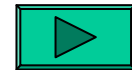
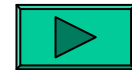
Rheocasting



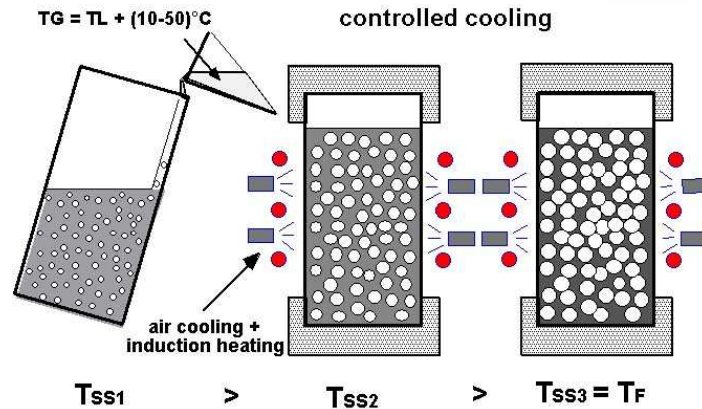
High Pressure Die Casting

Rheocasting Processes

- **New Rheocasting Process (NRC) – UBE**
- **Semi-Solid Rheocasting (SSR) – MIT**
- **New Semi-Solid Casting – Hitachi**
- **Sub-liquidus Casting (SLC) – JLH Technologies & THT Presses**
- **Slurry on Demand (SoD) – AEMP**

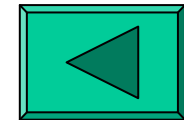


New Rheocasting (NRC) - UBE

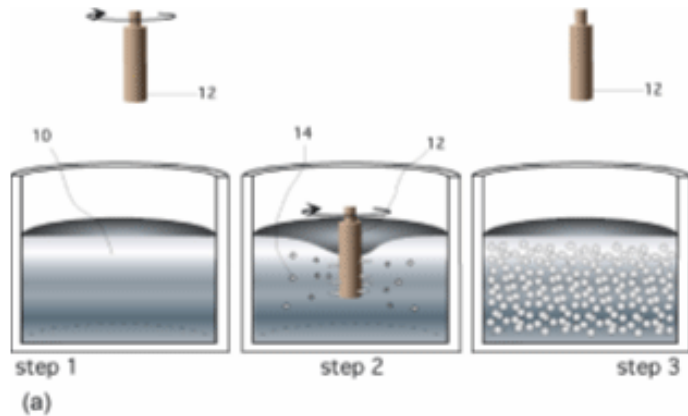


Contech –USA
Citation – USA
Intermet – USA
Stampal - ITALY

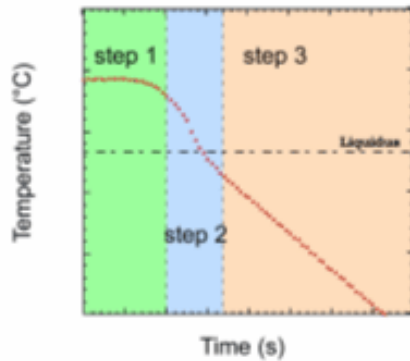
Stampal - producing engine brackets for Fiat PUNTO
50000 pcs per month



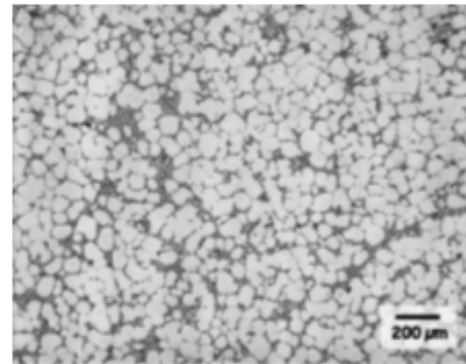
Semi-Solid Rheocasting – MIT



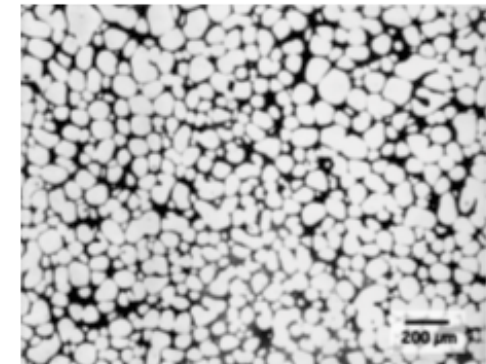
(a)



(b)



