

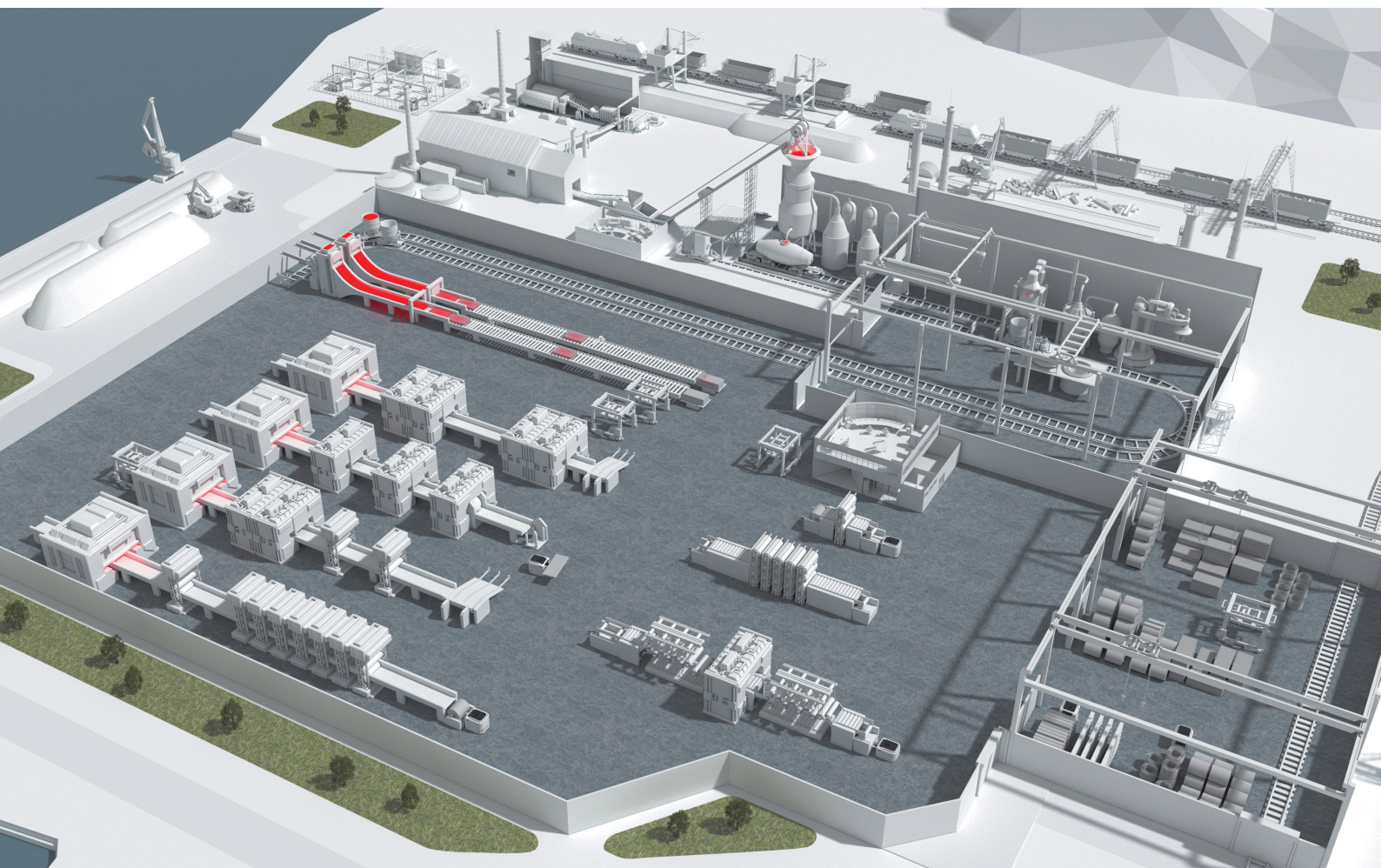
WHITE PAPER

Energy efficiency in iron and steel making



Reducing energy consumption, costs and emissions in the iron and steel industry

The iron and steel industry emits 2.3 Gt of CO₂ per year, which amounts to 7% of total global carbon emissions.¹ To meet global climate and energy goals, the IEA estimates that these emissions must be cut by 50% by 2050.¹ This will require both decarbonization of the steel process – meaning removing coal/fossil fuels from the energy supply – and improving energy efficiency.



