VIRTUAL STEELMAKING
Manufacture advanced high-strength steels for an aircraft undercarriage, design a door panel for a passenger car or calculate the design stress for the steel cable stays on a suspension bridge. Step inside a virtual steel plant, operate the equipment and produce and test your own grade of steel.

steeluniversity.org is a free and innovative e-learning resource focused on all aspects of steel, including steelmaking technology and the multitude of steel applications.

This award-winning initiative is sponsored exclusively by the World Steel Association. It provides highly interactive, game-like simulations of the major steelmaking processes in real-time.

steeluniversity.org covers the entire steelmaking process, from raw materials to the finished steel product. Individual modules address end-use applications and their design, product testing and steel recovery and recycling.

The aims of steeluniversity.org are to inform and excite students of all ages about steel and to provide practical examples of metallurgical and scientific principles for teachers to use in their classes and lectures. It also supports the continuing professional development of employees in the steel industry supply chain.

Prizes and Awards

European Academic Software Award Winner (2004)
Royal Academy of Engineering Education Innovation Prize Finalist (2006)
Association for Iron & Steel Technology - AIST Benjamin F. Fairless (AIME) Award Winner (2008)
steeluniversity.org comprises a series of advanced and sophisticated educational modules which support traditional teaching and learning practices.

A 4D ‘fly-through’ module provides a first-hand overview of the main production processes used to make steel in a modern steelworks. Integrating the latest techniques in computer technology, you are taken on a journey from a ship unloading iron ore, all the way through the various production processes to the finished steel.

The first series of modules take you through the basic steelmaking processes using a simple menu-driven facility. Each module can be studied and operated as separate units. The thermodynamics and kinetics of the chemical reactions taking place in these operations can be explored to provide a detailed understanding of how they can be controlled.

You can make four different grades of steel, each with a different composition, property profile and end-use application. There are two levels of difficulty. The more difficult route requires you to respond to unexpected events during the simulation. This demands a more in-depth understanding of the process. Realism is enhanced by industrial sound effects. At the end of each simulation you receive feedback on the quality of the steel produced and costs incurred.

Some of the simulation exercises are now linked. By registering and logging on to steeluniversity.org, you will be able to save and retrieve data relating to the various simulations and exercises. For example, you can now save your results from the EAF simulation and refine the actual casts you have made in the secondary steelmaking plant. There is also a facility for students to assign themselves a teacher who can then view their results and provide feedback on simulation attempts. Several modules require you to select steels that are fit-for-purpose in transport, construction, energy, packaging and general engineering markets. You can take samples from a virtual steel plate and test them to check compliance with the specifications. In another exercise you must design and make your own high-strength steel. This involves a detailed understanding of the metallurgical mechanisms that control the properties of steel.

In another module you are introduced to life cycle assessment methodologies and learn how to apply them to the production and use of steel. This helps you to recognise the importance of sustainability and the effect of your actions on the environment.
Tour of a virtual steelworks

This module takes you through the production stages and process route of an integrated steelworks. The tour covers all aspects of an integrated plant, from ironmaking and steelmaking through to casting, primary forming and cold rolling.

After an overview of the steelmaking process route, you start your tour by flying over the steelworks. The tour begins with the arrival of raw materials at the dock. After following the process route through the various stages of production, you are then free to walk around the whole site and explore inside each of the main production units. You can look at the processing steps in more detail and watch the steel being made.

You may also like to try the Life of Iron challenge. Find and collect hidden objects and information from around the virtual steelworks site and use these facts and figures to help you complete a quiz.

Blast furnace

The blast furnace module allows you to explore the history, key processes and the future of blast furnace ironmaking. Using a combination of illustrations and animations to support the detailed text, the module describes the blast furnace process from start to finish. This includes raw materials and their preparation, important reactions and operating practice in the blast furnace, instrumentation and process control.

To complete this module an interactive simulation is planned, allowing you to take control of the blast furnace.
Basic oxygen steelmaking

This module includes a simulation of basic oxygen steelmaking, one of the two main steelmaking processes. In the basic oxygen furnace, hot metal from the blast furnace is converted into steel. In this simulation, you decide the levels of scrap and alloy additions to make. You then take control of the oxygen lance and furnace stirring to decarburise and dephosphorise the steel. The steel must be tapped within the required composition, time and temperature limits.

Details of the chemical reactions occurring during this process are provided. The module also covers slag formation and constitution, and process-control issues.

