Sustainability of ferrous metallurgy – steeluniversity.org

The IISI has developed a comprehensive package of interactive internet-based e-learning resources on steel processing technologies and applications, targeted at undergraduates, their teachers and steel industry engineers to help improve the knowledge of ferrous metallurgy and the sustainability of the steel industry.

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The challenge

There is global concern within the steel industry about the decline in the number of students taking metallurgy and material science degrees, and about graduates who are seeking employment in the industry. Without an influx of young, talented and highly motivated engineers and scientists, the steel industry will find it difficult to retain its ability to innovate and remain competitive. Furthermore, those graduates who do join the industry often do not have sufficient ferrous metallurgy knowledge to become quickly effective in the operation or development of steelmaking processes or their applications. Consequently, steel companies and plant manufacturers around the world are spending increasing resources providing training programmes for their new recruits. While some of these may be tailored to the companies' specific requirements, much of the basic knowledge is common to the whole industry.

Another consequence of this decline is that the number of academics and universities with specialist knowledge of ferrous metallurgy and with up-to-date experience of the modern steel industry is also in decline and could soon reach terminal levels. Without action now, the teaching and researching of ferrous metallurgy in many universities will, in the medium term, become unsustainable. It is therefore vitally important that the steel industry presents an improved image of itself to the academic community and to potential recruits, who also need to be excited by steel and convinced that a career in the industry is stimulating, challenging and rewarding.

The solution

The International Iron and Steel Institute (IISI) had the vision to address this complex scenario through the development of a comprehensive package of interactive e-learning resources on steel processing technologies and applications. Targeted at undergraduate students and their teachers and in-company engineers in the steel industry, **www.steeluniversity.org** will help to fill the gap in the knowledge of ferrous metallurgy.

steeluniversity.org will provide the student/trainee with practical examples from the steel industry that illustrate and apply fundamental scientific, metallurgical and engineering principles. It will also provide a range of realistic simulations of steel processing from raw materials to semi-finished steel products and their applications, in which the learner takes control of a virtual steel plant and makes operational decisions. Other exercises involve the selection of appropriate steels for different applications and markets. Virtual on-line testing of steel properties is also envisaged.

During the pilot phase of the project, professors and students in Materials Science Departments around the world were asked to list the subjects most difficult to teach and learn. The most common answer was 'thermodynamics'. While it is not the intention to 'teach' basic thermodynamics principles through steeluniversity.org, it will provide practical, engaging examples of how thermodynamics is used in steelmaking and hence give the student improved motivation to understand the subject.

Several self-assessment exercises are incorporated into the steeluniversity.org programmes, so that the students can gauge their progress and satisfy themselves and their teachers that the intended learning objectives have been met. The aim is also to provide students with a more in-depth understanding of steel processes, products and applications and also of the associated environmental issues. It should give them a feeling of what it is like to work in the industry. To be most effective the steeluniversity.org resources should be 'alloyed' with other more traditional methods of learning, such that they supplement what is taught in the lecture theatre or experienced in laboratory classes.