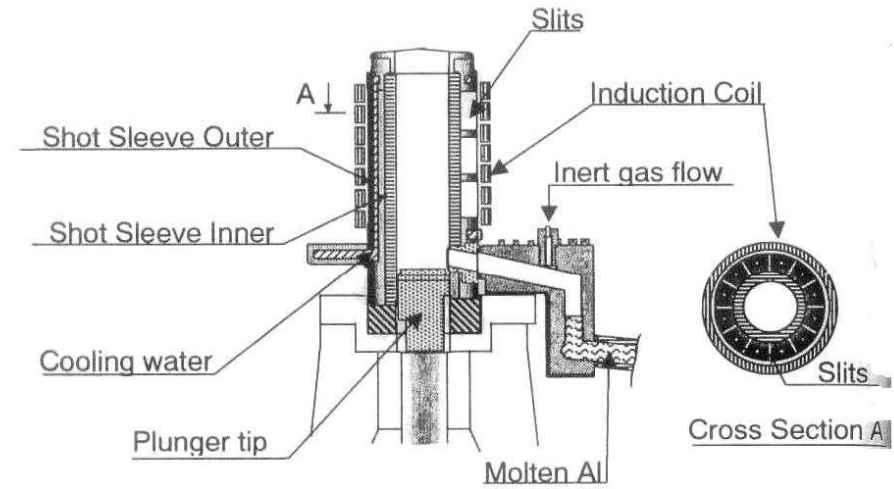
Processed Alloy, as-cast



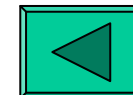
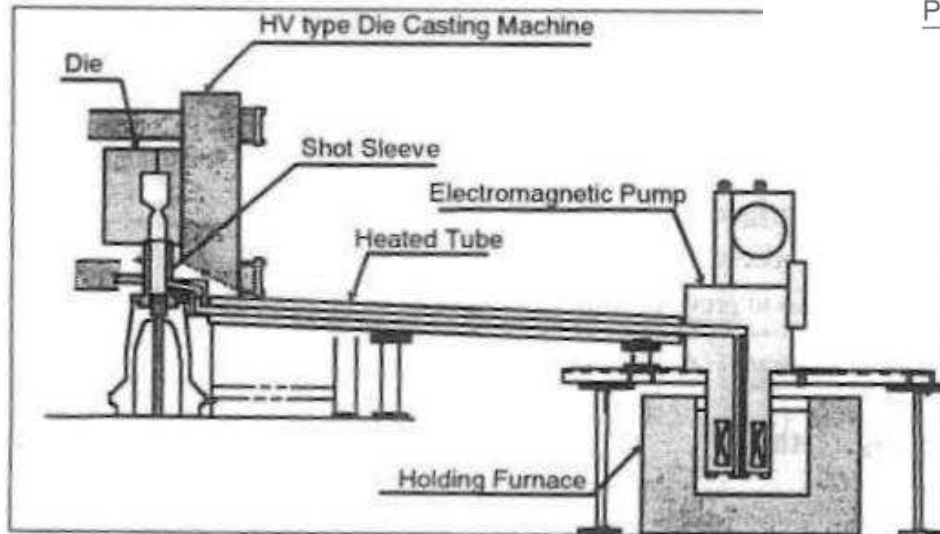
Reheated to 585°C



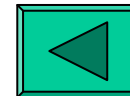
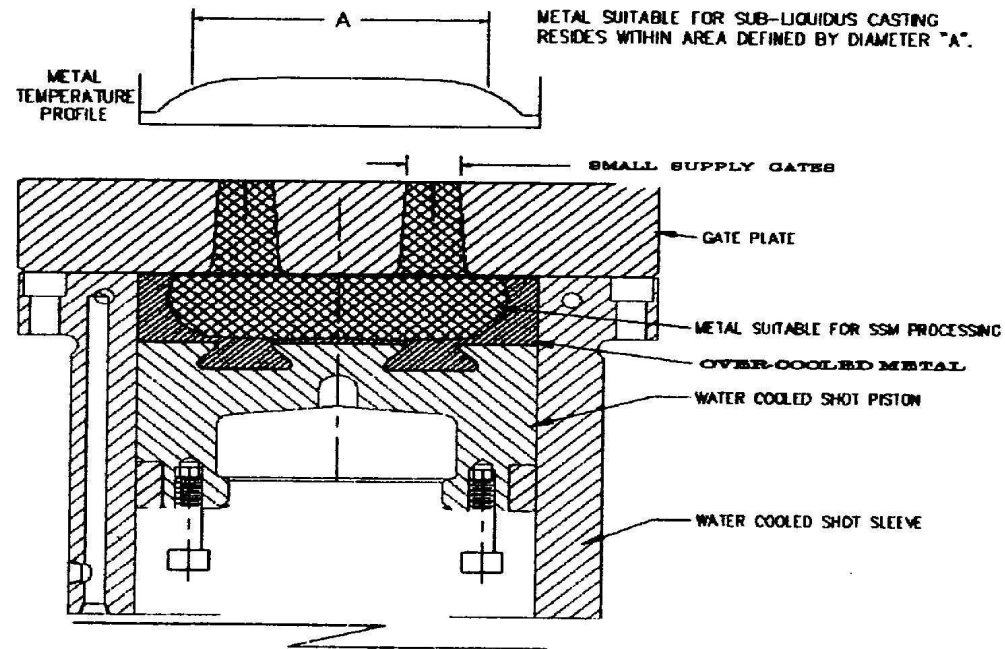
Hitachi Process



