THE DEPARTMENT OF MANAGEMENT AND ENGINEERING

The Department of Management and Engineering (DTG) began its activities in Vicenza in 1991. Its mission is to establish a university seat for Engineering in Vicenza, in collaboration with the city's political and economic structures. The Department of Management and Engineering comprises 75 lecturers, 45 PhD students, and 35 technicians.

The main objectives of the Department's activities are:

- To establish specific research fields.
- To support cooperation between Industrial and Management Engineering and the city.
- To support the University's training and education activities.
- To establish a network of academic and industrial collaborations.

The Department's main research units include:

- Systems for energy and environment
- Industrial Technical Physics (Thermal fluid dynamics and heat transfer)
- Mechatronics
- Machine Design
- Industrial manufacturing
- Industrial Systems and Logistics
- Electrical Engineering
- Managerial Engineering
- Operations research
- Statistics
- Political economy
- Metallurgy

THE ACTIVITIES OF THE METALLURGY GROUP ON FOUNDRY

The foundry industry holds a historically and economically significant position within the Italian metallurgical and mechanical sectors. It effectively combines practical experience and technological expertise with exciting innovations. This metallurgical field has seen, and will continue to see, substantial developments in recent years.

The most significant innovations can be broadly categorized into three main areas:

- **New Materials**: The introduction of novel materials into foundries and the optimization of conventional ones.
- **New Processes**: The development of new processes, particularly for non-ferrous alloys, and more generally, in terms of controlled solidification.
- **Numerical Methods**: The expanded and increasingly reliable use of numerical methods for process simulation.

In the coming years, the competitiveness of foundries will directly correlate with the resources (both human and economic) dedicated to these research and development topics. Equally important will be the ability to efficiently transfer the knowledge gained from these applications. This necessitates organizing, managing, and executing activities in:

- **Research**
- **Education and Training**
- **Characterization/Technological Services**

The **Metallurgical Group** at the Department of Management and Engineering of Padova University is actively engaged in these subjects, working with both ferrous and non-ferrous alloy foundries.

It's clear that industrial companies in these fields are rarely equipped to conduct in-house research and training activities, or to provide personnel training and education. Therefore, the **Metallurgy Group's aim is to collaborate with these companies.** To achieve industrially significant results, this interaction must encompass both applied research and training/education.
Applied research plays a crucial role in supporting the growth of foundries. Historically, this growth has been tied to productivity. However, in the near future, it will be essential to link it directly to an **increased quality level of products.**
In detail, research activities have been carried out and are in progress about

- **Aluminium alloys**: Study of casting processes, both conventional and advanced, Microstructure and defects in castings, Correlation, by means of modelling, between microstructure and properties, Prediction of microstructure and properties of castings, Post-casting treatments (heat treatments, but also finishing, painting, anodising), Thermal investigations on castings and dies (*Figures 1-4*), Application of casting processes to Aluminium matrix composites;
- **Cast Iron:** Microstructural investigations, classification and morphology of defects, process modelling, correlation between microstructure and properties, set up of heat treatments, development of methodologies for restoring historically relevant manufacts, microstructural optimisation (*Figures 5-8*);
- **Magnesium alloys**: Microstructural investigations on castings, Classification of defects (*Figure 9*);
- **Steel**: Casting of conventional and innovative (duplex, superaustenitic) stainless steels: characterisation, Correlation among processing conditions, microstructure and properties.

Training and education are also fundamental, on their side, being the base for developing and upgrading the different professional skills involved.
For what concerns, in detail, training and education activities, the medium-long term objective is the set up of different kinds of Courses (technical, scientific, management) for a continuous cultural growth of the foundry personnel and, mainly, for the development of the professional profile of the Foundry Engineer, which is widely and usefully diffused abroad, but is still lacking in Italy.
More practically, the activities carried out by the Metallurgy Group at DTG specifically on foundry topics can be summarised in terms of