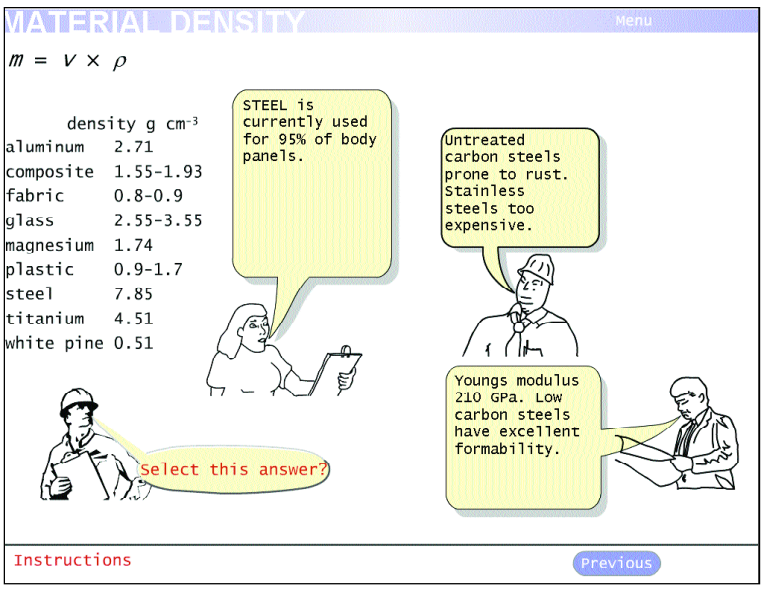
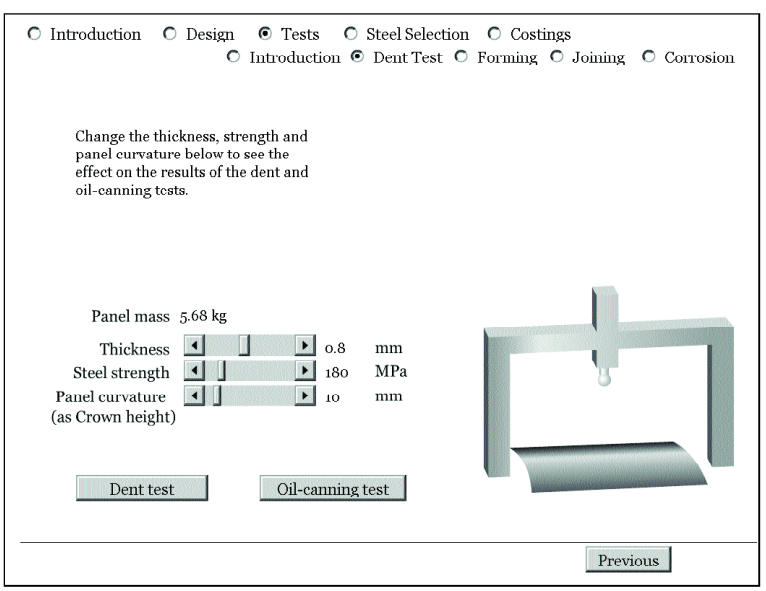


Figure 1 ***The Project team in the car door material selection exercise making a decision!***



Students will be offered the opportunity to register at www.steeluniversity.org to maintain a learning log that records their progress. However, it is not intended that steeluniversity.org will offer degrees or other qualifications. Students who have studied at steeluniversity.org should be more marketable to the steel industry when they are seeking employment. Examples will also be provided on how some universities have integrated steeluniversity.org resources into their formal course work and curriculum.

Another planned feature will be a database of experts in academia, research institutes and the steel industry who are active in teaching and research concerning steel and related technologies. This will provide a one-stop shop to facilitate searches for potential partners in collaborative projects, problem solving and consultancy. IISI member companies will be able to promote training and recruitment opportunities and also to illustrate successful career development case studies within the industry. Universities will be able to promote their courses and research activities on the site.

steeluniversity.org is a novel multi-corporate virtual learning centre and provides the foundation for a unique global industry-university partnership.

What steeluniversity.org already offers

Initially IISI supported the development of two demonstration modules which were promoted as ILSAP (Internet Learning of Steel Products and Applications). These deal with the selection process of a high-strength steel for a lighter weight car door outer panel, building on another major IISI project, ULSAC (UltraLight Steel Auto Closures), and secondary steelmaking.

Car door material selection In this module the student plays the role of a materials engineer in a multi-disciplinary team, requiring input from other team members, including marketing, design and production engineers and a project manager (see *Figure 1*). The material selection process has to take account of design features, material properties, costs and other important functional, performance, fabrication and recycling requirements. The student is required to specify a steel grade, thickness, coating type and thickness that will achieve the target weight reduction (see *Figure 2*). At the end of the exercise feedback is given on how well the student has met these objectives.

