

Introduction

The origins of Sheffield Forgemasters can be traced back to 1805. In that year, Edward Vickers, a traditional miller, made the largest steel ingot of its time. He manufactured (cast) steel bells, which were exported around the world. Over 200 years later, Sheffield Forgemasters International Ltd (SFIL) is the largest independently owned Forgemaster and one of the oldest steel businesses in the world. It is one of the biggest private sector employers in South Yorkshire.

With its headquarters in Sheffield, SFIL is the parent company of seven subsidiary companies. These provide steel forgings, castings and engineering solutions to customers around the world. The business operates in many sectors, including defence, nuclear, offshore oil and gas, power generation, marine and construction.

Despite a steady decline in steel manufacture in the UK over the past few decades, SFIL has continued to grow. It is now a world leader in heavy steel castings and steel forgings. Like any business, SFIL can be affected by various factors in the external environment in which it operates. These factors are often grouped under six headings: political, economic, social, technological, environmental and legal (PESTEL). Companies need to understand these factors to make sure they develop strategies to remain competitive. They need to find ways to manage and influence the external environment effectively. This case study shows how SFIL uses research and development (R&D) to sustain its competitive advantage. As Dr Graham Honeyman, chief executive of SFIL, has noted:

‘Research and development is the fastest growing area of this company and is fundamental to the strategy of the business.’

R&D is the function within an organisation that carries out technical and/or scientific research in the development of new or existing products, processes or services. SFIL has invested heavily in all areas of the business in implementing new processes and technology. It has established a new subsidiary, RD26 Ltd, that focuses solely on R&D. RD26 Ltd provides services to both SFIL’s internal and external customers. It does this by developing unique engineering solutions to meet customer needs. This case study features two of these solutions: a new way of manufacturing large components for the nuclear energy industry and an innovative method of repairing a damaged subsea oil platform in the middle of the North Sea.



The purpose of innovation, research and development



In an engineering business, innovation is a core activity. It is important for its survival and can help the business remain competitive in changing markets. Innovation can take many forms. It does not simply cover new product development. Innovation can be applied to product renewal or the design of new processing technologies. It is important to understand the difference between invention and innovation. Invention involves creating something new, but it only becomes an innovation if it is a practical and marketable application.

SFIL has to meet the challenges of competition from low-cost manufacturers and suppliers. It does this by continually developing new ideas – ideas that can be developed into new products, materials and process improvements. Companies can adopt different approaches to new product development:

- a product oriented approach – a product is developed and then a market is identified for it
- a market oriented approach – a product is developed in response to an identified customer need.

A product can also be developed in response to a competitor's product. An existing product may be enhanced through research into how to make the product better. Research can also lead to technological developments that improve the manufacture of the product or the way it is delivered to the customer.

R&D activity

R&D is very costly. However, it is an important investment. Money spent on R&D can secure the future of an organisation. SFIL spends between 5% and 10% of its annual profits on R&D across the company, compared to a national average of 3%, and has substantial R&D capabilities. RD26 Ltd can support projects related to the manufacture of carbon, low alloy and stainless steel grades for almost all heavy forging and casting applications. The majority of its R&D activity involves the optimisation of its manufacturing processes, material developments and the implementation of new manufacturing processes. One focus is on raising quality and reducing costs through improved methods of working. Another is on researching new materials and techniques in forging and heat treatment practices.

R&D can also be in response to a specific client or industry need. For example, in 2009 production had to be stopped at an oil platform in the North Sea. Cracks had appeared in the subsea structure joined to the oil storage tank underneath the platform. The damage occurred because the grouting material applied to fix the caisson (watertight structure) had failed. The operator of the platform came up with a temporary solution. However, SFIL was approached to help solve the problem. The company has particular expertise in high integrity steel castings for the offshore sector. The large repair casting that was created won the Cast Metals Federation (CMF) Cast Component of the Year Award 2012.

There are different challenges facing the nuclear industry. Nuclear power is increasingly seen as one solution to meet future energy demand. This will create opportunities for UK businesses with expertise in nuclear engineering and associated technologies. SFIL has identified the nuclear power sector as a key market opportunity. As such, it is placing R&D effort in this area. This is looking at innovative ways to manufacture the large components required in civil nuclear reactors.



Research



Research is a detailed study of a subject. It can lead to new ideas, new information and new understanding that can be used to solve a problem. One part of RD26 Ltd is RD Testing, a commercial facility that provides mechanical and metallographic testing and analysis services. Specialising in the testing and analysis of steels, its customers include steel foundries, forges, rolling mills and steel stockholders. Its research activities cover all aspects of the manufacturing process. It has made significant developments through research into metallurgy.

In looking for a solution to the problem on the oil platform, the client proposed a new structure, sited 2,000 metres below the platform. RD26 Ltd used its expertise to support the casting design to meet the strict requirements. This included researching the material properties and dimensional accuracy needed to withstand severe operating conditions.