1) participation to qualified national and international projects; in detail, they can be mentioned:
    - the EC Leonardo Pilot-Project COPROFOUND, aimed at producing training media on different foundry processes and on their numerical modelling (*Figure 10*);
    - the MURST project – “legge 451” on Research and Education about the “Application of New Materials, Innovative Processes and Numerical Computation Techniques in Foundry”, in co-operation with Venezia Tecnologie and EnginSoft;
    - the development of a software for the optimised design of cast iron castings, in co-operation with ESTECO;
    - the participation to the EC Growth Research Programme, with the Ideal Project (**I**ntegrated **De**velopment Routes for Optimised Cast **Al**uminium Components), in co-operation with Centro Ricerche Fiat, EnginSoft, Teksid, Audi, Ford, Daimler-Chrysler, Jönköping University, Foundrysoft, Magma, Danish Technical University;
    - the EC Leonardo Pilot-Project METRO, aimed at setting up high quality metallurgical Courses, by integrating the teaching, training and technical competences of 7 European Partners;
    - the participation to the 6th EU Frame Programme, with the NADIA Project (**N**ew **A**utomotive components **D**esigned for and manufactured by **I**ntelligent processing of light **A**lloys), in co-operation with Centro Ricerche Fiat, EnginSoft, Teksid, Ford, Daimler, Jönköping University, Magma, NTNU, SINTEF, Raffineria Metalli Capra;
    - the participation to the 7th EU Frame Programme, with the MUSIC (MUlti-layers control&cognitive **S**ystem to drive metal and plastic production line for **I**njected **C**omponents), in co-operation with

Enginsoft Spa, Electronics Gmbh, University of Aalen – GTA, MAGMA Gmbh, Fundacion Tekniker, Eurecat - Technology Centre of Catalonia, Oskar Frech Gmbh + Co. KG, Saen, Maier S.Coop, Audi AG, RDS Moulding Technology, Motul, Regloplas AG, Fraunhofer-Institute IFAM, Assomet Servizi;

2) participation to standardisation boards, keeping the co-ordination of the Aluminium Foundry Group of UNIMET, the National Standard Board in the field of non-ferrous alloys;
3) carrying out of training initiatives specifically devoted to foundry (about 30 days/year);
4) several research contracts on foundry-related subjects;
5) organisation of technical and scientific Conference on foundry topics (*Figure 10*);
6) bachelor theses in co-operation with Companies of the Foundry field (more than 30 theses in the last three years).

ESTABLISHED COOPERATIONS

Some of the activities of the Metallurgy Group are carried out with the co-operation of technical and scientific Associations, such as

- Italian Association of Metallurgy (AIM),
- Assofond (Italian National Foundry Association),
- the Foundry Group of the Centro Produttività Veneto,
- UNIMET (the Italian Standard Board for non-ferrous metals),
- Alupromotion,
- Aital.

Furthermore, co-operations have been established also with Industrial Research Centres, Training and Education Consortia and Industrial Companies. They can be mentioned Venezia Tecnologie (ENI Group), EnginSoft, Edimet, Tecnolabor, Proservice Technology, SAV, Valbrem, Fonderie Galliatese, MOMO, Morphlogic, Aluminium Rheinfelden, Meridian MPI, Acciaierie Beltrame, Acciaierie Valbruna, Alcoa Trasformazioni, Qualital, Zanardi Fonderie, Esteco, Teksid Alumininum, Centro Ricerche Fiat, Jönköping University, NTNU, Aalen University, DTU, MAGMA, AUDI, Inasmet, RTM, Zanon.