Electromagnetic stirring system at shot sleeve



SLC Process



Advantages and Disadvantages of Rheocasting

Advantages	Disadvantages
<p>Cost of material same as standard casting alloys</p> <p>Semi-solid state achieved direct from liquid.</p> <p>Oxidation reduced – reduced oxide entrapment.</p> <p>Reduced loss of metal during reheating.</p> <p>SSM scrap can be recycled in house.</p>	<p>Hydrogen Absorption</p> <p>Process consistency</p>

Advantages of Using The SSM Forming Methods

- High wall thicknesses and different wall thicknesses can be designed
- Low gas porosity due to laminar filling and good airing
- Low solidification porosity due to a high solid fraction proportion ($f_{\text{solid}} \sim 50\%$)
- Production of thin walled components
- Allows for the casting of wide range of alloys inclusive of high strength wrought alloys.
- Joining by LASER, MIG or WIG welding possible
- Heat treatment from T0 - T7 possible
- Near netshape or netshape parts production
- Improved tool life

Applications For SSM Forming

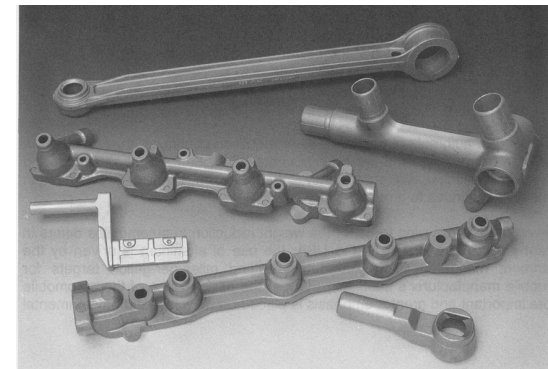
Properties	RC	TC	SC	HPDC	LP casting
Shrinkage	3	3	2	1	2
Porosity					
Blow hole	2	2	2	0	2
Segregation	2	2	1	2	2
Mechanical Properties	3	3	2	0	1
Wrought alloy Application	3	2	1	0	2
Hot Tearing	3	3	1	0	2
Metal Fluidity	2	2	3	3	2
Casting Cycle Time	2	2	1	3	2
Die Life	3	3	1	2	0
Product Cost	2	0	1	3	3
Total	25	22	15	13	17
Key : (3) Excellent, (2) Good, (1) Some what poor, (0) Poor					

Examples of Applications of SSM Forming

	Master Break Cylinder		Fuel Rails	
Manufacturing Process	PM	SSM Forming	SF	SSM Forming
Annual Production (millions/yr)		2.8		1.0
Part Weight (lbs)	1.7	0.98	1.5	0.735
Min. Wall Thickness (mm)	6.3	3.2	5.1	3.8
Leak rate (%)	2	0	4	0.1
Machining Steps	18	5	82	26

PM – Permanent mould SF – Solid Forging

Winterbottom, W L



Applications of SSM Technology in the Automotive Industry

- BRAKE CALIPERS

- CLUTCH CYLINDERS

- SUSPENSION ARMS

- WHEELS

- PISTONS

- KNUCKELS

- ENGINE MOUNTS

- PULEYS

- ROCKER ARMS

- BELT COVERS

- MOTOR HOUSINGS

- SPACE FRAMES

Thin walled structural parts in doors A-Pillar

Door AUDI A3



Rear seat cover **BMW R 1200 C** motor bike

Condition:
As cast

Specification:
Perfect surface, low porosity



Component for AUDI A6 V8 Energy Management System for Bumpers



The Specification:

- No machining necessary
- High strength and elongation in condition T6
- Assembling forces > Material yielding strength

Weldable Thixoforming Components

AUDI A3 4-Door model: A-pillar



Rear door hinge AUDI A2

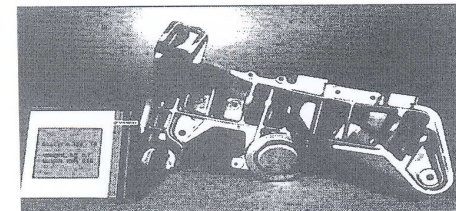
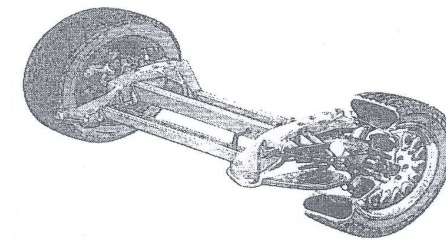




Thixoforming parts lead to weight optimized solutions with a weight saving of 40-50 % in comparison to steel designs.

