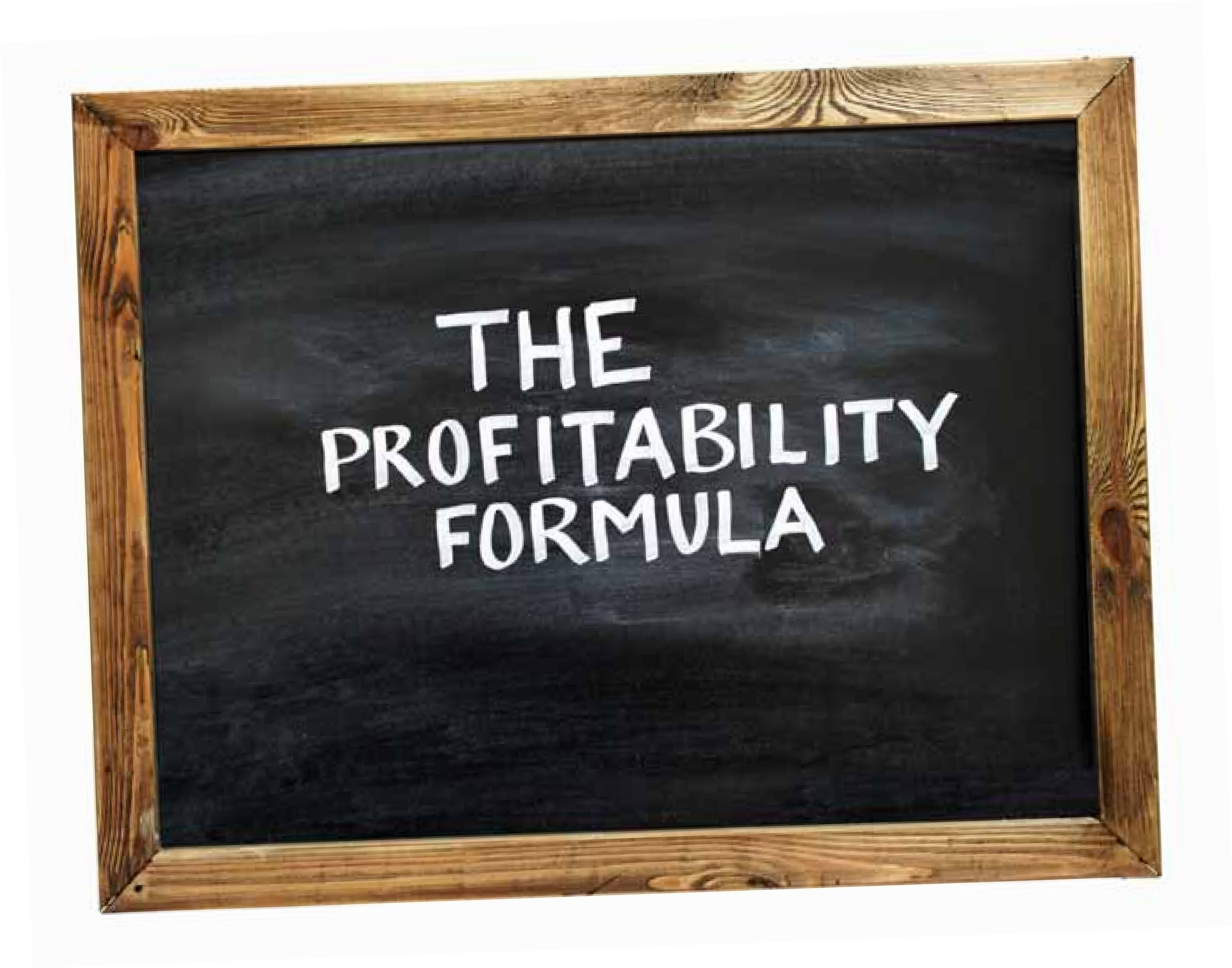


Four steps to higher efficiency

The profitability formula

The great formulas in science have opened doors to new ways of thinking, resulting in rapid development and new technologies. The introduction of welded plate heat exchangers represents a similar paradigm shift for the refinery business. As a new, much more efficient technology enters the scene it challenges the old truth that heat exchangers mean shell-and-tubes.

The easy solution to a tough equation

The refinery business is under constant pressure to increase efficiency. A highly competitive market in combination with rising energy and feedstock costs require refineries to increase production while decreasing operating costs.

