PRODUCT DEVELOPMENT WITHIN THE FRAMEWORK OF A NATIONAL CASTING TECHNOLOGY CENTRE

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ABSTRACT

The need for a state of the art advanced National Casting Technology Centre (NCTC) has been widely supported throughout industry and recognised as an important facilitator in the growth of the foundry industry. This initiative also aligns itself with the government's Advanced Manufacturing Technology Strategy (AMTS), which is an implementation strategy in support of the South African government's Integrated Manufacturing Strategy (IMS) and National R&D Strategy (NRDS). The AMTS aims at supporting and developing the downstream high technology manufacturing industry, inter alia through the aerospace, automotive and metals sectors.

In light of the above and in an effort to retain and expand the current national skills, expertise and facilities in advanced casting technologies, the National Product Development Centre at the CSIR has initiated a process of establishing a National Casting Technology Centre (NCTC). The establishment of the NCTC provides a supportive technology platform for the Advanced Metals Initiative (AMI), which was launched in 2003.

The primary objective of the NCTC is to preserve and expand the national expertise and capabilities in cast metals manufacturing by supporting the local casting industry with process development, technology transfer and skills enhancement in order to increase their global competitiveness.

Keywords: casting technology, metals, foundry

1. BACKGROUND

The South African foundry industry is predominantly made up of small to medium sized companies, mainly serving the local markets in the mining, automotive and general engineering industries. As most local foundries are small, they do not have the resources to perform advanced casting research and development. The local foundry industry is facing strong technology challenges for the future as the industry moves more into the international market place. The general increase in global competitiveness and the strong demand for advanced cast components internationally, has led to significant improvements in cast manufacturing technologies worldwide.

The local foundry industry has over the past decade failed to keep up with global advances in new casting technology developments, both from a capital investment and a skills development point of view. As a result, this is seriously hampering the competitiveness of the local foundry industry in the international market place.

Various industry studies have been completed over the past year, including "*Foundry Industry Analysis*"[1], "*Foundry Technology Roadmap"* [2] and "*Technology, Skills Development, and Institutional Constraints in the South African Foundry Industry: Policy Recommendations for Improving Competitiveness in Casting*"[3]. One of the prominent outcomes of these industry studies is the clear recognition that there should be stronger initiatives from government in support of the foundry industry. The establishment of a National Casting Technology Centre has specifically been highlighted as a key initiative needed in this regard and has received widespread support throughout the foundry industry.

Responding to this need, the National Product Development Centre (NPDC) of the Manufacturing and Materials Technology Business Unit of CSIR initiated the process of establishing a National Casting Technology Centre (NCTC) towards the end of 2003. The primary objective of the centre is to preserve and expand the national expertise and capabilities in cast metals manufacturing by research and development on new casting technologies and through supporting the local casting industry with process development, technology transfer and skills enhancement. The NCTC will benchmark itself against other international centres and learn from their experiences. It is essential that the centre also networks closely with all relevant stakeholders, including government, industry, research and development groups and educational institutions. Through these activities NCTC will contribute towards the sustainability and competitiveness of the South African foundry industry in the international market place.

2. OPERATIONAL MODEL

The operational model and activities of the centre can best be described by the diagram below.

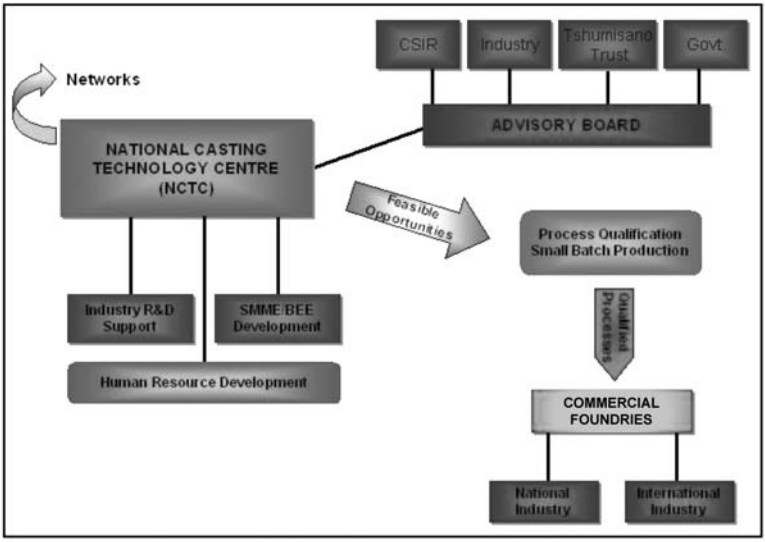


Figure 1: The NCTC Operational Model

Although the NCTC has a physical facility with equipment and a core staff, it is also linked in a national network of collaborating research and development (R&D) units. One of the key collaborators is the casting group at the Technikon Witwatersrand (now part of the University of Johannesburg), that specialises in sand casting technology. Another collaborator is the Centre for Rapid Prototyping and Manufacturing (CRPM) at the Central University of Technology. The equipment and expertise in the NCTC and its collaborating R&D units are made available for research teams working in the field of advanced casting technologies. The facilities will also be accessible for private companies that need specialised equipment for directed R&D.

The NCTC is advised by a national Advisory Board with representatives from stakeholders that have an interest in a competitive South African foundry industry.

Through its links with industry and with programmes such as the Tshumisano Technology Stations programme technology (usually qualified casting processes) are transferred to commercial foundries. Where special new opportunities exist, new start-up companies could be established in collaboration with initiatives such as the GODISA Trust.