Decarbonizing the iron and steel industry

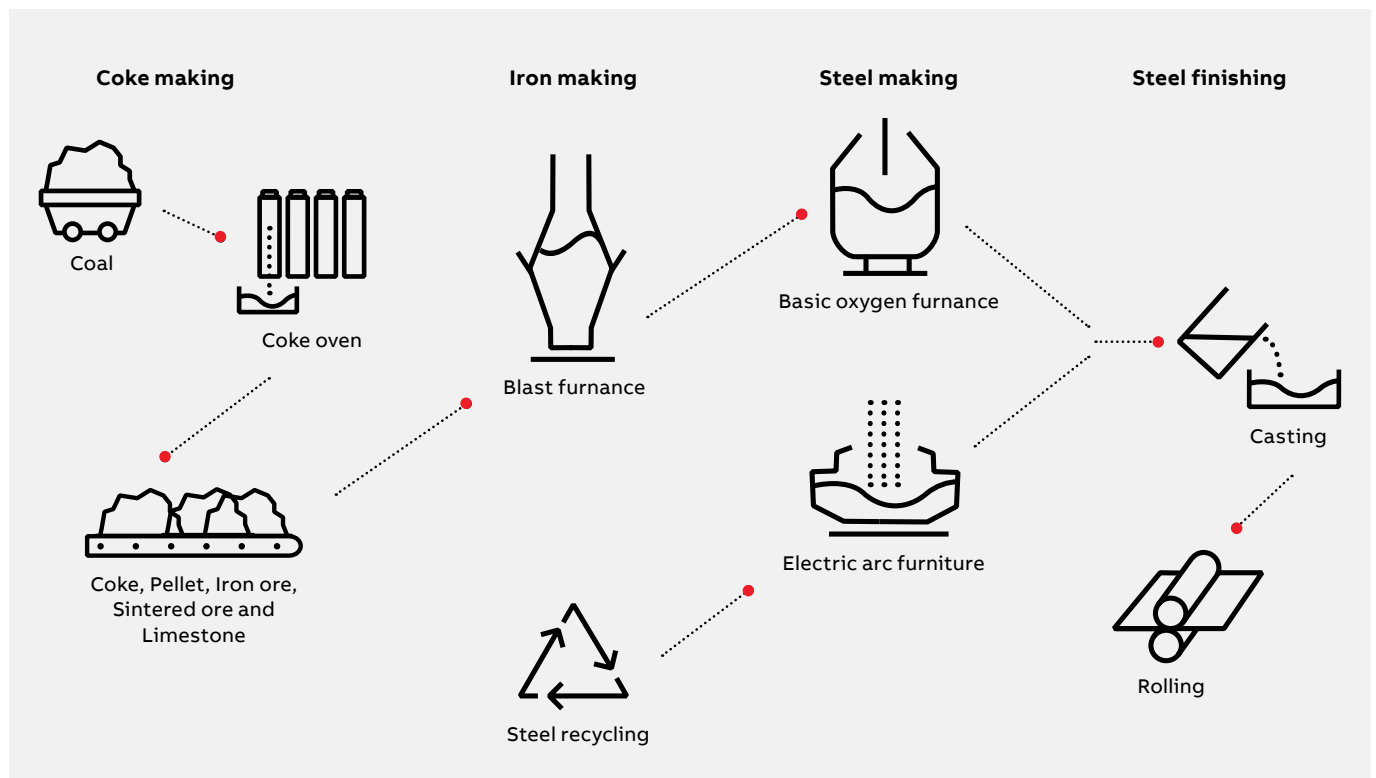


The largest industrial consumer of coal

On average, producing 1 ton of steel using traditional technology releases 1.85 tons of CO₂ emissions.² The majority of these emissions come from the two main steps in the process. First, the conversion of iron ore into iron using blast furnaces and second, turning iron into steel using basic oxygen furnaces. Even today, coal is used in iron and steel making to generate heat and to make coke. As a result, the steel industry uses coal to meet 75% of its energy needs making it the largest industrial consumer of coal.³

70% of the steel produced in the world uses coal.⁴

Energy and coal use in iron and steel making processes.



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New processes are being developed which could completely decarbonize iron making.



In the steel making process, electric arc furnaces are a viable alternative to basic oxygen furnaces. Because these are electrically powered, they offer the potential to eliminate the use of fossil fuels and transition to renewable sources of electricity. Furthermore, new processes are being developed that use hydrogen to replace carbon and coke as reducing agents in production, which could completely decarbonize the iron making process.