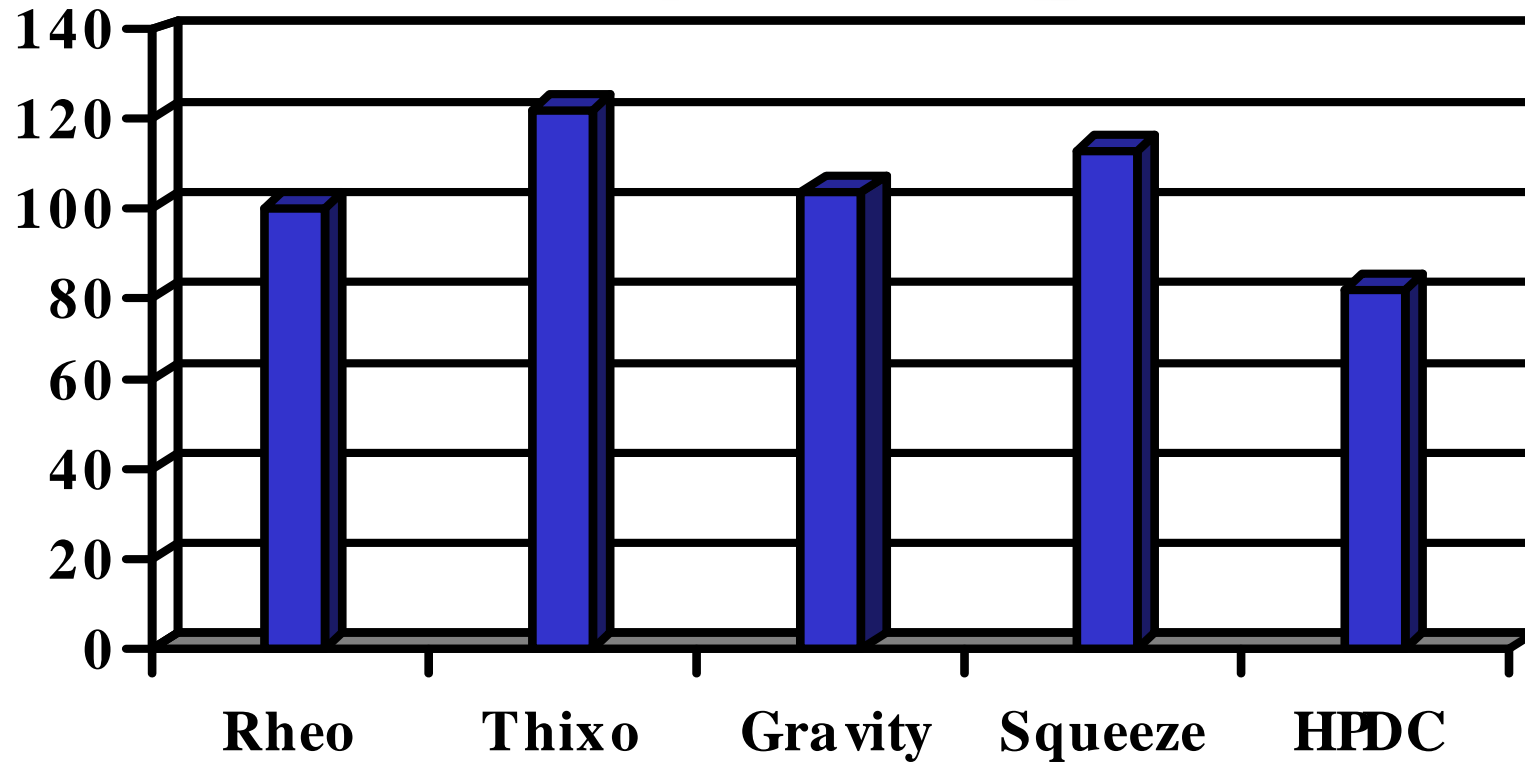
Alfa Spider 2.0/16V

Rear suspension arm

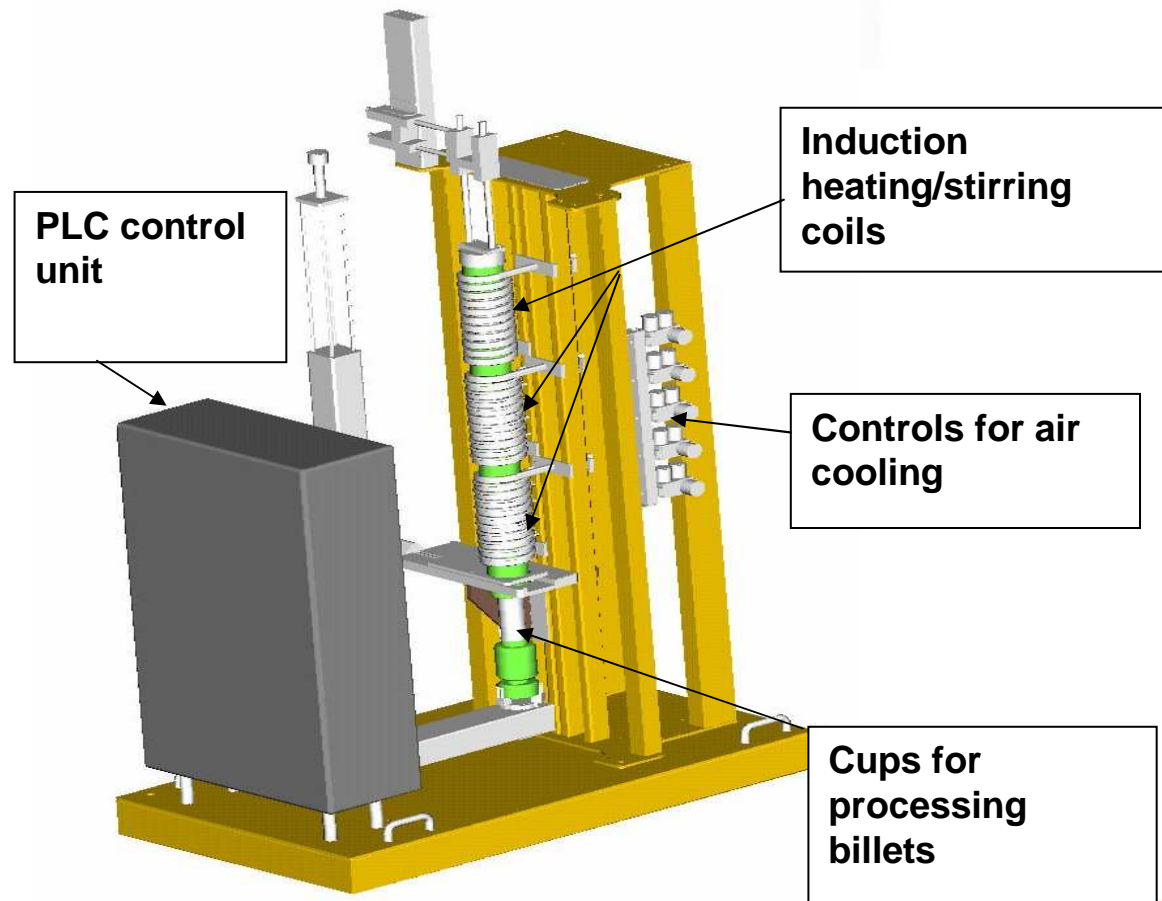


Techno-Economic Analyses

Comparison of production costs for an A356 engine bracket, cast by different processes by Stampal, Italy
(SSM Rheo process is evaluated as 100%)