Alfa Laval offers a well-proven and straightforward solution to this seemingly impossible equation. The key is to use compact heat exchangers instead of shell-and-tubes. This brings major savings in operating and capital costs, and often makes it possible to ramp up production.

Using compact heat exchangers offers benefits in four areas. When adding these up, the secret to staying ahead of the competition becomes obvious.

We call this the profitability formula.

Energy savings

-54%

According to Energetics Incorporated the U.S. refinery industry could cut energy use by up to 54% by implementing more energy efficient technologies.

10 MW

Saving 10 MW (34 MMBtu/h) of heat equals annual fuel savings of €3,000,000 and 17,500 tons in reduced CO_2 emissions.

Up to 50% of a refinery's operating budget is tied up in energy costs. Energy efficiency is a top priority, and one way to increase it is by recovering and reusing energy. This is done in all refineries to some extent, but most still use outdated shell-and-tube heat exchangers with low thermal efficiency.

Efficiency up to five times higher

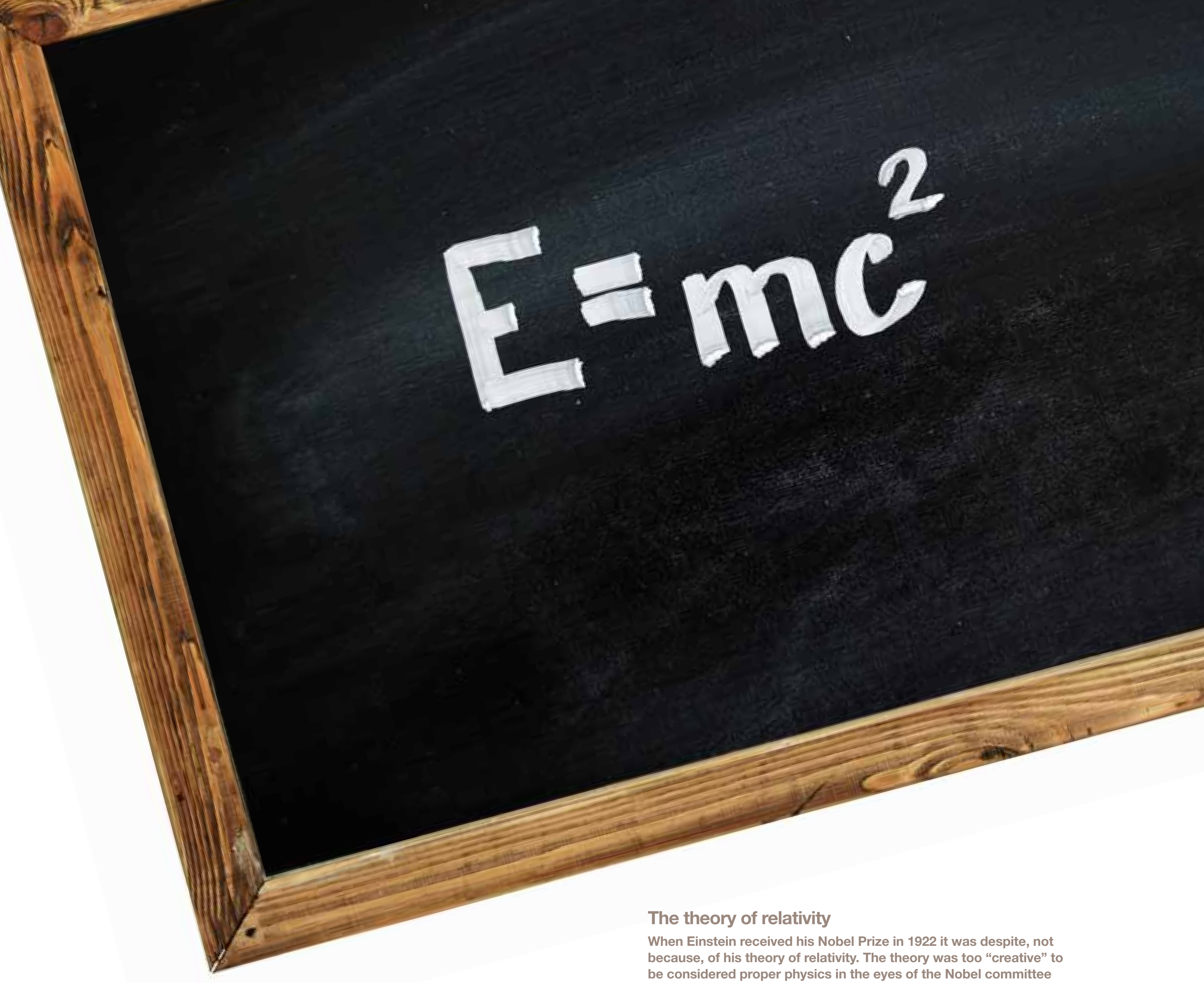
Heat recovery efficiency can be increased by up to 50% by simply switching from shell-and-tubes to welded plate heat exchangers. More energy is then put back to use, energy that would otherwise have gone to waste.

