Shell

Sparking the Spirit of Innovation

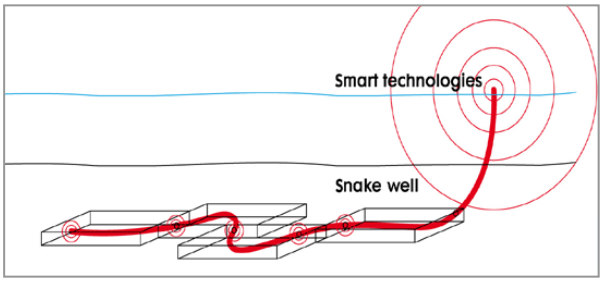
Technology to the Rescue

Energy demand is driven by lifestyle and by population. As the world's population grows and economies develop, demand for energy is expected to double by 2050. In spite of new developments in the wind, solar and nuclear energy sectors, fossil fuels will remain the primary source of energy for many years into the future. The problem is that oil and gas sources are often extremely hard to access. A key solution to this is technology – developing new and innovative methods of accessing vital energy resources. In this lesson, we look at some of the new, often ingenious breakthroughs that Shell has made to introduce new technologies into its operations worldwide.

The Snake Well

It is surprising to learn that, when an oil field reaches the end of its normal production life, up to two-thirds of the oil can still be left in the ground. This oil is too difficult to extract because it is located in various small pockets that cannot be accessed under normal operating conditions.

According to the International Energy Agency, the world's economies would benefit from an extra 300 billion barrels if access was made possible. The innovative snake well is one of the solutions which Shell engineers have come up with in order to improve access. Snake wells are so called because they can be drilled horizontally and 'snake' from one pocket of oil to another. Without the snake well, several individual wells would have to be drilled in order to access each pocket. The snake well significantly lowers the cost of drilling.



Smart Fields

In order to manage the production process effectively, data is required on a variety of measures including pressure, temperature and flow rate of the oil or gas. The advanced technology used to obtain this data is called Smart Fields®. It uses sensors with fibre-optic cables to relay digital information back to a control centre. Engineers at the control centre can then locate blockages and other problems. For example, they can electronically adjust valves in the pipelines in order to manage and control the flow of oil or gas. This technology can increase the amount of hyrdocarbons (oil and gas) recovered from a field by 5% to 10%.

The Toy Shop and the Swellable Seal

One day a Shell researcher visited a shop to buy a present for his children. There, he saw a toy dinosaur that grows to three times its original size when it is soaked in water. The idea dawned that perhaps this was the way to solve a common problem - how to stop the flow of water that occurs in oil wells. The standard way of constructing a well is to drill down vertically to the oil reservoir and then insert a steel pipe called a casing into the hole. The casing is pierced to allow the oil to flow into the pipe. Another steel pipe is inserted into the casing and the oil is pumped up through this pipe. The problem is that lots of water also flows into the pipe. In fact, at times the amount of water extracted with the oil can be as much as 90%. This water must then be separated out and this is a costly and time consuming process. The invention that came to the rescue in this case is the swellable seal. These seals are made of synthetic rubber elastomers. An elastomer is a type of polymer with elastic properties. These seals swell on contact with water and so stop it flowing into the well. In many wells, these seals have actually tripled the volume of oil being produced by reducing the amount of water that gets in by up to 70%.

Why Don't Fish Freeze?

Going deeper to produce oil and gas can be extremely expensive. The near freezing water temperature kilometres below the sea's surface causes oil to congeal and gas to form hydrates like ice crystals, causing the pipelines to become blocked. In addition, the pressure is extreme. For example, at a depth of around 2 kilometres below sea level the temperature might be about 1.5 °C and the pressure 20000 kPa, which is about 200 times the pressure at the surface. In searching for a new solution to this problem, Shell scientists asked the question 'why don't fish freeze?' The answer lies in a protein produced by the fish which protects them from the effects of extreme

cold. The scientists have now produced a new chemical based on this protein which is injected into the oil and gas as they are extracted and this solves the problem.

Seeing under the Surface

Oil and gas is often located in small pockets in porous rock spread out over a large area rather than in large deposits. These pockets can be very hard to find. New seismic technologies help explorers see below the surface of the earth to locate these sources. Small explosions are set off at the surface and the resulting sound waves reflect off the underground rock layers. The resulting data is analysed by computers which produce high-resolution three-dimensional images of the underground reservoirs. These images are transmitted to 12 virtual reality centres around the world where they are used by geologists and engineers to decide on the best locations to drill wells.

The 140 kilogram Football

It was an amazing sight. Three elephants called Murugan, Susela and Jumbo were kicking a football around their enclosure in Amsterdam zoo. This was no ordinary football. It weighed 140 kilograms and was made of C-Fix, a new material that had just been invented by a Shell researcher. In fact, the elephants were testing the durability of material. This material is now used as cement to bind together sand and gravel in order to make concrete. The name stands for carbon fixation because it released less carbon than conventional cement, thus reducing CO_2 emissions.

Floor Tiles from Plastic Bottles

The material used to make plastic bottles is called polyethylene terephthalate (PET).