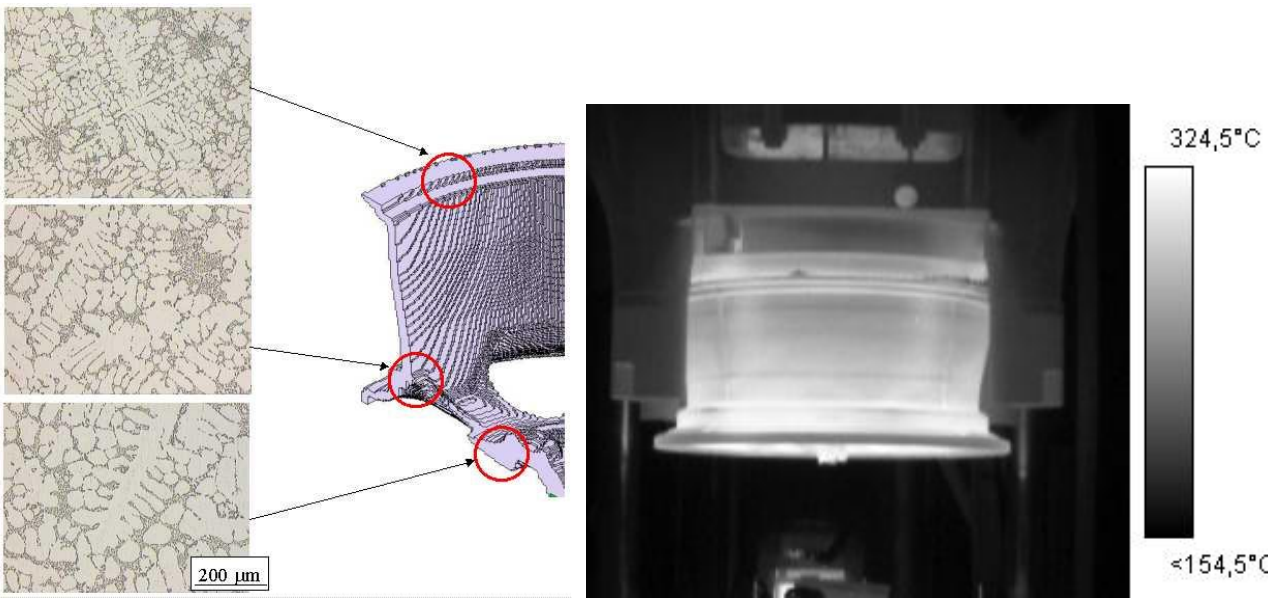

Fig. 1. *Microstructure distributions on Aluminium wheel and thermal mapping of the wheel during extraction from die*