Investing in more efficient heat exchangers is very profitable for energy-intensive plants like refineries. The payback periods are short, often less than six months.

Cut fuel and emission costs

Considering that a normal refinery has about 2,500 heat exchangers, it is easy to see how fuel costs can be cut dramatically.

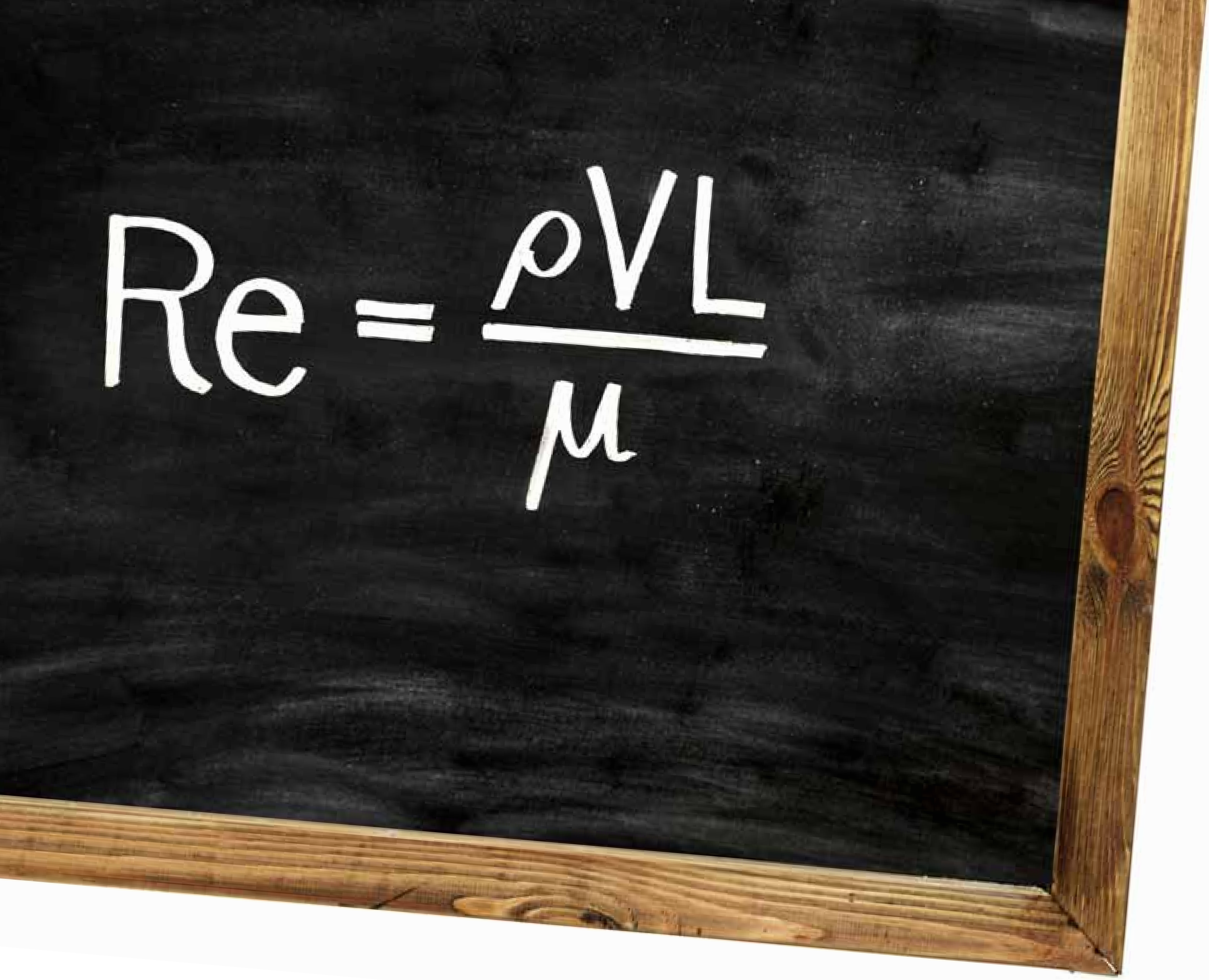
As an added bonus, reduced fuel consumption also leads to lower emissions of CO_2, NO_x and SO_x. If the plant operates under a cap-and-trade system this will cut operating costs even further. A 150,000 bpd refinery can easily cut CO_2 emissions by 50,000 tons per year when improving heat recovery in the crude pre-heat train. This translates to $1,000,000 savings in emission costs.