Electric arc furnace steelmaking

The electric arc furnace (EAF) is the second of the two main steelmaking processes. It is the major production route for recycling steel scrap, often into higher quality steel. In this real-time simulation you must first select the appropriate type of scrap and the correct quantities. You will divide the scrap into appropriately mixed batches and then charge them into the electric arc furnace where it is melted by applying a high electric current through three graphite electrodes. Once melted, the steel is refined through the injection of carbon and oxygen, and the addition of various elements and alloys to achieve the required composition before you deliver the molten steel to a ladle.

The EAF module is linked to the secondary steelmaking simulation. This enables you to continue refining your own successful casts in the subsequent steelmaking process.
Secondary steelmaking

In this module you have to further refine your ladle of liquid steel from the electric arc or basic oxygen steelmaking furnace. You are presented with a ladle of molten steel together with vacuum degassing, ladle arc furnaces, chemical re-heating and stirring station facilities. You must select which ones to use and deliver the liquid steel to the appropriate continuous caster within specification, with the required inclusion content, at the right time and temperature and at minimum cost. This involves driving the ladle cars and cranes.

Decisions also have to be made on what additions to make, where and when to make them and how to remove some unwanted elements.

Continuous casting

In this simulation you play the role of a plant metallurgist in charge of bloom, slab and billet continuous casting machines. Your goal is to successfully sequence-cast three ladles of steel into semi-finished products ready for hot rolling. Many operational decisions have to be taken to control the casting speed and the flow of metal from ladle to tundish while keeping a close eye on the time and temperature settings. Avoiding a break-out or nozzle blockage is critical to the success of the process. The internal and surface quality and final inclusion content are vital factors that need to be considered to ensure the steel meets the customer’s specifications.
Hot rolling

The hot rolling module introduces the various plant configurations and processes for rolling different products. The module also covers basic rolling theory. In the simulations you can roll an I-beam for construction applications from a bloom in a universal beam mill or an ultra-low carbon steel strip for car body panels. In the plate rolling simulation, you can also explore the metallurgical and scheduling challenges involved with rolling a multi-plate order to produce sections of an offshore wind turbine.

Heat treatment

In this module you will learn about the principles of heat treatment and examine different heat treatment methods, the reasons behind their use and their effects on steel and its properties.

The module describes many of the different methods of annealing and explains the main reactions that are taking place. You can explore the reasons behind quenching in different media, the equipment used for this, and the tempering process that usually follows. A wide range of surface treatments are also introduced. These can be used to produce components with different properties at their surface and within their core. A number of steel applications, made possible only through heat treatment, are presented.

The use of different furnace types, depending on the steel type, component shape/size and property requirements is also discussed.
Material selection for a car door panel

In the automotive module, you take the role of a materials engineer who is part of a team that is designing, making and selling a lighter and cheaper car door panel. Decisions have to be made about the thickness and shape of the panel, the strength of the steel, its formability and weldability, and how to protect it from corrosion. Steel industry developments in this area have led to significant advances in high-strength and ultra-high-strength steels used for automotive applications.

Steels in construction

The construction industry is the largest market for steel products. This module illustrates the diversity and versatility of steel and its wide variety of types, shapes, properties and applications in buildings and other major structures. The design equations used in structural steelwork are described, failure mechanisms examined and the difference between strength and stiffness explored. Fabrication and corrosion protection methods are also studied.

Case studies of major construction projects illustrate the detailed use of steel in these applications. They also show how 3D building information modelling software is used to consolidate the design and engineering of building structures.
Offshore

The variety of steels and steel components used in offshore applications are explored in this module. The module ends with an exercise to design and make 9,000 tonnes of high strength steel for an off-shore platform. Your aim is to successfully supply the order and make a profit.

Engineering steels

Engineering steels are extensively used in the automotive, aerospace, railway, oil and gas, mining, power generation, defence, agriculture, chemical, construction, general engineering and manufacturing sectors. Cars, buses, trucks and off-road vehicles account for over half the market for engineering steels.

Using interactive exercises and examples, this module explores the wide range of engineering steels, from plain carbon steels to high alloy, ultra high strength steels. In each case the composition and processing methods used to ensure the steel is suitable for its intended application are examined.
Packaging

Steel is an excellent packaging material due to its strength, formability and durability. Through innovation, the weight of steel packaging has been reduced and cost-efficient packaging solutions can be achieved in a multitude of shapes and sizes. This module covers the history of steel packaging, the manufacture of packaging steels and the subsequent processing to different types of packaging.