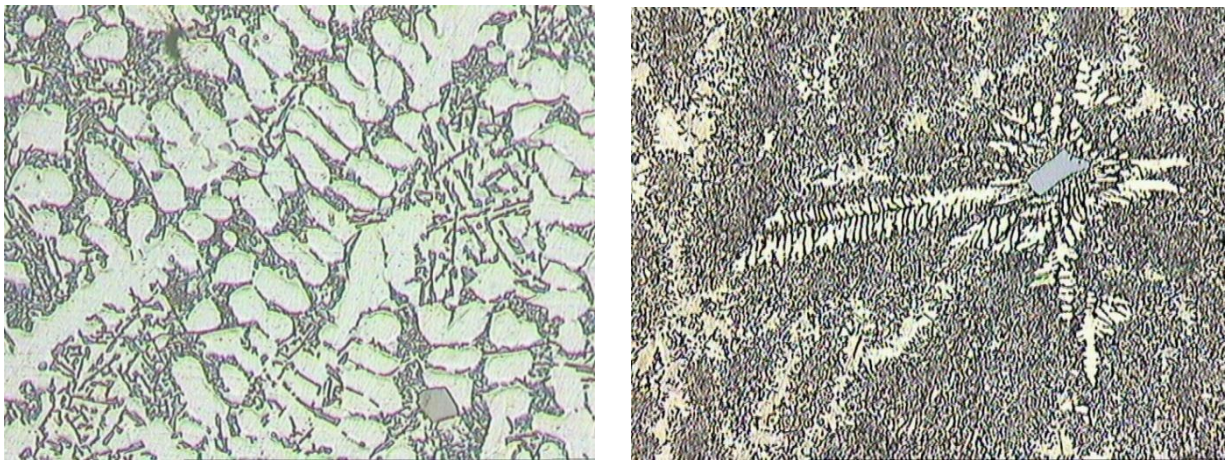

Fig. 2. *Microstructure in cast Aluminium-Silicon alloys*

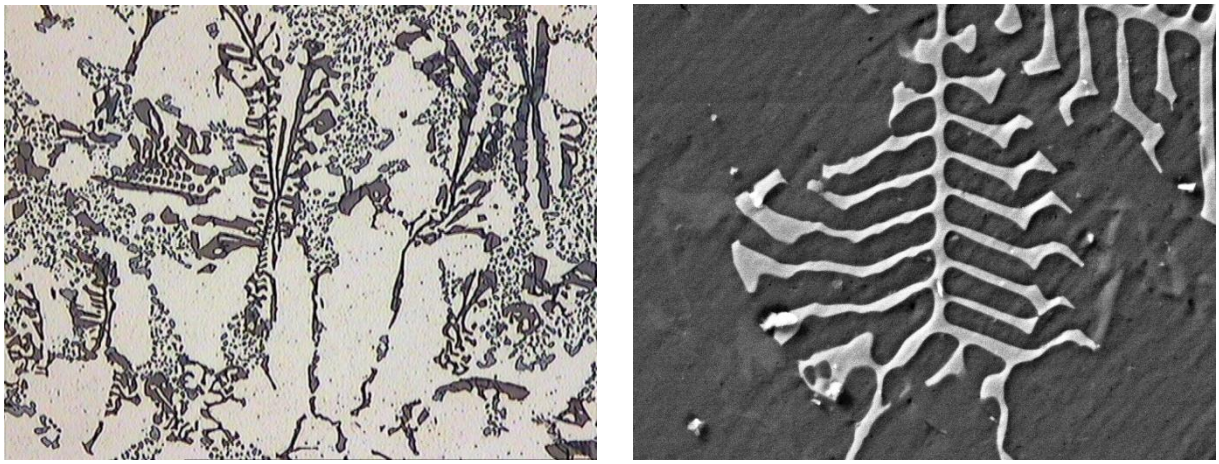

Fig. 3. *Light microscopy and SEM images of intermetallic phases in gravity cast Aluminium-Silicon alloys*