The theory of relativity

When Einstein received his Nobel Prize in 1922 it was despite, not because, of his theory of relativity. The theory was too “creative” to be considered proper physics in the eyes of the Nobel committee and after many years of controversy they awarded him for his work on the photoelectric effect instead.

But time proved Einstein right, and today one of the formulas in his theory has become a celebrity on its own. The formula states that matter can be transformed into energy, and one can calculate that 100 kg of matter (any kind) contains enough energy to operate all refineries in the US for a year (roughly 10^{19} J or 10^{16} Btu).



Reynolds number

The Reynolds number was introduced by George Stokes in 1851 as a means of describing the characteristics of a flow. A flow with high turbulence and lots of small eddies has a high Reynolds number and a smooth, laminar flow has a low Reynolds number.

The flow in an Alfa Laval heat exchanger is highly turbulent and has a high Reynolds number. High turbulence is one of the secrets behind the superior performance and compact size of Alfa Laval's welded plate heat exchangers. Turbulence makes heat transfer much more efficient than in a shell-and-tube, causing more heat to be transferred per surface area.

Less maintenance

One of the key features of a compact heat exchanger is highly turbulent flow. Apart from improving heat transfer, it also means the heat exchangers clean themselves from fouling and clogging residues. The self-cleaning effect is especially large in spiral heat exchangers. The single-channel design causes fouling deposits to be flushed away wherever they start to build up. This means spiral heat exchangers are the perfect choice for heavy-fouling duties, e.g. when cooling fluid catalytic cracking (FCC) bottom products or visbroken residues.

Less downtime and lower cleaning costs

The downtime for maintenance is minimal for spiral heat exchangers. The self-cleaning effect leads to longer service intervals, and the easy-access design makes cleaning quick. Alfa Laval's spiral heat exchangers are cleaned in place using chemical or high-pressure cleaning. The whole process from start to finish is typically carried out in less than two days.

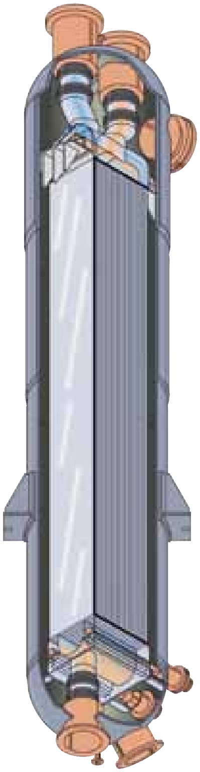
Energy savings

Fouling also leads to higher energy consumption. Heat transfer efficiency drops as fouling builds up, meaning the boiler or burner has to provide more heat. Pumping the fluid through a fouled heat exchanger also requires more power. Reduced fouling will have a positive effect on energy bills, uptime and cleaning costs.

€1,650,000

By exchanging their 12 existing shell-and-tubes for 8 Alfa Laval spiral heat exchangers, a Russian oil refinery saved €1,650,000 per year in cleaning costs. The payback period was one year.