However, it must be realized that both electric arc furnaces and producing hydrogen also require a significant amount of energy. For example, in 2019, 157 million tonnes of steel was produced in the EU. 60% of this – 94 million tonnes – could be produced using hydrogen methods.⁵ Since it takes about 50 to 55 kilowatt hours (kWh) to produce 1 kg of hydrogen, it has been calculated that making 94 million tonnes of steel using H_2 would require 296 TWh of electricity. This would account for 10% of the EU's total electricity consumption.^{5,6} Therefore, it's important that losses are minimized and efficiency is maximized at all stages of the iron and steel production process.

Technological steps towards decarbonization⁷

Improving the efficiency of blast furnaces and basic oxygen furnaces

- Optimizing the blast furnace mix
- Fuel injection technologies
- Using coke oven gas

Using biomass

- Sustainable biomass from sugar or eucalyptus
- To replace fossil-based fuels and reductants

Electric arc furnaces

- Using renewable electricity
- Using recycled scrap steel or direct reduced iron

Hydrogen

- To replace fossil fuels
- To power electric arc furnaces
- To act as fuel and reductant in direct reduced iron processes

Energy use in iron and steel making

A significant industry challenge

Iron and steel production is very energy intensive, with energy and raw materials accounting for 60-80% of the costs.⁸ Globally, the industry accounts for 8% of global final energy use and it is estimated that steel production has doubled in the past two decades, which has caused a subsequent doubling of the industry's greenhouse gas emissions.⁹ Furthermore, it is predicted that by 2050, the demand for steel could increase by another 40%.¹⁰

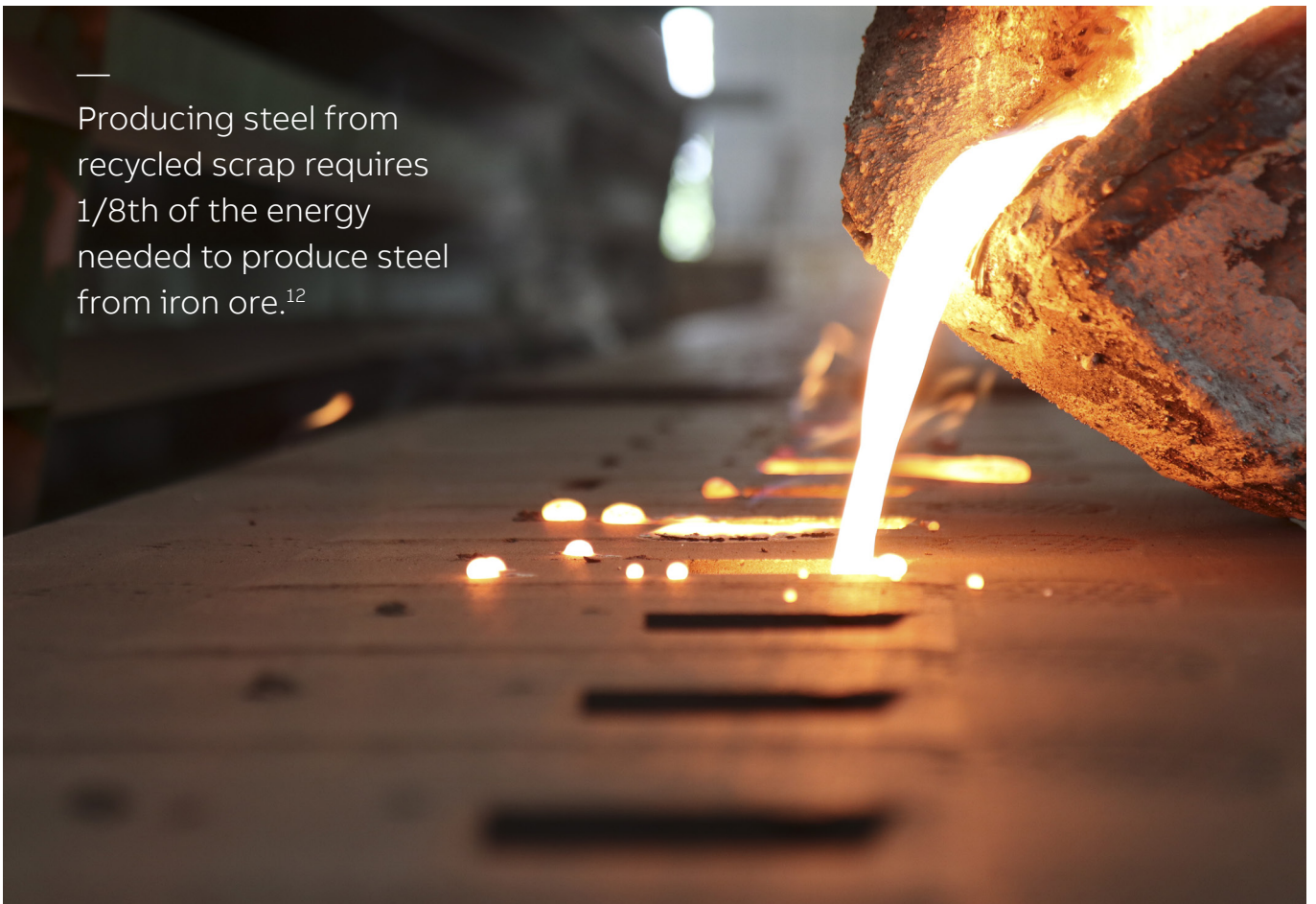
Due to the need to reduce energy consumption and emissions, and energy costs, there is a big push in the industry to find ways to improve energy efficiency. These include improving the energy efficiency of current processes, improving material efficiency and developing new steel making technologies. Hydrogen and renewable energy are also likely to play a big role in fossil-free technology.