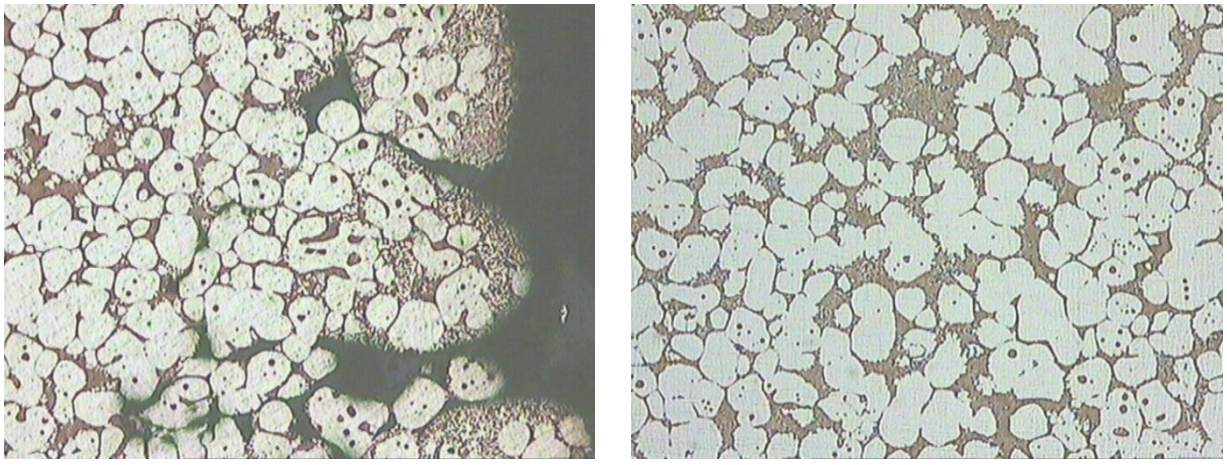

Fig. 4. *Microstructural features of semi-solid cast Aluminium-Silicon alloys*

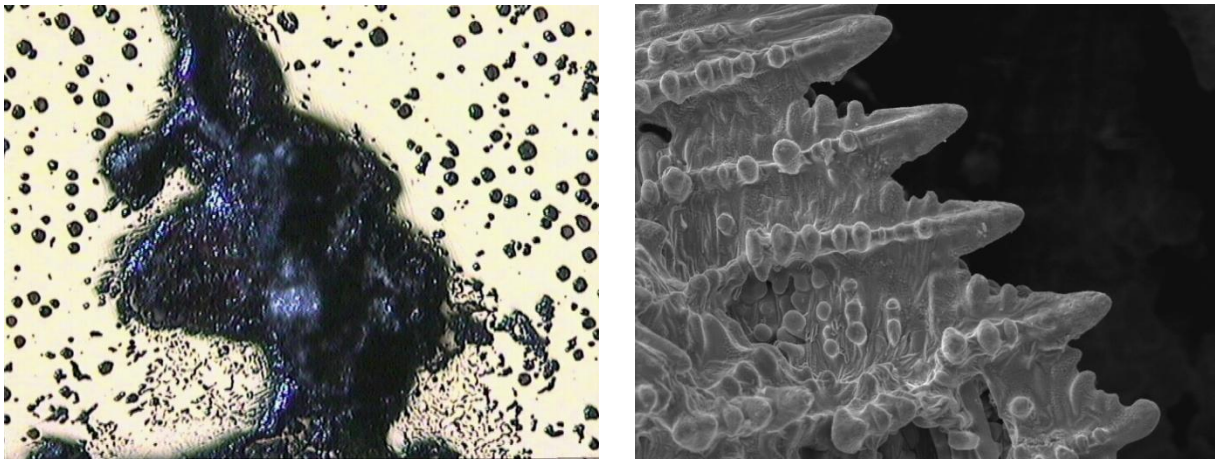

Fig. 5. *Defects in cast iron: loss of nodularity around a cavity (on the left) and dendrites grown on the wall of a shrinkage cavity (on the right)*

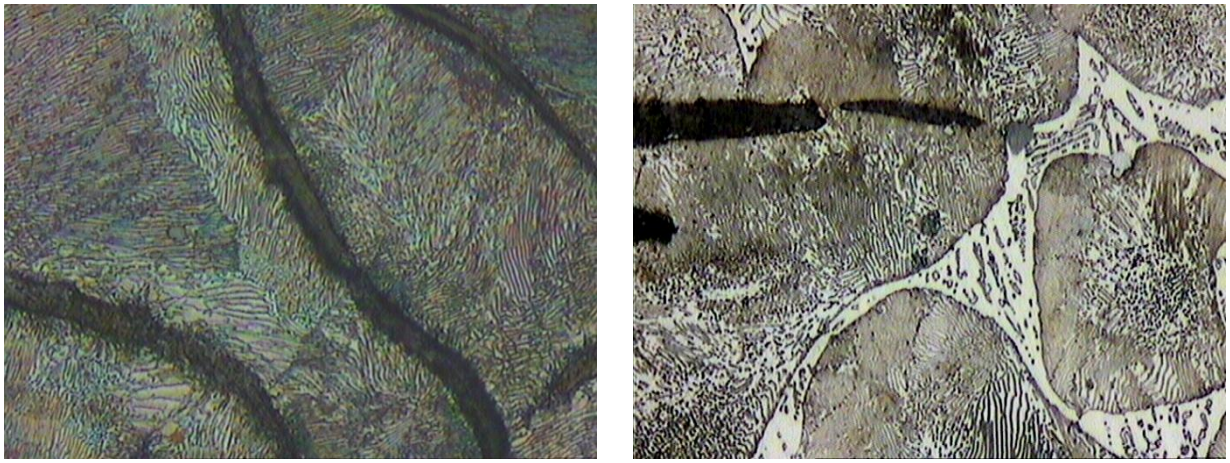

Fig. 6. *Microstructure of a perlitic grey iron (on the left) and steadite eutectic in a grey iron (on the right)*