Increased production



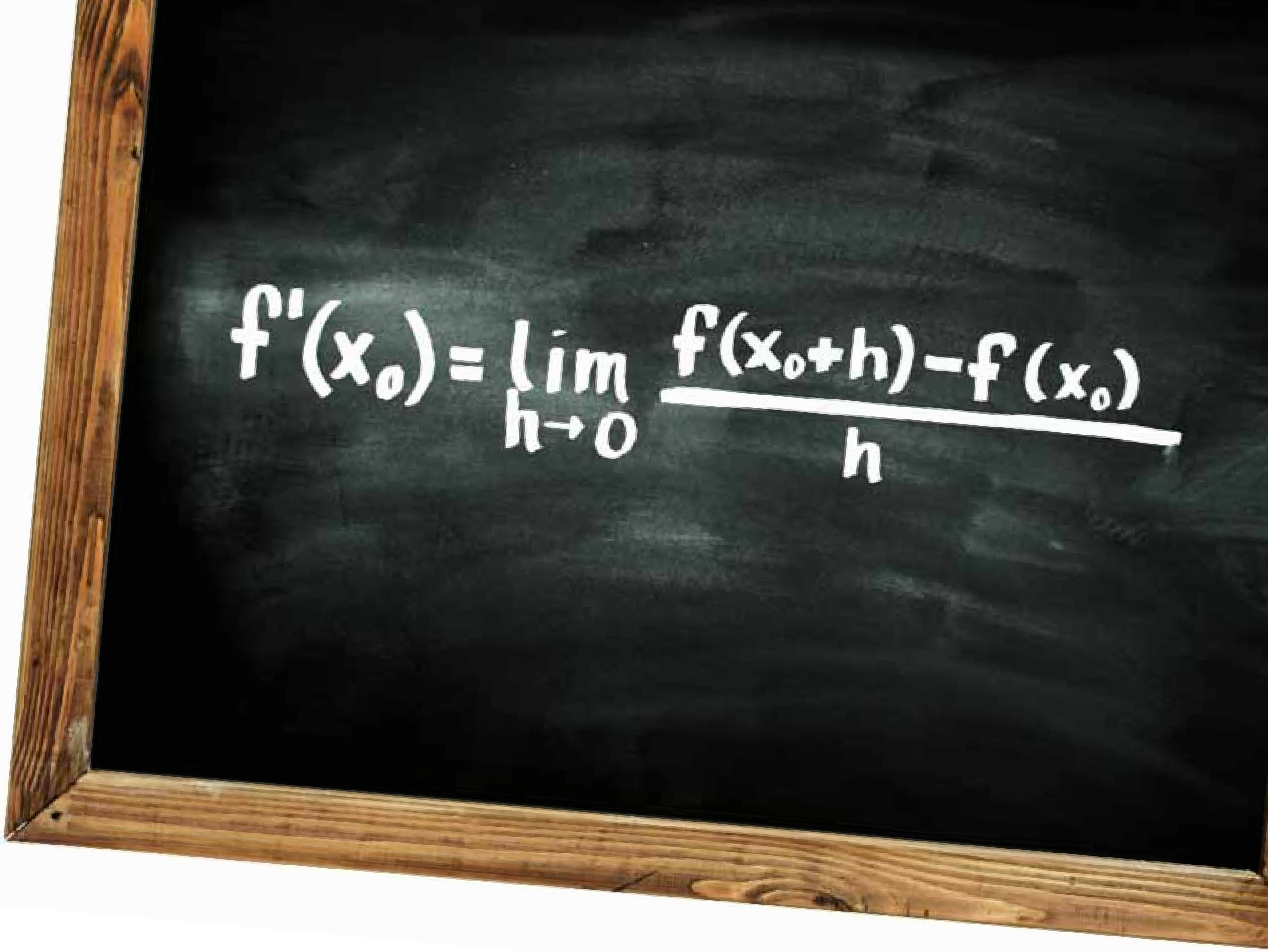
+50%

A refinery in the Middle East increased production capacity of its catalytic reforming process by 50% when replacing 12 existing shell-and-tubes with one Packinox heat exchanger.

Debottlenecking
Many refineries have bottlenecks related to heating or cooling. Investing in more efficient heat exchangers is often the best way to resolve these limitations. The higher the efficiency of the heat exchanger, the more heat can flow through it, resulting in higher production capacity.

Maximum performance
Compact heat exchangers offer significantly higher capacity per square meter floor space than shell-and-tubes. As restrictions in space and building structures often apply, switching to compact heat exchangers is a straightforward way to boost production without having to rebuild the plant.

Less downtime
Compact heat exchangers require less downtime for maintenance than shell-and-tubes, since service intervals are longer and the cleaning process is faster.