Secondary steelmaking This demonstration module involves an on-line simulation of a secondary steelmaking shop that incorporates an argon stirring station, ladle furnace, an RH degasser, a tank degasser and a CAS-OB unit (see *Figures 3* & *4*). The students have to make one of several steel grades (including a candidate steel for the car door panel) and are presented with a ladle of steel from the BOS. From here they must decide what additions to make (when and where), which equipment to use and in what sequence, in order to get the ladle to the right caster, within specification, at the required time, at the right temperature and at minimum cost. They have to learn how to manipulate the cranes and ladle cars efficiently and also how to cope with unexpected interruptions and complications.

Supplementary learning packages are also available within this module which cover deoxidation, desulphurisation, decarburisation and dehydrogenation, steel cleanness and the importance of slag composition. *Figure 5* illustrates

the principles of decarburisation. A detailed user manual, to assist with the calculations of the required additions is also available on-line.

It is possible to use this simulation as a competition between individuals or teams and again feedback is given at the end of the exercise on how successful the student or team has been in meeting their objectives (see *Figure 6*).

Future development of steeluniversity.org

Before embarking on the next, more ambitious phase of the project, a market evaluation was undertaken by IISI to determine whether these first two demonstration modules achieved the goals that were set for the pilot project and to check that these resources are of real value to students, professors, trainees and trainers in the steel industry. Among the many favourable comments received from around the world were:

- *"Unique, informative and entertaining"*
- *"A revolutionary tool in the hands of university staff, bringing practical applications and demonstrating the significance of knowledge in the class room"*
- *"A fantastic tool to educate people concerned with the steel industry in a very efficient and powerful way"*
- *"Wo w"* – Chief Executive of a US steelmaker
- *"I was very impressed with the calibre of the modules"*
- *"The simulation is amazingly realistic, conveying the feeling of working in a steel factory"*

Encouraged by this positive and enthusiastic reception of the demonstration modules, IISI is now planning to create a further 20 modules and process simulations to form a comprehensive web-based curriculum of ferrous metallurgy and steel technologies. The first step was the appointment of a full-time Project Director for steeluniversity.org in October 2003. In 2004/5 the first modules to be developed will include electric arc steelmaking, continuous casting, steel properties and strengthening mechanisms, steels in construction and life cycle analysis. These will be followed by more modules on basic oxygen steelmaking, blast furnace, coke and sinter, refractories, hot and cold rolling, coating and finishing, phase transformations, heat treatment, recrystallisation, grain growth, stainless steels and steels for packaging, energy and more automotive applications.

In this way the student will be able to simulate the production of steel from raw materials to products and their applications. The modules will be interlinked so that students can access the resources from different applications of steel and see how an appropriate steel is designed and selected and then work out how it can be made – deciding the composition and microstructure that are needed to generate the required properties and what process route and casting, rolling and heat treatment to use to produce that microstructure. Alternatively they can start by studying part of the steelmaking process in detail and then find out what the steel being made is used for. Professors will also be able to utilise the site to find practical applications for the scientific, metallurgical and engineering principles they are teaching.