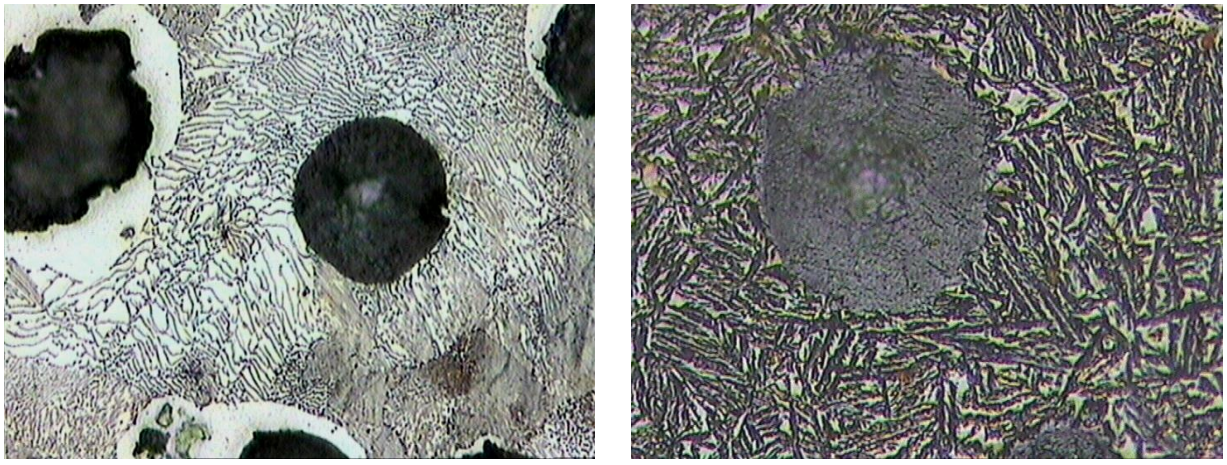

Fig. 7. *Microstructure of a perlitic-ferritic ductile iron (on the left) and of an austempered ductile iron (on the right)*