Derivatives

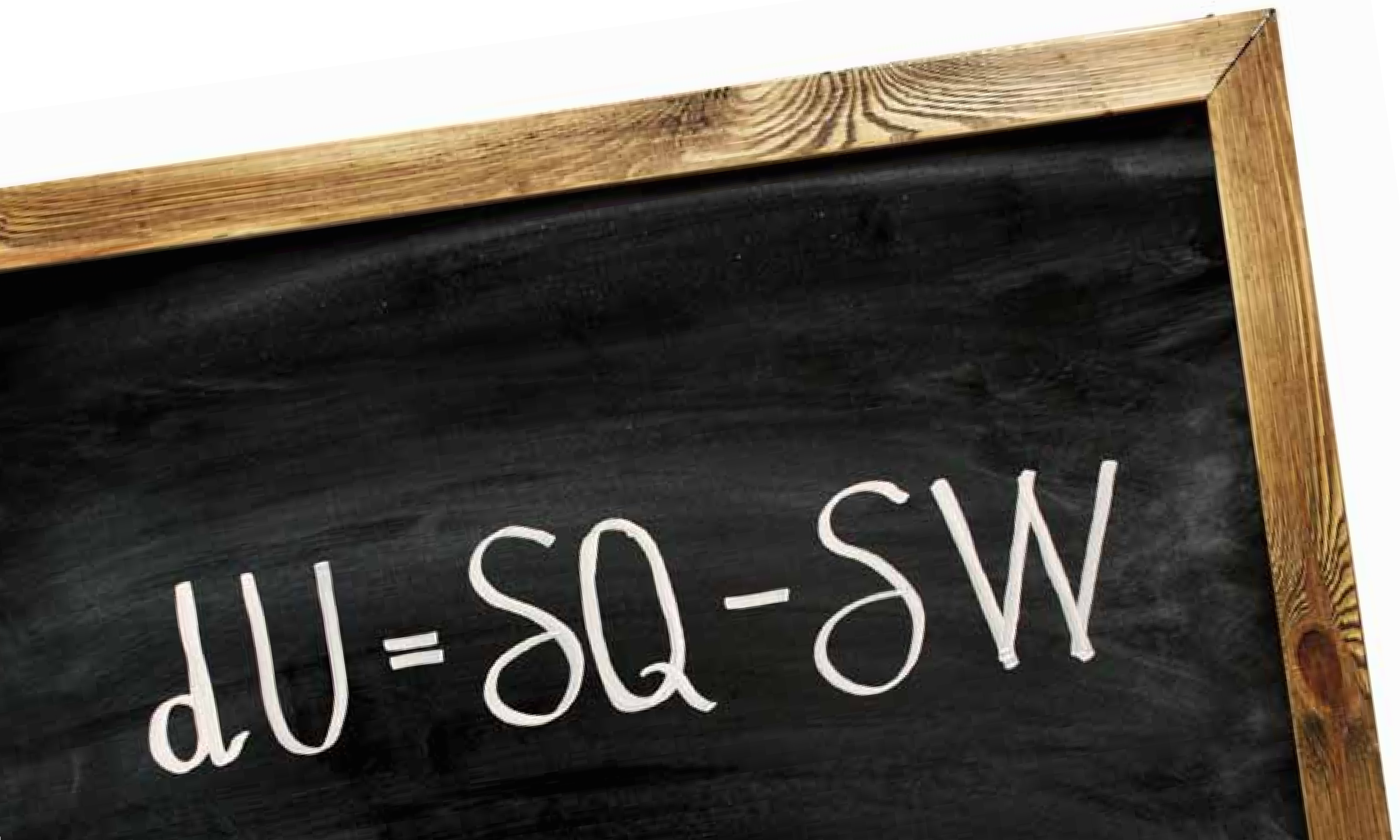
In mathematics a so-called derivative describes the rate of change in one quantity as a response to changes in another quantity, e.g. how the production rate of a visbreaking unit increases with higher thermal efficiency.

The first to use derivatives to compute rates of change was the Indian astronomer and mathematician Bhaskara II in the 11th century. Roughly 500 years later, Isaac Newton and Gottfried Leibniz developed the use of derivatives even further as they independently laid the foundations for the field in mathematics known as calculus. The derivative is an important part of calculus and is heavily used in science, engineering and economics.

The first law of thermodynamics

Thermodynamics deals with the use and conversion of heat. The laws of thermodynamics are a set of fundamental principles that govern much of the operation of all energy-intense plants. The first law of thermodynamics states that the amount of energy in a system such as a distillation column depends on how much heat and work are put in and taken out of the system. The more heat recovered and reused within the system, the less has to be added. Increased heat recovery also leads to less energy exiting the system, so the result is a reduced load on both heating and cooling systems.

Thermodynamics had a rapid development during the 19th century and was closely linked to the growth of industrialism and its need for better steam engines. Some of the front figures were Sadi Carnot, William Rankine, Rudolf Clausius, and Lord Kelvin.



Lower investment costs

Lower costs for the heat exchanger

The required heat transfer area is much smaller for a compact heat exchanger than for a corresponding shell-and-tube. This means much less material is needed to build the unit, which has a positive effect on price. Especially so when tough conditions call for exotic materials such as special alloys or titanium.