A Shell scientist has developed a way to combine the waste plastic from such bottles with other materials without any chemical reaction taking place. This process produces a stone-like material called Echotect that is used for floor tiles and counter tops.

Non-Stop Innovation

Technology is often called applied science. Each day, all over the world, scientists, engineers and technologists at Shell are working together to apply scientific knowledge, creating and improving a never ending stream of useful products and processes.

Innovation is notoriously hard to nurture, especially in large companies, so it is crucial to create a culture that supports new ideas and allows them time and space to grow.

Shell spends some $1.2 billion a year on research and technology development. To develop novel ideas that would otherwise not see the light of day, a programme called GameChanger was established.

Anyone can submit an idea to GameChanger, including those with no connection to the company. In fact, some 70% of proposed projects include at least one individual from outside Shell. Many of the developments, such as the new materials covered in the lesson, are not actually part of Shell's core business of oil and gas exploration and production.

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Shell is a global group of energy companies. Our aim is to meet the energy needs of society, in ways that are economically, socially and environmentally viable, now and in the future.

We believe that oil and gas will be integral to the global energy needs for economic development for many decades to come.

Shell companies operate in more than 100 countries and territories and directly employ around 102,000 people.

Shell has been exploring for, and producing, oil and gas for more than a century. We use the most innovative technologies available. Today, we have interests in exploration and production in nearly 40 countries and territories. Shell is meeting the challenge of growing energy demand by discovering new hydrocarbon resources that can be produced economically, efficiently and safely. Shell is also involved in the development of renewable energy sources as an alternative to fossil fuels. These include solar energy and wind energy.

In Ireland, Shell is the lead operator in the Corrib Gas Project. The Corrib field is located 83km off the coast of County Mayo and is expected to supply up to 60% of the country's gas needs at peak production. For further information on the Corrib gas project visit www.corribgas.ie.

You can find this and other lessons on www.sta.ie.

You can find out more about the work of Shell on www.shell.com.

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Sparking the Spirit of Innovation
Teaching Notes

Syllabus References

The relevant syllabus references are:

Leaving Certificate Technology

- Manufacturing Process and Materials
- Resource Management
- Pictorial Representations
- Research

Leaving Certificate Physics

- Vibrations and Sound

Leaving Certificate Chemistry HL

- Option 2A.2 Addition Polymers

Junior Certificate Science

- Sound

Learning Outcomes

On completion of this lesson, students should be able to:

- Discuss the benefits that technology brings to society through the development of new processes and materials.
- Appreciate how the Snake Well technology has reduced the cost of drilling.
- Understand how sensors, fibre optics, digital and seismic technologies are used to gather exploration data.
- Describe how elastomers are used to control water ingress at drilling operations.
- Outline some of the problems of extracting oil and gas at deep water levels.

General Learning Points

The following points can be used to review the lesson content and to inform discussion.

- The term polymer includes a large range of natural and synthetic materials and does not just apply to plastic.
- The monomers which form the polymer are usually made of carbon, hydrogen, oxygen and/or silicon.
- An elastomer is a polymer with elastic properties with relatively low Young's modulus and high yield strain.
- Gas hydrates, are crystalline water-based solids that look like ice crystals.
- The standard atmospheric pressure is about100 kPa (1 bar). In sea water, the pressure increases by approximately 1 bar every 10 metres below sea level.
- The SI unit for pressure is the pascal (Pa), equal to one newton per square metre (N/m^2 or $kg \cdot m^{-1} \cdot s^{-2}$).

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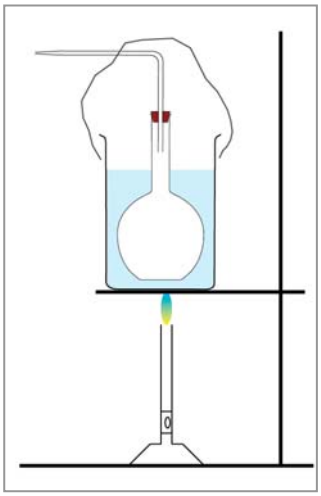
Student Exercises

Determination of the relative molecular mass of a volatile liquid

Requirements: A 1 L beaker, retort stand, gauze, support ring and Bunsen burner; a 500 mL boiling flask of known volume with a suitable single hole bung; clamp; a glass tube bent at a right angle and tapered at one end; some aluminium kitchen foil; thermometer, anti-bumping granules



The volatile liquid to be tested (e.g. volatile petroleum fraction, pentane, cyclopentane, acetone, hexane, cyclohexane, ethyl acetate, methanol etc.) and a 0 – 5 mL teat pipette should be available.

Procedure

Insert the tube into the bung. Caution: Do not force it; if it is too tight then select another bung or another tube. Then insert the bung in the top of the flask as shown. Weigh this assembly (m_1)

Remove the bung and add about 5 mL of the volatile liquid to the flask. Insert the bung again.

Set up the stand, support ring, gauze, beaker of water and Bunsen burner. Add about 450 mL of water and some anti-bumping granules.

Arrange the flask in the water and clamp it in place. Place some aluminium foil around the top; make holes in the foil for the tube and the thermometer to emerge.