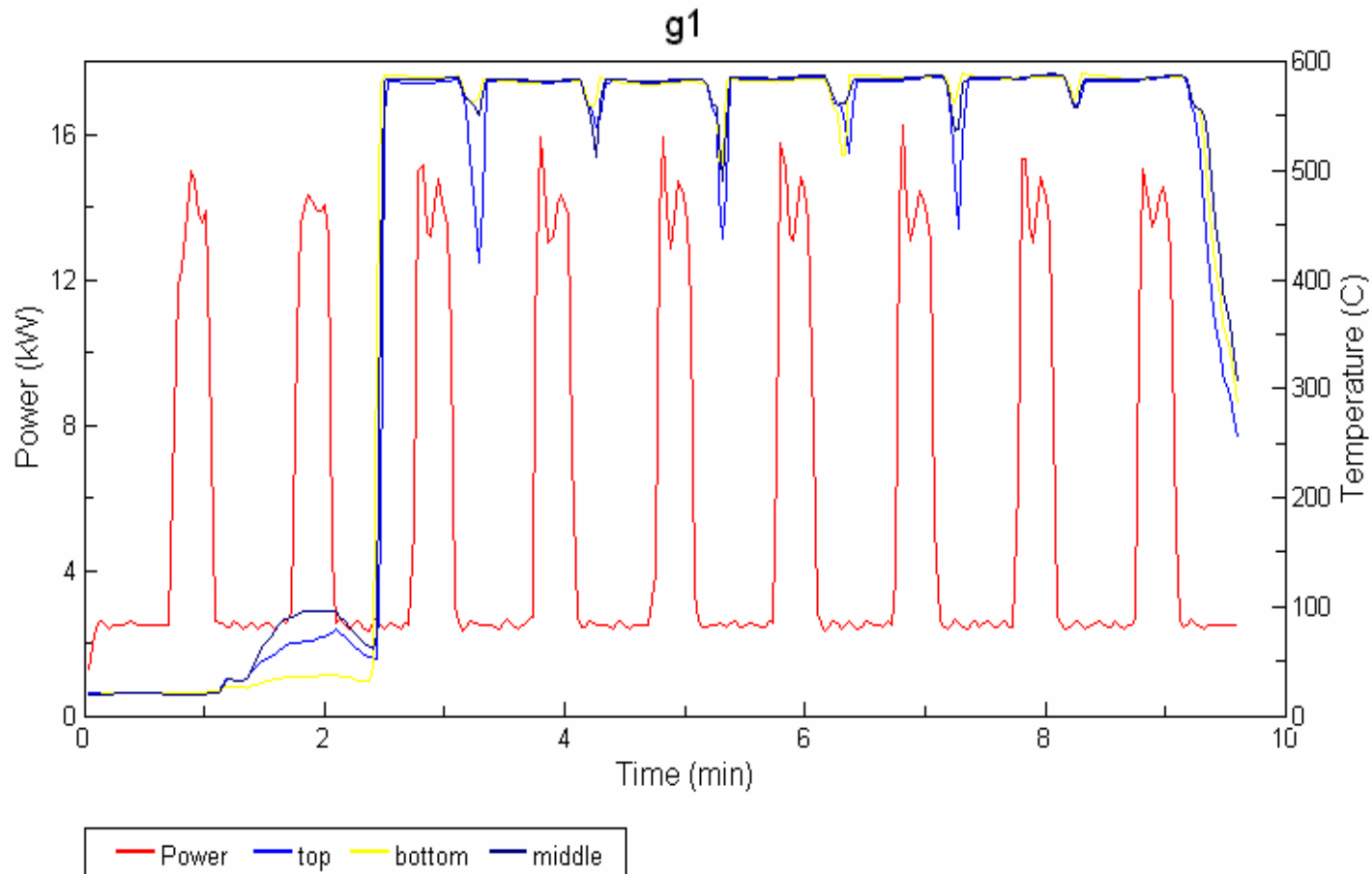
The CSIR Rheocasting System





Assemblage of the Semi Solid Metal slurry maker

Temperature and power profiles of 7 continuously rheocast
60 mm billets with production rate one billet/min.
The maximal temperature gradient is 5°C

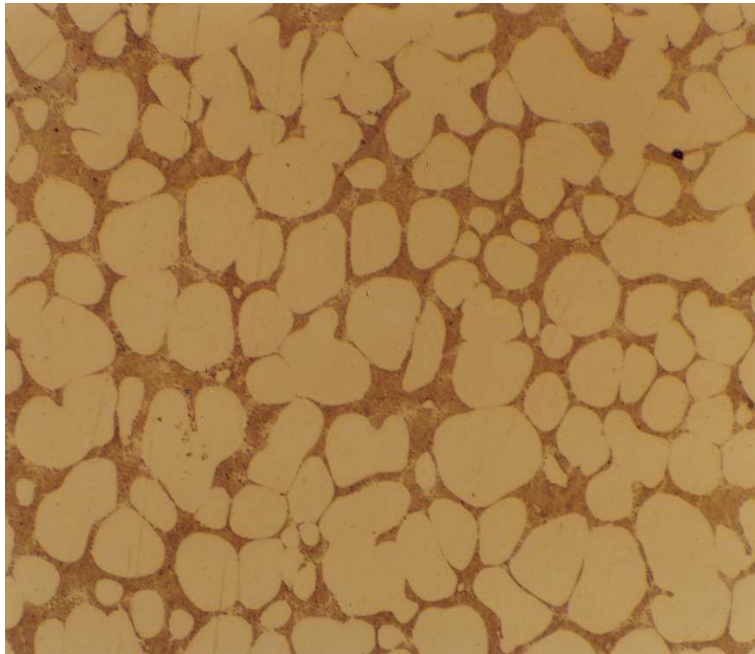




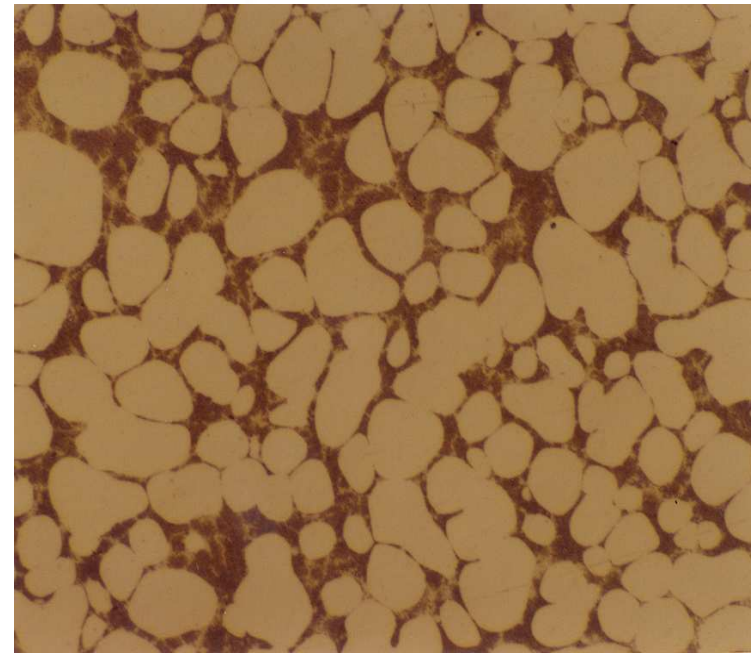
**Seven continuous cast billets 60 mm diameter and 180 mm length, casting No p1.
The last one has been “kitchen knife tested”**