Recycling to reduce energy use

The steel industry uses a high percentage of recycled raw material and most steel production uses recycled scrap steel. All the scrap steel that is collected globally is recycled, with a recycling rate of approximately 85%. In plants that use electric arc furnaces, up to 100% of the raw materials can be from recycled sources, while blast furnaces typically use up to 30%.¹¹

Compared to producing steel from iron ore, producing it from recycled steel saves significant amounts of energy because all the steps used to convert ore to iron, such as the blast furnace process, are avoided. As a result, producing steel from recycled material also generates significantly fewer CO₂ emissions than producing it from iron ore. It's estimated that every tonne of recycled steel scrap that is used to produce steel prevents 1.5 tonnes of CO₂ being emitted.¹¹ However, since the industry already has a relatively high recycling rate, further reductions in energy use and emissions will be hard to achieve via recycling alone.

Producing steel from recycled scrap requires 1/8th of the energy needed to produce steel from iron ore.¹²



Iron and steel production processes

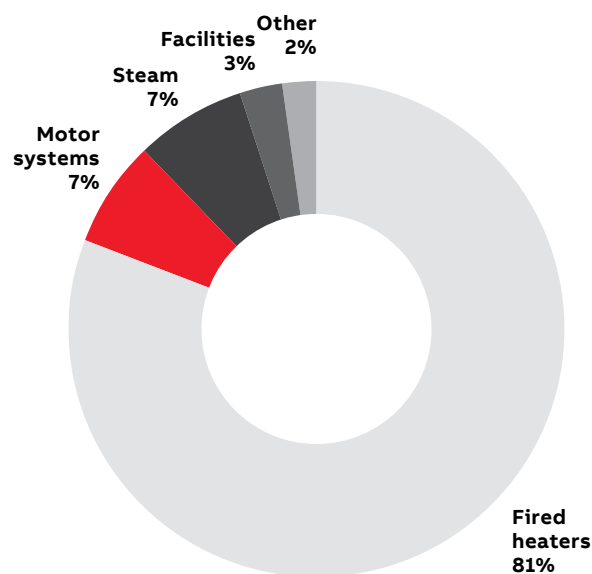
Energy intensive processes with significant losses

Fired heaters like blast furnaces and other furnaces use the majority of the energy involved in the iron and steel making process, consuming about 81% of the final energy. There can also be significant energy losses in an iron or steel plant, with up to 23% of the energy that enters the plant being lost to inefficiencies in equipment and distribution.¹³ While, motor systems account for a relatively small proportion of energy use, at around 7%, it has been estimated that up to 70% of the energy consumed by these motors is lost due to system inefficiencies.¹ This means that there are actually very good opportunities to reduce energy use in motor systems throughout the industry. These kinds of improvements are straightforward and quick to implement, and they typically have attractive pay-back periods.

Motor applications in iron and steel making

Motor systems are used throughout the whole process in applications including hot and cold rolling mills, blowers, fans, pumps, compressors, roller tables, conveyors and other materials handling systems such as overhead cranes. Within these applications, the losses can often use more energy than the actual work done by the motor. For example, a U.S. Department of Energy report found that in the iron and steel industry up to 70% of the energy input to motor systems can be lost due to system inefficiencies.¹⁴

Energy end-use in the steel industry¹³



Improving energy efficiency in iron and steel applications

Energy efficient motors

Motors are always required for applications like pumps, fans and compressors, and improving the energy efficiency of the motor system can have a big impact on the efficiency of the application overall. When looking for ways to improve the energy efficiency of a motor system, it is worth considering the efficiency of the system overall, life cycle costs, as well as the age and efficiency class of the motor.