Caution: ensure that the whole assembly is stable and not in a position in which it can be easily knocked over.

Boil the water. While it is boiling observe the tip of the tapered tube; if observed against the light you should be able to see an emerging stream of dense gas. Check the temperature; it should be 100 °C.

When there is no further sign of emerging gas turn off the heat.

Carefully remove the aluminium foil and the thermometer. Remove the flask but leave the bung and tube in place.

Cool the flask by immersing it in cold water. When it is cooled down to room temperature a few drops of the volatile liquid should be visible in the flask. Dry the outside of the flask thoroughly and weigh it again (m_2).

Remove the bung and measure the exact volume of the flask (V).

The relative molecular mass is the mass that would fill 22,400 mL at 0 °C and standard pressure, if it were still a gas.

The change in mass ($m_2 - m_1$) is the mass of vaporised liquid that filled the flask at 100°C. At standard temperature (0°C) this volume of gas would be $V \times 273 \div 373$.

The relative molecular mass is therefore
$= (m_2 - m_1) \times (22400) \div (V \times 273 \div 373)$

If you wish to take atmospheric pressure into account you can multiply your answer by Pa/Ps), where Pa is the current atmospheric pressure and Ps is standard pressure.

True/False Questions

a) Fish produce a special protein that prevents them from freezing.

b) Digital technology is never used at exploration sites.

c) An elastomer is a polymer.

d) The Snake Well allows several individual sources to be tapped from one vertical drilling site.

e) Shell does not carry out much scientific research.

f) Water does not present a problem when drilling for oil undersea.

g) Gas tends to form hydrates at deep water levels.

h) The pressure at 4,000 km below sea level is 100 times that at the surface.

i) Seismic technologies are used to locate objects under the sea.

j) Shell scientists have developed a material that can be used like cement.

Check your answers to these questions on www.sta.ie

Examination Questions

Leaving Certificate Chemistry (HL) 2010 Q. 11

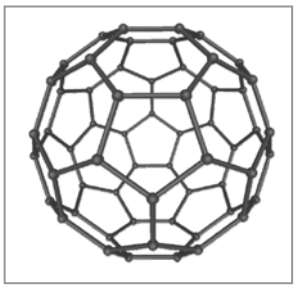
Diamond and graphite are macromolecular crystalline forms of carbon. Explain in terms of bonding

(i) the hardness of diamond,

(ii) why graphite is soft and can be used as a lubricant,

(iii) the electrical conductivity of graphite.

Buckminsterfullerene is another crystalline form of carbon that consists of football shaped clusters of 60 carbon atoms as shown. What type of bond joins the carbon atoms in these 'bucky balls'? The spatial arrangement of carbon atoms in each of these three structures was established by analysing the scattering of X-rays by the crystals. What was the surname of the father and son who pioneered this technique?



Oxygen is produced on an industrial scale by the liquefaction and fractional distillation of air.

(i) What substances are removed in the purification of the air feedstock before it is liquefied?

(ii) Describe with the aid of a labelled diagram how the fractional distillation of the pure liquid air is carried out.

(iii) Explain whether the fractional distillation of air is a continuous or a batch process.

(iv) Name and give one industrial use of a co-product of the fractional distillation of air.

Did You Know?

- Porous rocks hold deposits of oil like water in a sponge.
- Liquids are almost incompressible.
- The swellable elastomers mentioned in the lesson are called EZIP (Expandable Zonal Inflow Profilers).
- Polycarbonate (PC) is the most widely used thermoplastic because of its characteristics which include strength and being light weight. It is used in electronic devices, optics, mobile phones, space helmets, headlights and many other familiar products. Unfortunately, the production of PC requires phosgene ($COCl_2$) which is highly toxic. It was actually used as a poison gas in World War I. Shell scientists have developed a way of producing PC without using phosgene.
- Sunlight can reach depths of up to about 200 meters in water, so most of the ocean exists in total darkness. This layer that is in light is called the photic zone.
- The earliest oil wells were drilled in China in the 4th century. Apparently, the oil was used to evaporate sea water to produce salt.

Biographical Notes

Blaise Pascal (1623 – 1662)

Blaise Pascal was a French mathematician, physicist, inventor, writer and philosopher. He made important contributions to the understanding of fluids, of pressure and vacuum by developing the work of Torricelli.

Aad van Helden

Aad van Helden has a PhD in Physics and Colloid Chemistry and is a member of Shell's global strategic and innovation team. The idea to transform plastic drink bottles into floor tiles came to him over lunch one day. Recycling poor quality plastics and combining them with other substances to make a new building material is good news for the environment.

Revise the Terms

Can you recall the meaning of the following terms? Reviewing terminology is a powerful aid to recall and retention.

Casing, C-Fix, digital, Echotect, elastomer, fibre-optic, fossil fuels, GameChanger, high-resolution, hydrates, kPa, polyethylene terephthalate (PET), polymer, protein, seismic, sensors, Smart Fields®, snake well, sound waves, technology, virtual reality.

Check the Glossary of Terms for this lesson on www.sta.ie