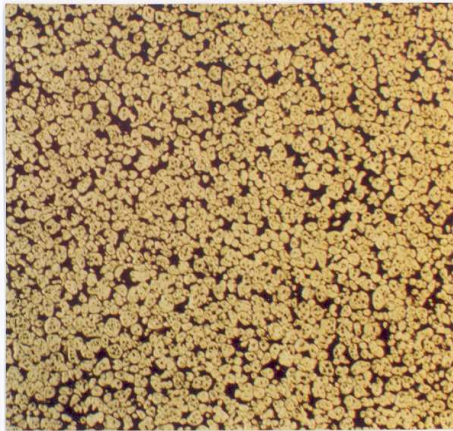
Longitudinal section and two kitchen knife tests of the 90 mm billets



Microstructure of a 60mm diameter billet – average grain size 68 μm and shape factor 1.43



Microstructure of a 90mm diameter billet – average grain size 85 μm and shape factor 1.52



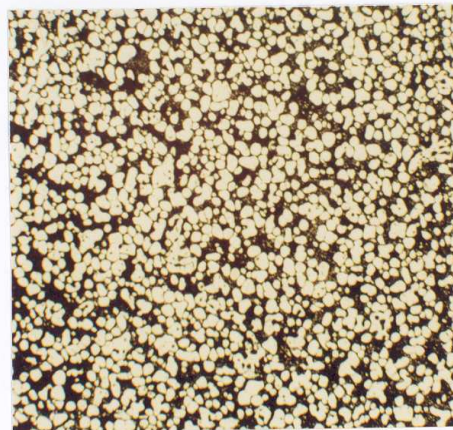
(a) Top surface



(b) Middle surface



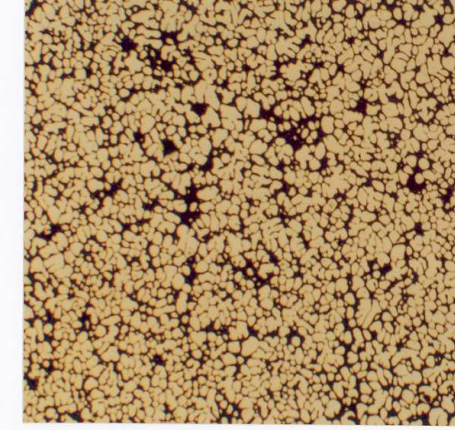
(c) Bottom surface



(d) Top centre



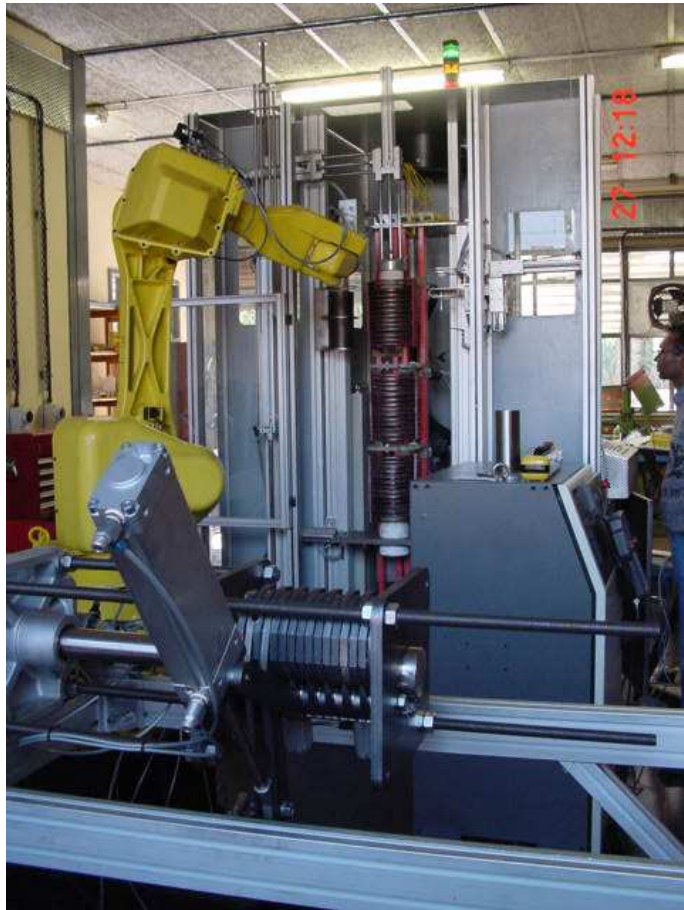
(e) Middle centre