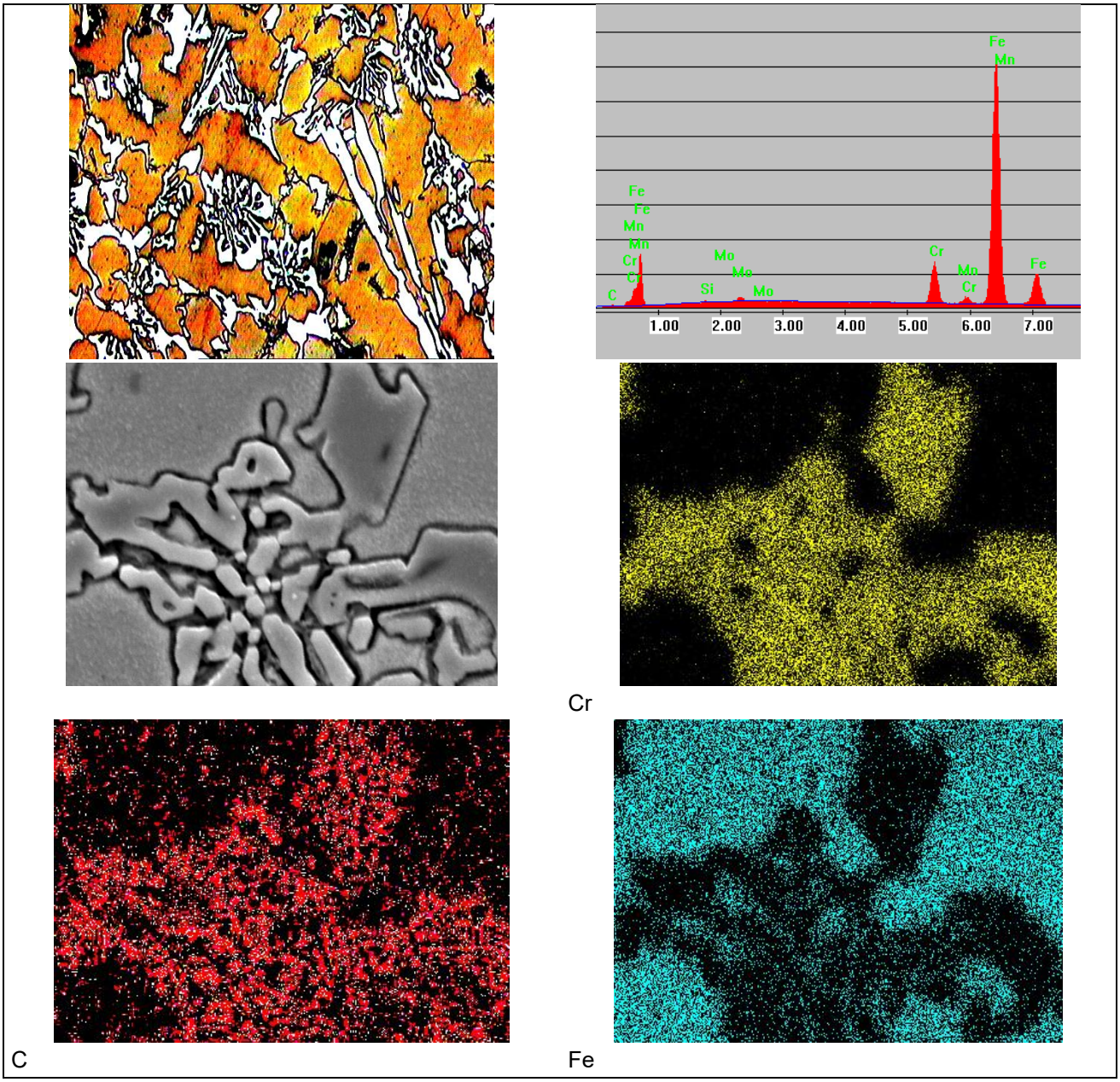

Fig. 8. *Light microscopy micrograph, EDS spectrum and EDS mapping of high alloyed cast iron.*

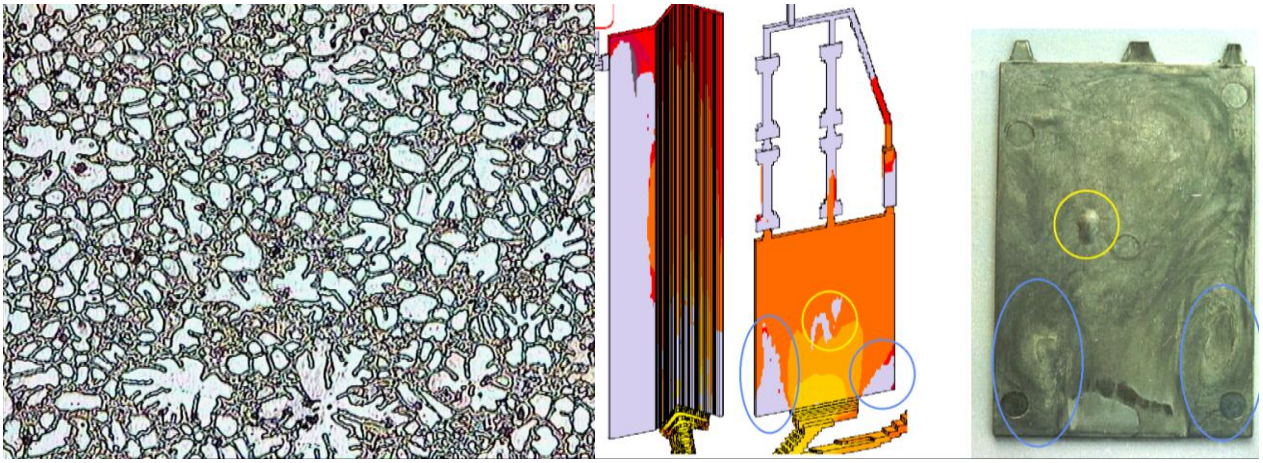

Fig. 9. *Light microscopy micrograph of a diecast AZ91 Magnesium alloy (on the left) and investigation on filling defects in a diecast AM50 Magnesium alloy (on the right).*

Fig. 10. *In order, Proceedings of "Ghisa 2000" Conference, of "Fonderia dell'Alluminio" Seminar, of "L'impiantistica nella fonderia della ghisa e delle leghe leggere" Seminar and book "Numerical Simulation of Foundry Project", published under the Coprofound EC Leonardo Project*

THE AVAILABLE EQUIPMENTS

The Metallurgy Group at DTG has set up two laboratories for metallurgical characterisation (*Figure 11*) and has the availability of one laboratory for mechanical characterisation, one mechanical workshop and one computer laboratory.