Energy is by far the biggest cost associated with a running an electric motor system, and it accounts for over 90% of the costs over a motor's lifetime, while the purchase price only accounts for about 5% or less.¹⁵ Many facilities also operate motors well beyond their expected lifetime and in some markets up to 60% of industrial motors are over 10 years old.¹⁶ These older motors typically have greater losses and hence lower efficiency than newer motors, with an energy efficiency class of IE3 or even IE2.

As a result, investing in more modern, more energy efficient motors, is likely to be an effective way to reduce losses, energy consumption and cost over the course of a motor's life time. The potential energy savings of upgrading to a motor with a higher IE efficiency class are quite easy to estimate: five international classes are specified by the IEC, ranging from IE1 to IE5, with IE1 being the least efficient and IE5 the most efficient. Each class of efficiency equates to 20% lower motor losses. For example, IE4 motors have 20% lower losses than IE3 motors, and 40% lower losses than an IE2 motor.¹⁷

Overall motor system efficiency

While reducing motor losses is worthwhile, and reduces the motor's operating costs throughout its life, the energy this saves throughout the whole motor system is only one part of the picture.

We should consider that while VSDs help increase the efficiency of motors of any age, many of the systems in which they are employed are old and lag behind current IE standards. In these cases, particularly noticeable savings may be realised through upgrading the motor to a higher class.

Overall motor system efficiency – a comparison of reduction in energy consumption in a motor system



It is important to note that any upgrades must also take the efficiency of the motor system as a whole into account – efficiency gains in the motor may be squandered if the rest of the system is inefficient. Motor systems can be or can become inefficient for many reasons. For example, poorly maintained equipment is often responsible for significant drops in efficiency. For pumps, it has been estimated that regular maintenance can reduce energy consumption by between 2% and 7%. As another example, over-dimensioned equipment, such as motors, fans or pumps will also reduce energy efficiency. Correcting oversized pumps could reduce electricity consumption by 15% to 25%, estimates suggest.¹⁸



Variable speed drives

Using variable speed drives (VSDs) to control motors can significantly improve the energy efficiency of motor systems and the applications they run. In the iron and steel industry, the majority of fan and pump applications operate at partial load and use mechanical control methods like valves, brakes and throttles to regulate flow. With these methods, motors run at a higher speed than necessary and waste energy, losing it as friction and heat. Variable speed drives (VSDs) can be used to overcome this type of inefficiency. VSDs control the speed and torque of an electric motor directly, enabling direct regulation of the flow. This means that the work the motor does matches the actual demands of the application and no more. This results in higher efficiency at a range of different flow rates and it eliminates the need for mechanical flow control and the associated losses.

Because VSDs enable motors to run at lower speeds, they can generate significant savings. This is because in applications with a centrifugal pump or a fan, the power consumption of the motor is proportional to the cube of its speed, and there is also a quadratic relationship between the speed and torque. Therefore, using lower motor speeds and lower motor torque will result in a measurable reduction in energy consumption and cost. On average, adding a variable speed drive to a fan, pump or compressor can reduce energy use by about 25%, and in some cases companies have seen savings of up to 50%.^{19,1} With these kinds of savings, the investment can payback in as little as a year.



Pumps

Pumping systems are used throughout iron and steel production to pump a range of gasses and liquids including by-product gasses, process air and cooling water. These pumping systems lose efficiency over time if they are not maintained properly and older systems will also be less efficient than more modern ones. It has been estimated that the energy efficiency of these pumping systems could be improved by 5-10% by using improved equipment and by reducing friction through better maintenance. In addition, optimizing pump systems, for example, by using more efficient pumps, improving pump controls, proper pump and pipe sizing, and using VSDs could improve energy efficiency by a further 10-20%.¹⁸



Fans

Fan systems are used in a variety of applications in steel production, including ventilation, extraction systems and material handling. The efficiency of fan systems can be improved in several ways, including choosing the most efficient fan type for the application, proper fan sizing, better airflow design, and using VSDs. For example, it has been estimated that the energy saving potential in fan systems in the steel industry in the US is about 6%.²⁰