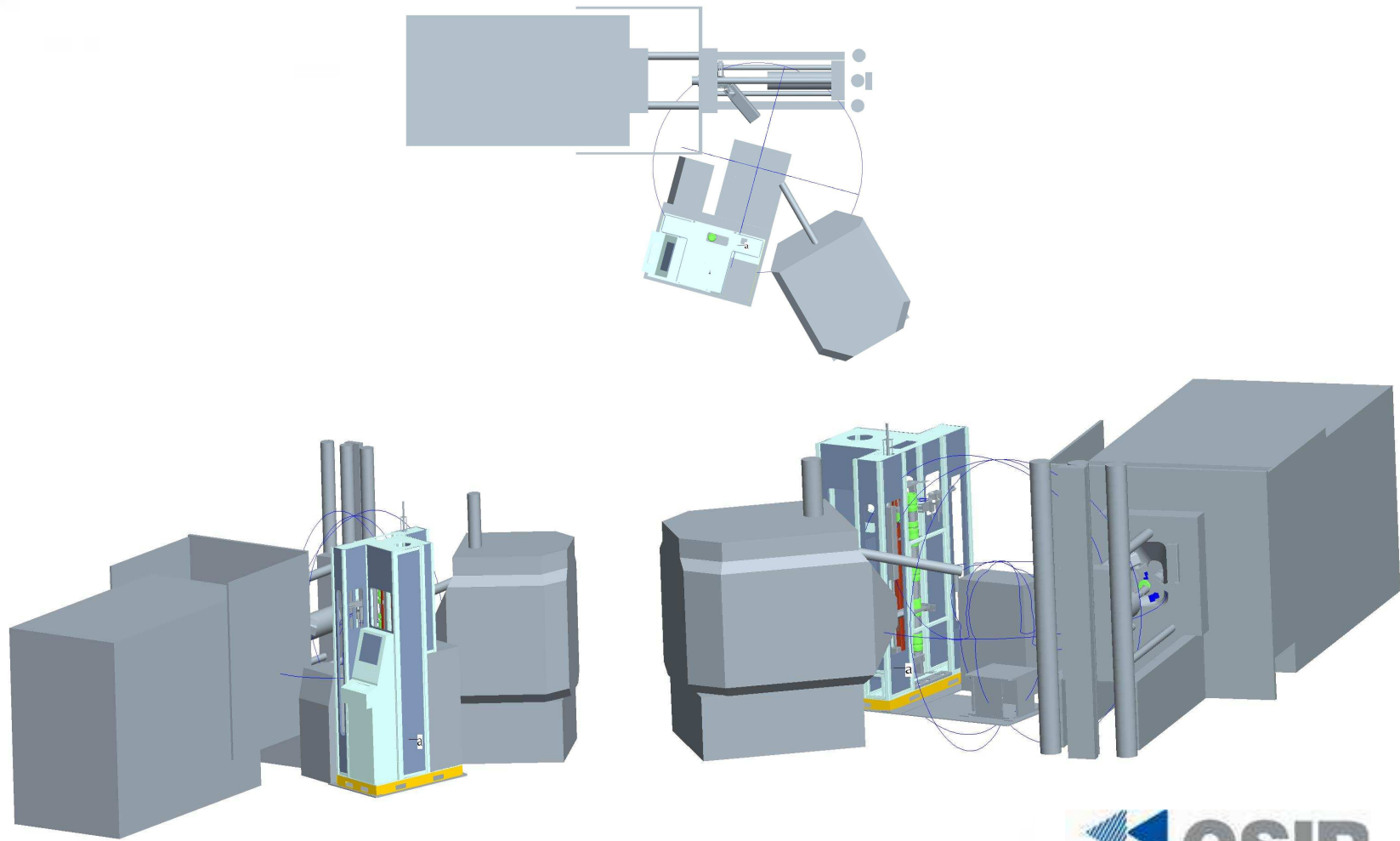
(f) Bottom centre

Microstructure's Homogeneity in 6 positions of a 60 mm billet

The CSIR Rheocasting System Industrial Prototype



Proposed SSM Production Cell to be Established at ASC



Conclusions

- **The SSM forming technology has demonstrated that it will be a competitive process for the manufacture of high quality, high volume components for the automotive industry in particular. The new slurry approaches to SSM forming has made the process economically viable.**