3. OFFERINGS OF THE NCTC

The offerings of the National Casting Technology Centre are driven by the needs of the local foundry industry and the medium and longer term requirements for staying abreast of international trends in casting technologies and improving the global competitiveness of the South African industry. The following areas offer opportunities for the NCTC network.

3.1 Foundry Support

Specialist consultancy services are offered directly to foundries on a contract research basis. Some of the industry support activities are listed below:

- Product development with emphasis on design for manufacture and process selection;
- Process development, such as casting process design, methoding, tooling design (including gating and runner design);
- Rapid tooling;
- Casting from Rapid Prototype patterns;
- Casting simulation and process optimisation;
- Trial production and component qualification and testing;
- Problem solving;
- Process control and automation;
- Heat treatment specification;
- Casting defect analysis using metallographic, spectrographic, dye-penetrant and X-ray techniques;
- Foundry specific directed research and development contracts;
- Quality Control issues.

3.2 Research and Development

One of the primary medium and long term aims of the NCTC is to develop new casting technologies and transfer these to the local foundry industry to enable the industry to demonstrate capability in the international market place. This demonstration of capability is an important marketing tool to entice international companies to consider South Africa as a partner in new generation component development and production methods.

The R&D activities of the centre should ideally be performed through partnerships with industry and Tertiary Education Institutions and could include the following:

- Developing new casting technologies (processes and equipment);
- Developing innovative ideas through to commercialisation;
- Developing and exploiting intellectual property;
- Transferring technology to industry.

The casting industry is largely influenced by three main technology drivers:

- development of light weight components;
- development of manufacturing processes for advanced materials;
- introduction of time compression technologies such as rapid tooling, casting and prototyping.

Therefore, the following R&D activities should receive attention:

- Process development for casting of:
  - Light weight alloys (Al, Mg, Ti)
  - High strength alloys (CG-Iron, Ni, Co, Ti, Intermetallics)
  - Alloys with increased life (Ni, Co, Ti-based, Intermetallics SC, DC, etc.)
  - Thermal resistant alloys
  - Corrosion resistant alloys (Stainless Steels, etc.)
  - Thin walled castings
  - Semi Solid Materials and Metal Matrix Composites;
- Non-conventional moulding and casting techniques;
- Specialised melting and degassing techniques;
- Cast alloy and refractory development;
- Process control and automation;
- Prediction of microstructure, residual stresses and distortion during casting.

3.3 Casting Technology Training and Skills Development

The NCTC aims to benefit the South African casting industry by encouraging foundries and academic institutions to participate in casting technology skills development programmes.

It is proposed that the centre be made available for all South Africa foundries as well as all tertiary educational institutions (TEIs) for performing hands-on casting training and skills development. The centre should also provide facilities for postgraduate research studies, as well as encourage undergraduates and even students at school to experience cutting-edge developments in cast metals technologies.

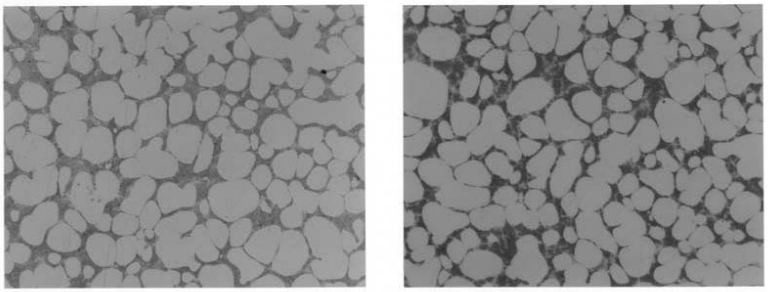
4. RECENT DEVELOPMENTS

Supported by the Innovation Fund, a team of the NPDC has developed and patented a unique technology for preparing billets of Aluminium in the semi-solid state [4]. An apparatus and method for rheo-processing of Semi Solid Metals have been developed in NPDC, as a part of the research program. The novelty of this technology is protected by international patent WO2004/070068 A1/19.08.2004 and South African patent application V16001. A slurry machine has been built and trials were conducted recently with aluminium alloy A356 (Fig. 2). Billets from 50 mm diameter/0.5 kg weight up to 122 mm diameter and 15 kg weight were cast with a production rate of one billet per minute.

Figure 2: NPDC Slurry machine

Figure 3: A 15.5 kg, 122 mm Dia, 480 mm length

The viscosity of the metal at the semi-solid casting temperature was found to be fully acceptable for High Pressure Die Casting technology. The metallographic investigations determined a fine SSM structure characterised by small grain sizes and a globular shape.



Microstructure of a 60 mm billet
Grain size 68 µm, Shape factor 1.46

Microstructure of a 90 mm billet
Grain size 82 µm, Shape factor 1.53

Figure 4: Microstructure of A356 aluminium-7% silicon alloy, rheo processed and cast by NPDC technology

This innovation will greatly improve the commercial viability of competitively producing Aluminium components through the semi-solid forming process.

A core competence in casting thin-walled structural components in Nickel-based alloys for aerospace applications has been established at the NCTC over the past year.

Following from a current Innovation Fund project on Titanium production, a team of the NCTC are embarking on developing technologies for casting Titanium alloys.

5. CONCLUSION

Through accepting the challenge to help improve the competitiveness of the South African foundry industry in the global market place, various exciting research topics and product and process development opportunities are offered to the local research and engineering community.

The challenge for the National Casting Technology Centre is to consolidate the R&D casting capabilities and related product development expertise in the country within the framework of the NCTC to form the basis of a national competence pool in support of the industry. This will require efficient technology transfer and skills development to strengthen the local human resource capacity.

6. REFERENCES

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