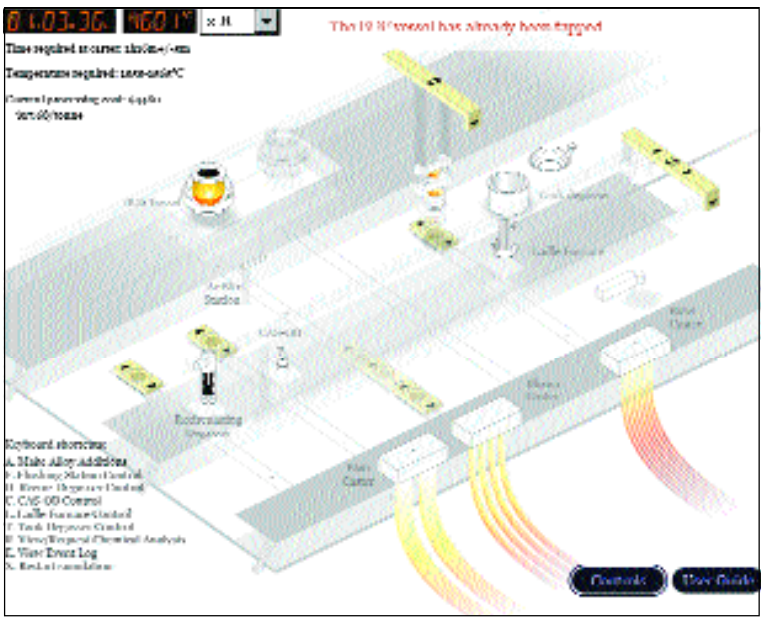


Figure 3 ***The secondary steelmaking simulation is underway***

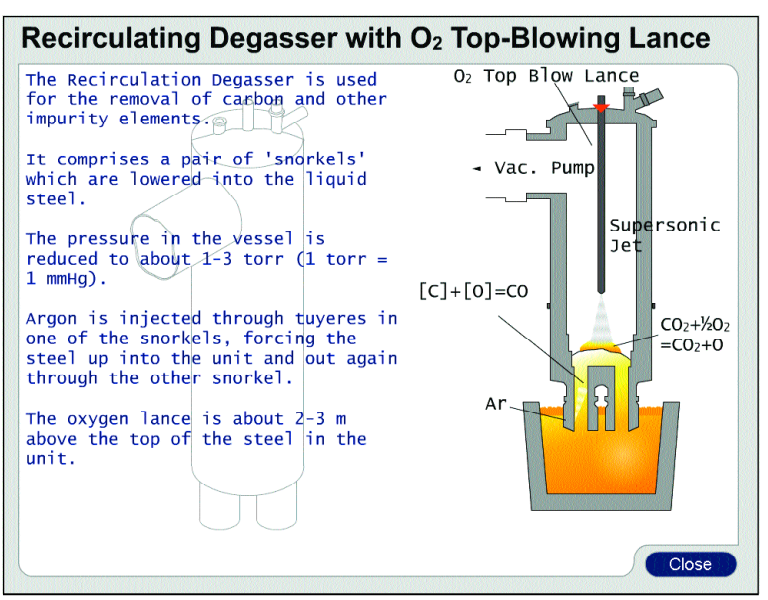


Figure 4 ***A vessel available in the secondary steelmaking simulation***

The interlinking of steel processing, products, applications and scientific principles