You will be able to explore the different types of steel packaging that are available, according to producers' needs and different consumer markets, and learn about the sustainability benefits of using steel packaging. There is also a material selection exercise, in which you play the role of a material scientist who is part of a team challenged to select the material, format and coating for a food can. You will have to make choices according to product and market needs, taking into consideration product processing requirements, material performance, logistics and can design.
Strengthening mechanisms

This module introduces the various metallurgical mechanisms that are used to strengthen ferrite and pearlite steels. You can learn how to measure grain size and how this can be refined to increase the strength of steel. You will be introduced to different atomic arrangements and discover how the addition of alloying elements to steel can affect its mechanical properties, either through solid solution hardening or precipitation hardening. The role of dislocations in the work hardening, plastic flow and yield strength of steel is also explored.

Through a series of interactive exercises and examples, you will be able to learn how to quantify the effect of these different mechanisms on the mechanical properties of steel. Finally, you will be shown how these mechanisms can be combined to develop specific properties for different applications.

Phase transformations

In this module you can explore some of the key concepts of phase transformations in iron alloys. After revisiting the basics of atomic arrangements, you will learn how atomic movements and volume changes may occur and why these are necessary during phase transformations. The effects of different alloying elements are also considered.

An interactive exercise on dilatometry demonstrates an experimental method that makes use of the volume changes occurring during phase transformations to generate cooling transformation (CCT) diagrams.

Different mechanisms of phase transformation in steel are also introduced, with additional exercises to explore the conditions that favour each process and test your understanding of this subject.
Thermodynamics and kinetics

A solid understanding of thermodynamics and kinetics is fundamental to the chemistry of ironmaking and steelmaking. In order to meet varied and stringent consumer demands it is necessary to understand how chemical reactions can be accurately controlled. The control of oxygen, carbon, phosphorus, sulphur, hydrogen and nitrogen is an essential part of the steelmaking process.

This module looks in detail at the chemical reactions taking place in the various secondary steelmaking vessels. It illustrates how the underlying thermodynamics and kinetics can allow these reactions to be manipulated to produce steel with the required composition.

Mechanical properties

When selecting a material for a particular application, engineers must be confident that it will be suitable for the loading conditions and environment it will experience in service. An understanding of the properties of materials is therefore essential.

This module provides an insight into the mechanical properties of steels, their selection for specific applications and the standards and specifications for several important markets. Virtual tensile, hardness and Charpy impact tests are available for you to try online, either individually or as part of a combined “sample and test” exercise. This involves you taking samples from a steel plate, after deciding how many test pieces to produce in various orientations. You then use the virtual test facilities to measure its properties and determine whether it meets a particular specification.
Sustainability

In this module you will examine sustainability and the environment, drawing on examples from the automotive, construction and steel industries. You will then progress to understanding principles of life cycle thinking and life cycle assessment (LCA). Some relatively simple LCAs can also be performed. This module highlights the importance of considering LCA in your decision-making, both in your work and everyday life. Additional modules planned for this section include environmental management in the steel industry.

Annual challenge

Each year, worldsteel hosts the steeluniversity Challenge, where participants are given 24 hours to process a new steel grade or product in one or more of the virtual steelmaking simulations.

Multiple attempts are allowed during the 24-hour Challenge period. There are two categories; students and new steel industry employees (with less than three years’ experience). The winner from each category is the individual or team who successfully processes the steel at the lowest cost. A prize and trophy are awarded to the winners at a major worldsteel event.

The Challenge is normally run in November and attracts entries from around the world.

steeluniversity.org

The development of the e-learning resources at steeluniversity.org is continuing and includes modules and simulations from the blast furnace to rolled products. Other modules will incorporate additional metallurgical principles and steel applications. The facility is being translated into other languages, with modules already available in Spanish, Chinese, Korean, Russian and German.

Supplementary features are also included on the site. These include ‘Study and Work’, which comprises a number of case studies highlighting how steeluniversity.org is being used in industry and academia. The section also includes information on career opportunities in the steel industry. There are links to useful websites, including steel companies, universities and other steel- and materials-related sites.

steeluniversity.org can be readily blended into traditional teaching and learning and is already being used by universities and steel companies worldwide. Its resources can be used for self-motivated or directed individual study, team projects or as a competition.

worldsteel hopes that steeluniversity.org will inspire and excite students about the value and wonders of steel, the opportunities steel presents to the sustainability of our world and about the challenging and rewarding careers in the steel industry.
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