

THE LEONARDO CENTRE'S INDUSTRIAL SAVINGS



Professor Rob Dwyer-Joyce, The Leonardo Centre for Tribology and Surface Technology, University of Sheffield.

Tribology is the study of friction, lubrication and wear and is at the heart of modern machines, everyday life, and saving energy. The Leonardo Centre for Tribology and Surface Technology collaborates with industry leaders across a range of sectors to make energy savings through the science of tribology. With dozens of partners, working with over 30 researchers, the Leonardo Centre's mission is at the core of the Department of Business Innovation and Skill's knowledge transfer initiative, "ensuring good research becomes good business". Recent projects have included optimising airplane engine manufacture with Rolls-Royce and working with Tecvac and NMB-Minebea to produce lightweight yet durable landing gear – which resulted in Airbus placing a £19m order.

But what is tribology? Why is it important? And what does any of it have to do with Leonardo da Vinci?

TRIBOLOGY

In the early 1960s, after a steep increase in reported failures of machinery due to friction and wear, a conference on Iron and Steel Works

Lubrication was set up. This led in 1966 to a report which estimated potential savings of £515 million per annum (in 1966 terms) for industry if existing tribological principles and practices were better applied. The report also suggested that as the United Kingdom's livelihood was tied to the success of its industrial efficiency, it could not

afford to overlook the economic and commercial advantages to be gained by the study of tribology. In order to link education and research with industrial efficiency, it recommended the establishment of Centres or Institutes of Tribology.

After considering the report, the then Minister of Technology



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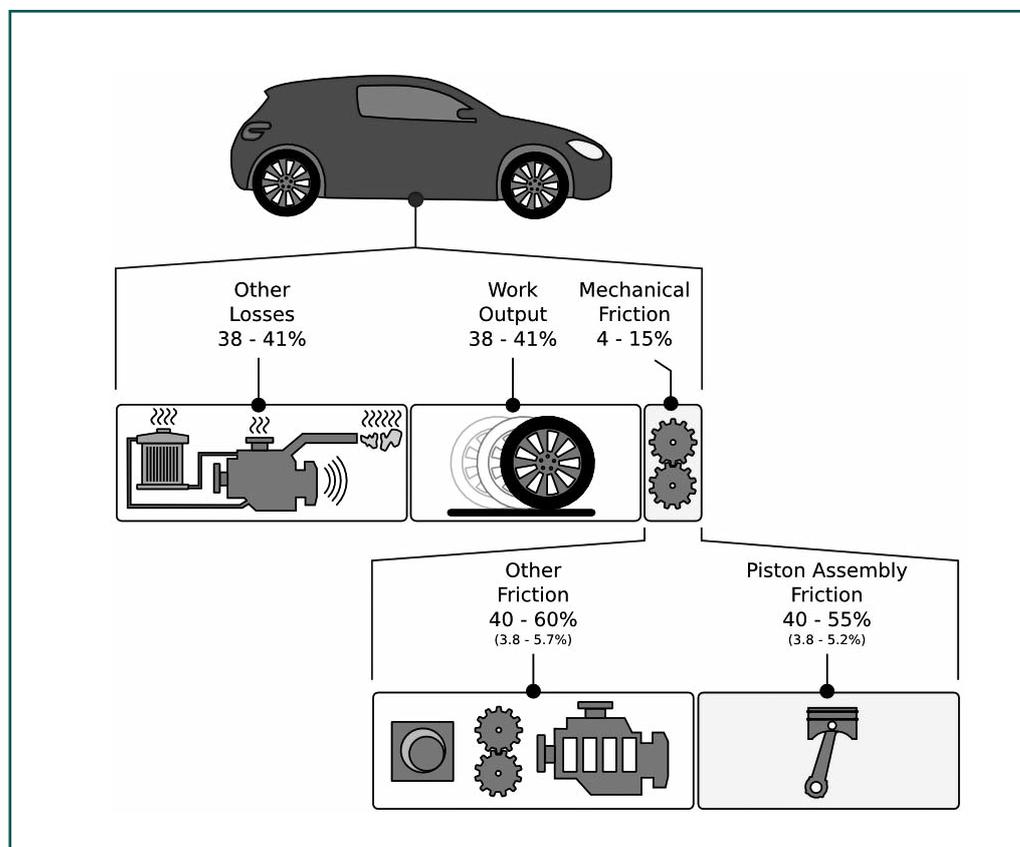


Figure 1. Depending on the vehicle and the operating conditions somewhere between 4 and 15% of the energy from the fuel is lost in overcoming friction in engine and transmission. The piston rings alone account for 3.6p in every litre of fuel. Understanding, predicting, and reducing the lost energy is at the heart of Tribology.

announced to the House of Commons, in September 1966, the establishment of the Committee on Tribology to advise on the implementation of the report.