In the forthcoming steel properties module, students

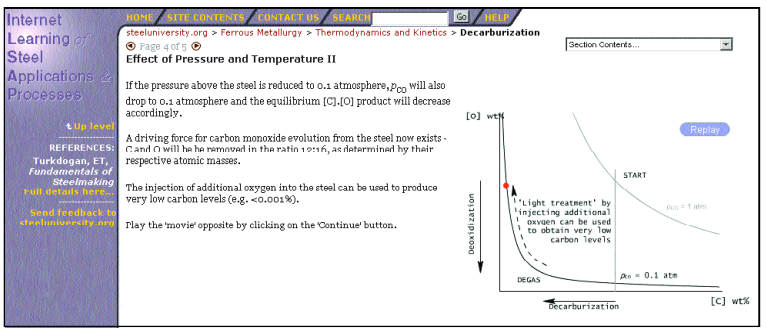


Figure 5 ***Principles of decarburisation***

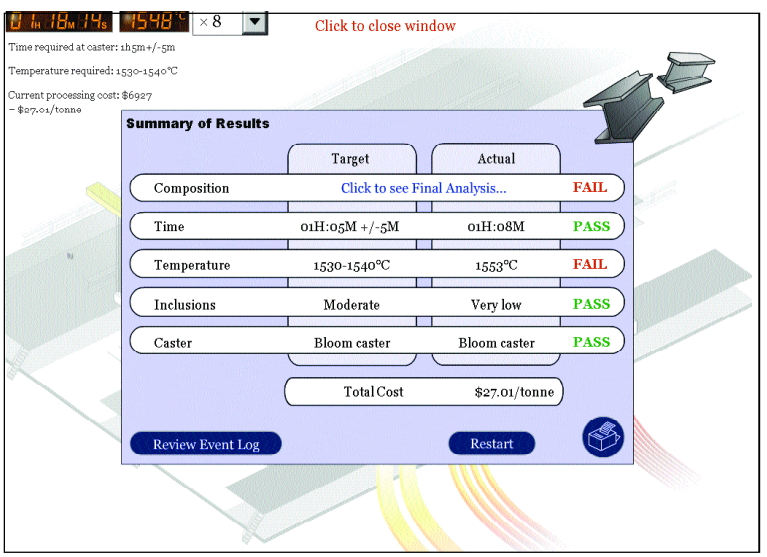


Figure 6 ***Feedback at the end of the secondary steelmaking simulation. This student needs to do some more studying!***

will be able to conduct on-line tensile and Charpy impact tests and be able to derive Young's Modulus, yield and tensile strength and ductility and ductile-brittle fracture transition temperature values for different types of steel. In the 'steels in construction' module, students will not only explore the diversity of steel product forms and types that are used, but will also examine the consequences of strength, modulus and design on structural performance and failure mechanisms.

In the life cycle analysis (LCA) module, students will be able to gain an awareness of the principles behind life cycle analysis and the procedures that are adopted when undertaking LCA. Examples from the automotive, construction and steel industries will be provided. These will enable the users to identify relevant environmental effects and impacts of steelmaking processes, products and applications. They will be able to understand and use the steps taken in LCA, Impact Assessment and Interpretation, by studying practical situations and scenarios that are relevant to the steel industry and its supply chain.

steeluniversity.org will give its users the understanding, the tools, and the confidence to use LCA in their decision making and will inspire them to make a personal contribution to a sustainable world.

Each module is prepared by an academic expert who writes the storyboard, with the support of an industrial expert. Based at the University of Liverpool, the MATTER team – which was set up in 1993 to develop and help integrate e-learning materials to into the mainstream teaching of materials science, engineering and related disciplines – plays an important role in the project by coding the storyboards, animations and simulations and hosting the website. It is envisaged that steeluniversity.org could, in future, be extended to provide learning aids for school pupils and their teachers, with the aim of supporting their studies of physics, chemistry, design and technology, engineering and manufacturing and encouraging them to study metallurgy, materials science or engineering at university or college. Another further development is at the post-graduate level in which individual topics can be dealt with in greater depth.

Conclusions

www.steeluniversity.org is an ambitious project that is intended to:

- Sustain ferrous metallurgy knowledge in universities and in industry – putting the urge back into metallurgy!
- Excite and inform students and their teachers about steel and provide practical steel-related examples to illustrate the applications of scientific, metallurgical and engineering principles
- Stimulate students about the challenging and rewarding career opportunities in the steel industry, by giving them an insight into what jobs in the industry are about
- Demonstrate the on-going innovations in steel processing and steel product developments to steel users and potential customers
- Provide valuable in-service training and life-long learning for employees in the steel industry supply chain at reduced cost
- Facilitate research partnerships between academic and steel industry experts
- Promote university courses and research opportunities in academia
- Demonstrate the commitment and contribution of the steel industry to a sustainable world and to the knowledge economy

Any feedback or offers of assistance and other contributions should be made to David J. Naylor, Project Director – email: naylor@iisi.be – at the International Iron and Steel Institute, Brussels, Belgium.