Lower installation costs

Installations costs can be cut considerably by using welded plate heat exchangers instead of shell-and-tubes when expanding plant capacity. The foundations can be made smaller and the heat exchangers are easier to fit into existing structures thanks to their compact nature.

Lower costs for utility systems

Before investing in new utility systems such as cooling towers and boilers, it is wise to see if the same result can be achieved by increasing heat recovery efficiency instead. Recovering more energy in the process often leads to reduced heating and cooling needs. Switching to compact heat exchangers means production can be increased while using the same utility systems.

-70%

An evaluation performed by one of Alfa Laval's customers showed that their equipment costs would be 70-80% lower if using Alfa Laval Compablocs instead of shell-and-tubes on an atmospheric distillation column.

Reliability

$3,000,000

A refinery in the US recovered an extra 7 MW by installing two Alfa Laval Compabloc heat exchangers in the crude pre-heat train in one of its refineries. Savings in fuel and emission costs totalled $3,000,000 and the payback period was four months.

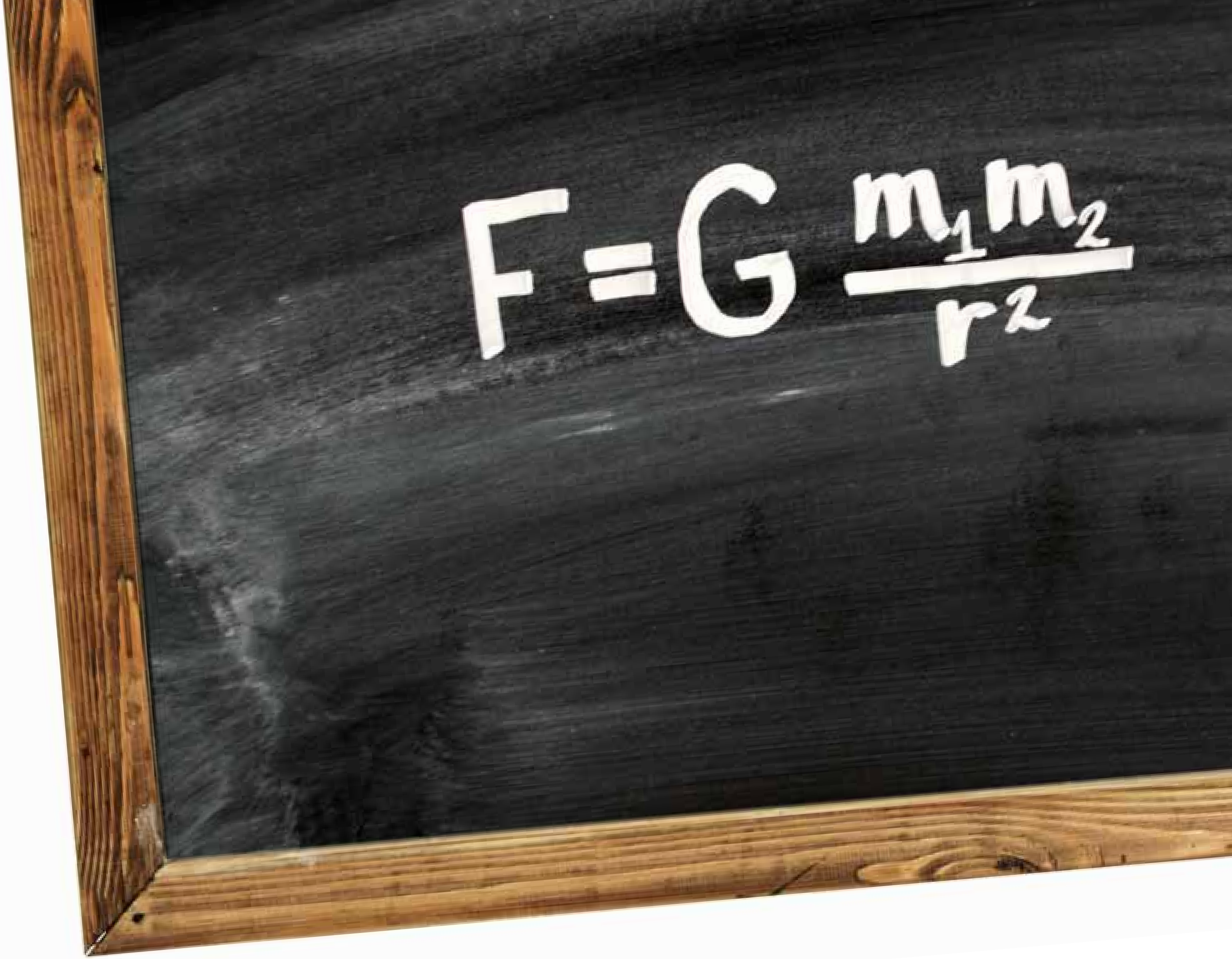
The best of both worlds

Compact heat exchangers combine the benefits of traditional plate heat exchangers with those of shell-and-tubes. Alfa Laval's compact heat exchangers bring you high efficiency, compact size, minimum maintenance, low pressure drops and the ability to operate at high pressures and temperatures.