Research team



The research team monitored the expansions and contractions of the metal, through cooling after casting and through heat treatment, to test for strength and fatigue resistance. The team used computer simulations to help achieve the extremely high quality standards required. These simulations modelled the extreme loadings likely to occur in operational conditions. Researchers can also build models to replicate a system. These can be physical models or computer-based representations. RD26 Ltd uses 3D solid

modelling to design parts, assemblies, tooling and processes for casting and forging activities. In seeking ways to improve the manufacture of nuclear reactor components, extensive research was conducted by RD26 Ltd using modelling techniques. These were key in developing the optimum chemical composition and methods design for the foundry castings. Laboratory trials were conducted to determine the correct tempering process. This is the process of heating metal to a high temperature below the melting point, then cooling it, usually in air, to obtain the necessary balance of mechanical properties. On a larger, plant-based scale, trials were undertaken to investigate material flow, heat transfer and the frictional conditions. Researchers used a scanning electron microscope to investigate microstructure property relationships. These trials are expensive. However, the size of the reactor components means that there is no room for error once the process is used in commercial production. Engineers need to get the product 'right first time'.

Development

Development involves turning ideas generated from research into a commercial product or process. The research stage might generate numerous ideas and a business then needs to select the appropriate ones to develop commercially. RD26 Ltd has a track record of turning ideas into commercial solutions, products and processes.

'We have created new processes for manufacture in civil nuclear, such as the integral forging of nozzles into ultra-large components, the delivery of highly complex castings for offshore oil and gas exploration and we are now working with some of the world's most renowned engineering companies [on] collaborative research and development work.'



Advances in materials and processes

Recent developments at SFIL have led to advances in materials and processes. Material advances have allowed the company to develop products with higher strengths and toughness using specific grades of steel. This requires close control during the steelmaking process to produce ingots with the required quality. A major process development has enabled the company to forge large complex components for the nuclear industry. One component incorporates a support ring and integral forged nozzles. This combination of features has not been achieved by any other nuclear engineering company. Such new shape forgings create not only greater manufacturing efficiencies but also delivers a component that has higher integrity than one that has been machined and welded to create the same shape. To produce this component, new forging procedures were developed using specially designed tools. Everything was designed and fabricated in-house. This included designing the computer-controlled apparatus for localised heating of the component.

SFIL also created one of the largest tubesheets ever produced by designing a special rotating forging tool and a six-metre diameter forging platform. This component, a perforated steel sheet with holes to accept pipes or tubes for use in civil nuclear power generation, had to meet exacting international nuclear standards at the first attempt. To support this work, RD26 Ltd has developed strong partnerships with UK universities, who contribute to the R&D process.



Challenges and benefits of R&D



R&D is not without its challenges. These include the risks associated with the costs, the timescales and technical issues in each project. For the oil platform project, SFIL faced several technical challenges. Its R&D team needed to understand the dimensional changes that would occur in a casting of extreme size and shape. Heat treatment also presented challenges. The structure was the largest item ever quenched (the process for cooling a metal casting) in the foundry, and the quench tank had to be modified and re-engineered to accommodate the piece. The product had to be delivered on time, because the structure could only be installed during favourable weather conditions.

Other challenges include maintaining health and safety, looking after the wellbeing of employees and sustaining the environment. These are factors that apply across SFIL, and not just in its R&D facilities. SFIL is committed to reducing the environmental impact of its operation. Manufacturing operations are tightly managed to comply with environmental legislation. Emissions, energy consumption and waste processes are monitored continually. The company has also invested over £3 million in modern burner technology to reduce its natural gas usage.

However, expenditure on R&D can bring significant benefits. It has created a distinct competitive advantage for SFIL. Being the first in the world to produce large-scale cast and forged nuclear components helps to distinguish SFIL from its competitors. The investment in R&D also enables SFIL to focus on major projects across the business and to form partnerships with high-profile companies in the delivery of its solutions and products.

'The research and development facility enables us to be much more flexible in defining the characteristics of each component and tailoring the manufacture process to suit. The resources here are enabling us to take on increasingly technical challenges and to look at entirely new ways of creating components, which allows for greater manufacturing efficiency and stronger, lighter, more complicated end products.'

Conclusion

R&D is a core business activity particularly in the engineering and manufacturing sectors. It helps UK organisations compete globally, through the development of innovative manufacturing and technological products, processes and materials. It helps UK engineering companies expand and contributes to UK economic growth. R&D is embedded within SFIL's culture. It drives the innovation needed to meet the challenges of emerging technologies. Over 200 years after it was originally founded, it allows SFIL to remain at the forefront of the world's most technically driven markets, developing at the pace demanded by its clients and customers.