From its beginnings in UK Government, tribology has attained global significance, tribology centres being established from Nigeria to the Netherlands and a total of 36 countries are currently represented in the International Tribology Council.

The savings predicted by the Iron and Steel Work Committee are no less pertinent today. The report of a two year investigation in China estimated the savings obtainable by the application of tribological principles to be equivalent to 1.5% GNP, this for an average R&D expenditure of US\$200,000 for US\$1 million savings. Professor H Peter Jost, President of the International Tribology Council, has said, *"adjusted for UK conditions, it could be estimated that savings through tribology in the UK can be in the region of £8-£10 billion for an applied R&D expenditure of approximately £60-£100 thousand."*

With Chancellor George Osborne's recent incentives to encourage business in the UK, including the lifting of tax relief on the enterprise schemes from 20 to 30% and that on research and development activities from 140 to 200%, the extra savings provided through tribology could allow businesses to flourish, Sheffield's Leonardo Centre having an important role to play.

LEONARDO DA VINCI

It may seem surprising that a tribology research centre should be named after a person who to the public is generally known for his paintings; however, he was a genius in Engineering Design. The fundamental principles of tribology – friction and wear – are innately connected to the

process of rubbing surfaces. It was Leonardo da Vinci who conducted some of the first experiments in this field.

Leonardo kept illustrated note books in which he detailed his experiments. Sketches showing blocks being pulled along surfaces appear in the Codex Atlanticus, while in the Codex Forster he expressed for the first time the laws of friction, *"the friction made by the same weight will be of equal resistance at the beginning of its movement, although the contact may be of different breadths and heights"*.

Leonardo also investigated methods to reduce friction. One particular experiment, described in the Codex Madrid, illustrates perfectly the link between this pioneering work and its continuation at the Leonardo Centre for Tribology and Surface Technology at the University of Sheffield.

Instead of the sliding motion that had typically been used, Leonardo designed many bearings which used a rolling action. Of these he wrote:

"Their movement will be facilitated by interposing between them balls and rollers. But if the balls or rollers touch each other in their motion, they will make movement more difficult than if there were not contact between them, because their touching is by contrary motions and this friction causes contrariwise movements."

While Leonardo discovered how to make ball bearings operate, the Centre's work is being used to make them more efficient. A recent project, directed by Professor Allan Mathews and Dr Adrian Leyland, discovered a surface coating which could increase a bearing's life span by 84.1%. Considering it can cost up to £400,000 to replace the bearing in one off-shore wind turbine, there is a



Figure 2. Leonardo's designs for a rolling bearing from the Codex Madrid 1490. Leonardo understood the importance of reducing friction, including a spacer to separate the balls and how lubricants could be used. A modern bearing, in 2011, retains many of these features.

real economic imperative of building on the work of this 15th Century pioneer to meet this century's needs.

THE LEONARDO CENTRE, SHEFFIELD

Located in the former steel producing heartland, the Leonardo Centre is building on a rich heritage to provide cutting edge solutions for manufacturing and innovation. It is ideally placed to help businesses, taking advantage of Sheffield's newly announced enterprise zone, one of 21 in England, achieve maximum efficiency in both their manufacturing processes and products.

While the knowledge and expertise is developed in the University, it is the Leonardo Centre's links with industry which drives its research. Current national and international projects work with wind, rail, automotive and aerospace industries, while a new toothbrush designed last year with Unilever took 20% of the European market on release.

Tribology is concerned with tiny distances, gaps, and tolerances. Millions of pounds can be saved by micrometre scale adjustment. The piston rings in a car engine operate with a micrometre size oil film and yet consume 3.6p out of every litre of fuel in friction

losses. Professor Rob Dwyer-Joyce, of the Leonardo Centre, has developed new sensors to tune piston ring performance and potentially halve these losses. Dr Matt Marshall recently worked on a project investigating abradable linings in aero-engines and how their efficiency directly corresponds to fuel consumption. It is estimated that saving 1% of fuel consumed could save the airline industry \$160m a year. Dr Marshall's project investigated how to make this adjustment safely in a mechanism that must operate at temperatures of up to 1800°C.

GROWTH

After the announcement of March's budget, there is a clear need to promote business and innovation in order to stimulate the economy. Research and development being undertaken at the Leonardo Centre is a key to this process by offering businesses the opportunity to make savings through the science of tribology – the study of friction, lubrication and wear. By using the Centre's expertise in these areas as well as its knowledge of surfaces and coatings, the Centre is able to help stimulate growth in a wide range of industries including automotive, aerospace and energy: a unique and productive legacy for the enquiring mind of Leonardo da Vinci.