The all-welded, robust design ensures trouble-free performance that does not change over time. Many of Alfa Laval's heat exchangers have been in operation for decades and are still delivering top results.

A long-term commitment

Alfa Laval has a long-term commitment to its customers. We offer service and maintenance programs that are tailored to each customer's specific needs. Most of our products can be regularly upgraded so they will not only keep their performance, but actually improve it over their lifespans.



Newton’s law of universal gravitation

In 1687, Isaac Newton published his famous gravitational law in “Philosophiae Naturalis Principia Mathematica”. For over 200 years the formula was one of the indisputable facts of physics and gravity was considered to be a force, just like any other mechanical force.

The next step to deeper knowledge didn’t come until Albert Einstein questioned Newton’s law and proposed that gravity should be seen as curving of space. As experimentalists caught up with Einstein’s thinking they proved him right when they showed that large stars actually bend the light passing by them since they cause a curve in space. All development comes from challenging established truths and industry standards, and constantly trying to improve. This is equally true if you are trying to develop a better theory of gravitation, or if you are trying to improve the profitability of your refinery.

A Packinox refinery installation

Shell

To improve overall performance in its semi-regenerative catalytic reforming process, the Shell refinery at Berre-l'Etang in France replaced 12 shell-and-tube feed/effluent heat exchangers with a single Packinox unit. This resulted in a 33% increase in capacity and reduced pressure drop from 4 to 1.5 bars. The improved heat recovery also led to substantial savings on energy and lower emissions for the fired heater.

Capacity increase:	**33%**
Energy savings:	**5.6 MW (19.1 MMBtu/h)**
Annual emission savings:	**€300,000**
Payback time:	**12 months**

Rosneft

In 2006, the Rosneft Tuapse refinery in Southern Russia decided to improve energy recovery in one of its three crude pre-heat trains. A total of three Compabloc heat exchangers were installed. The first replaced two shell-and-tube units, and the other two were installed to deal with new energy recovery duties. Among the energy-saving objectives achieved was an 8–10°C (14–18°F) increase in furnace inlet temperature of the crude. This resulted in both significant energy savings and reductions in emission from the heater.

Energy savings:	**1.3 MW (4.4 MMBtu/h)**
Annual emission savings:	**€100,000**
Payback time:	**24 months**

Total

Total experienced major problems with two shell-and-tube heat exchangers serving as bottom coolers in the fluid catalytic cracking (FCC) process at its refinery in Leuna, Germany. Each unit had to be taken out for cleaning and service after only 10 days of operation, meaning one of the units was constantly being serviced.

To eliminate this costly situation, Total decided to replace the units with two Alfa Laval spiral heat exchangers. These required no service at all over 8 years of non-stop operation, and are now included in the plant's standard 5-year maintenance programme.

Annual savings in cleaning:	**€180,000**
Payback time:	**24 months**

Tamoil

To improve heat recovery at its refinery at Collombey in Switzerland, Tamoil decided to recover energy from the atmospheric-distillation-tower overhead vapours. Installation at the top of the tower was no problem since Tamoil decided to use four compact and light weight Alfa Laval condensers to handle the task. Tamoil now recovers 16.5 MW (56.3 MMBtu/h) of energy and uses it to preheat both crude and boiler feed water. This has led to savings on fuel consumption and lower emissions from the fired heater.

Energy savings:	**16.5 MW (56.3 MMBtu/h)**
Annual emission savings:	**€1,000,000**
Payback time:	**7 months**

Alfa Laval in brief

Alfa Laval is a leading global provider of specialized products and engineering solutions.

Our equipment, systems and services are dedicated to helping customers to optimize the performance of their processes. Time and time again.

We help our customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuffs, starch and pharmaceuticals.

Our worldwide organization works closely with customers in almost 100 countries to help them stay ahead.

How to contact Alfa Laval

Contact details for all countries are continually updated on our web site. Please visit www.alfalaval.com to access the information.

www.alfalaval.com/refinery

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