In practice, the energy savings will depend on the application, however the savings can be significant. For example, in a basic oxygen furnace where large fans are used to control air quality and to control gasses in batch-type processes, where flow demand varies greatly, adding VSDs has been shown to reduce power demand by 20%. And, when VSDs are added to an improved fan system, energy savings of 50% have been obtained.²¹



Compressors

Different types of compressor systems are used throughout iron and steel making, from the overall process pneumatics air supply, up to and including applications like air separation processes, which use very large compressor motors. According to some estimates, more than 85% of the electrical energy input into a compressor is lost as waste heat. However, there are good opportunities in most systems to improve energy efficiency. These include better maintenance to ensure optimum performance, minimizing leaks in pipes and equipment, using filters and cleaning systems to ensure good compressed air quality, right sizing compressors and pipes, better compressor control and using VSDs. Typically, adding a VSD to a rotary compressor system can reduce energy consumption by up to 15%. In addition, heat recovery units may be able to recover 50 to 90% of the available thermal energy from compressor systems for useful work.²² Since air separation, in particular, is a very energy intensive process, high efficiency motors and compressor systems should be used to minimize electricity consumption and costs.

Water treatment

The steel industry uses large quantities of water for processes like cooling, descaling and dust scrubbing. For example, an integrated steel plant has an average water intake of about 28.6 m³ per tonne of steel produced. However, after use around 90% of this water is cleaned, cooled and returned to the source. At each stage of the cycle, from extraction to use to cleaning and return, pumps are used to transport the water, and this pumping consumes a lot of energy. Therefore, an effective way to reduce energy use is to prevent unnecessary pumping. One way to do this is to reuse water this reduces the energy needed to extract and transport water. Another way is to ensure that the correct amount of water is provided. For example, in a hot strip mill, automatic flow control systems with integrated VSDs can be used to regulate water levels in the header tanks to prevent the cooling water from overflowing.²³

Rolling mill processes

In steel rolling mill processes, motor systems drive applications like the actual rolling mills, as well as cooling, lubrication and descaling pumps, furnace combustion and fume extraction fans, run out tables and other material handling equipment. Due to the high loads and temperatures that these applications handle, they are very energy intensive. As a result, motor systems account for about 40-45% of the total primary energy consumption of a steel rolling mill. Since rolling mill applications involve quickly changing loads, wide torque ranges and high accuracy, modernizing the motor systems with VSDs and more efficient motors can reduce energy consumption and maintenance, as well as improving production quality.²⁴

Air separation with ABB products

Air separation is the dividing of atmospheric air into its constituent gases, typically nitrogen and oxygen. The process is required in steelmaking during the oxygen converter process. Oxygen is blown through molten pig iron to create low-carbon steel. In order to obtain the oxygen needed for this process, large synchronous motors drive air separation compressors. High-purity gases can be obtained, but the method is highly energy-intensive, requiring large motors. ABB has produced and delivered a 44 megawatt 6-pole synchronous motor that has achieved a world record in energy efficiency. The motor has an efficiency 0.25% greater than contractually required by the customer, an air separation plant. This type of motor typically has an average efficiency of between 98.2 and 98.8%. The energy efficiency improvement realised by ABB could result in saving 100 MWh of energy a year – equivalent to the annual energy consumption of 240 European households.²⁵

CUSTOMER CASE



Futureproofing rolling mill efficiency

Kanthal® – a world-leading brand in sustainable heating technology and resistance materials – chose ABB solutions for their new drive system at their Hallstahammar blooming mill. The decades-old DC motor and drive system was removed and replaced with a modern AC design. The system provides numerous benefits including enhanced reliability, improved performance, and an increase in total efficiency of around 3.5%.

CUSTOMER CASE



Optimizing processes in the long term

When steel producer SSAB needed to upgrade their hot strip mill in Borlänge, they formed a long-term partnership with ABB. A three-phase installation and commissioning program between 2021 and 2023 – tied to planned maintenance shutdowns – will modernize the old roller table motors and drives with new, optimized multidrives and AC motors, integrated into a distribution control system. These motors and drives will result in improved continuous operation with reduced energy consumption, maintenance, and spare part requirements.

Conclusion

While iron and steel making will continue to require significant amounts of energy, as discussed, there are clear opportunities in the industry to improve energy efficiency and reduce the use of fossil fuels. Production processes can be decarbonized using electric arc furnaces and with hydrogen-based technology. And, by modernizing applications which rely on motor systems to reduce inefficiencies, measurable savings in energy use and energy costs can be achieved. Thanks to savings like these, investments in technologies like VSD-motor systems can quickly pay back, while also helping companies to meet global climate and energy goals.



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