In such laboratories, there are equipment and know-how for investigating microstructure, defects and mechanical behaviour (both static and dynamic) of metallic materials:

- a complete set of equipment for metallographic preparation of specimens (cutting and micro-cutting machines, systems for cold and hot resin mounting of specimens, machines for grinding, polishing and lapping, devices for chemical and electro-chemical etching),
- light and stereographic microscopes, both interfaced with a system for acquiring, elaborating and analysing images,
- a hardness and a microhardness testing devices,
- a salt-spray machine for accelerated corrosion tests,
- scanning and transmission electron microscopes (SEM and TEM) with microprobe (EDS),

- an environmental scanning electron microscope (ESEM) provided by microprobe (EDS) and heating stage up to 1000°C,
- a X-ray diffractometer,
- ATAS system for data acquisition and elaboration of cooling curves,
- an infrared camera, for the acquisition of thermal maps (working range: from –20°C to 1400°C, acquisition rate: up to 20 images/s),
- a device for wettability measurement of metallic alloys,
- a device for thermal conductivity measurement of metallic materials, and infrared camera for the acquisition of thermal maps,
- an industrial X-ray device for non-destructive radiographic testing,
- tensile and axial and multi-axial fatigue testing machines,
- an extensimeter cabinet,
- instrumented tribometer for wearing tests,
- instrumented drop tower for impact tests,
- numerical codes for evaluation of phase diagrams and precipitation at various temperatures,
- numerical codes for simulation of metallurgical (casting, welding) processes.

METALLURGY LABs
METALLOGRAPHY and ADVANCED CHARACTERISATION
S. Nicola Building - Sector D – Ground floor

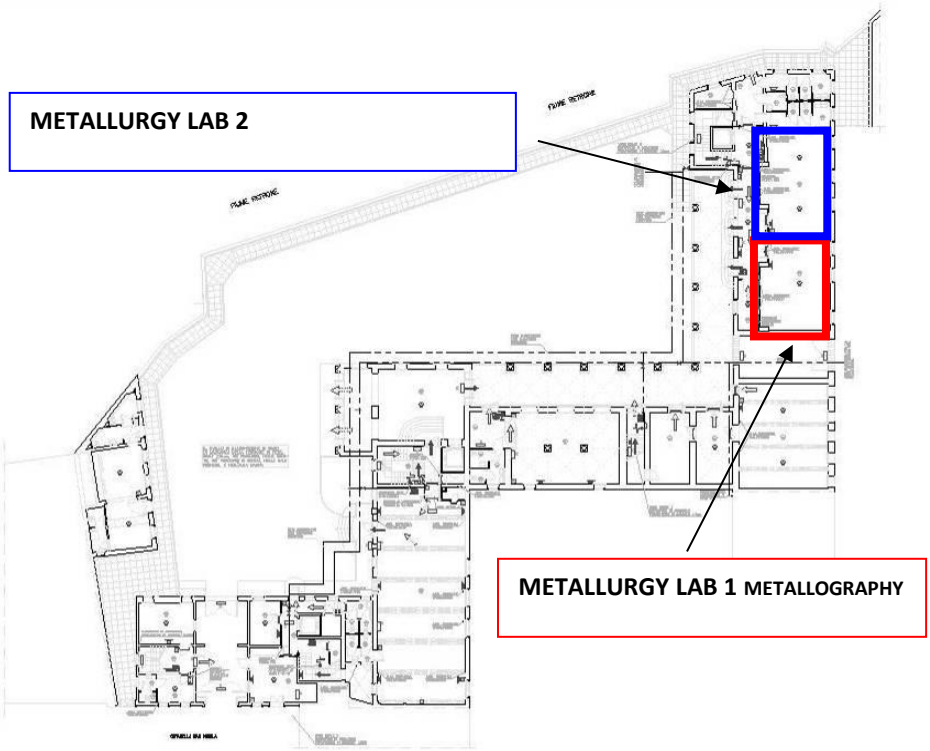

Fig. 11. *Metallurgy labs with the available equipment at the DTG of Padova University*

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