WEAR CHECK
Condition Monitoring Specialists
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SLIDING THROUGH TIME:
Lubrication from stone age to modern age
Part 1 of 3

by Steven Lumley – technical manager, WearCheck

Lubrication from Stone Age to Modern Age

From stone age to modern age, pharaohs to phenols, the history of lubrication is a story that demonstrates how a seemingly simple substance - oil - has propelled human progress, shaped industries, and ushered in a world of smoother operations and optimised performance.

Now, while the field of tribology - which is the science of friction, wear and lubrication - has advanced significantly over the last 100 years, the roots of lubrication extend back further than one might imagine. Lubrication, in its simple form, has been in existence at least since the beginning of documented times.

Early humans recognised the importance of reducing friction, and intuitively understood that applying a lubricant between two surfaces would ease their movement. Before the Common Era, tallow (animal fat) and naturally occurring elements were used for lubrication for chariots and in transporting construction materials. In fact, one of the earliest examples of tribological practices can be found in the ancient Egyptians' use of lubricants to reduce friction in the movement of large stones during the building of the pyramids. Other ancient civilisations like the Greeks and Romans used olive oil and other plant-based oils as lubricants.

Fast forward past the dark ages, (trust me, nothing much happened with lubricant development then) and twelve centuries later, tribology as a scientific discipline begins to take shape during the Renaissance with our favourite Italian polymath - Leonardo da Vinci - whose observations about friction and lubrication laid the foundation for further exploration.

Before the dawn of the industrial revolution, whale oil was commonly used as a lubricant, but with the worldwide decline in whale populations and the widespread use of machines, other sources of lubricants had to be found.

The discovery of crude oil in Pennsylvania in 1859 set the stage for the new oil economy, and led to the development of petroleum-based lubricants, which quickly replaced animal- and vegetable-based lubricants due to their superior performance and availability.

Today, lubricants are highly developed, using complex chemical methods designed to push their potential to the absolute limit. There are specific oils formulated for specific purposes, and our machines - from shipping, to transportation, to industrial factories - work faster and more efficiently than ever before. Our world could not function as it does today without modern lubrication advancements.

But how did we get here? Who first decided that mechanical lubrication was a good idea? And who helped develop these processes over thousands of years to get us to where we are today?

In this trip down memory lane, we will chronicle the significant milestones of lubrication through the ages - but don't be fooled, this isn't your run-of-the-mill timeline of notable inventions and courtly characters. Au contraire, like all good sagas, this tale is filled with intrigue and subterfuge, heroes and villains, great victories and heartbreaking defeats, all played out against the backdrop of human progress. So, join us as we pay tribute to the true significance of these early achievements and the remarkable people through history who pioneered an industry.

ANCIENT HISTORY (AKA A REALLY, REALLY LONG TIME AGO)

3500 BCE (Before Common Era) – 476 BCE

Historical context

Ancient history is the historical time period between the origins of human civilisation and the fall of the Western Roman Empire. Honourable mentions – this epoch includes the birth of civilisation in Mesopotamia, the emergence of written records in cuneiform and hieroglyphs, the rise and fall of fourteen different empires and kingdoms, with guest appearances by the bronze and iron age and one great flood.

3500- ish BCE

The oldest historical evidence of ancient oil use was discovered in archaeological records near the city of Hit in Mesopotamia, modern day Iraq. Hit, which straddles the Euphrates River, is the site of an oil seep known locally as The Fountains of Pitch.

This petroleum-derived pitch (bitumen) had the advantage of being both adhesive and slippery, making it suitable for a variety of applications, and so began our love affair with one of the world's most powerful substances.

Our Sumerian friends used the black goo as a caulk agent for waterproofing ships, as a lubricant on wheeled carts and as an adhesive to secure the handles of various tools, and even as a setting agent for jewels and mosaics, which no doubt made it a firm favourite with the arts and crafts crowd.

3000-ish BCE

Some of the most widely known uses of petroleum in ancient history were undertaken by the Egyptians. There are Egyptian hieroglyphs that depict the use of bitumen as an embalming fluid, to grease chariot wheels and in the construction of monumental structures like the pyramids. Egypt's primary source of bitumen was the Dead Sea, which the Romans later named Palus Asphaltites (Asphalt Lake).

2600-ish BCE

Archaeologists discover a greasy substance on a sled wheel dating back to 2600 BCE that belonged to an Egyptian pharaoh. Analysis later showed that this substance was a mixture of beef and sheep tallow (a rendered form of animal fat made up of triglycerides) mixed with lime powder. This discovery led to the conclusion that our ancient Egyptian friends also used tallow as a lubricant for their sleds to transport materials such as wood and rocks.

1900-ish BCE

Paintings and hieroglyphics found in the tomb of Tehuti-Hetap (a fourth-dynasty nomarch) in Deir El-Bersha in Egypt showed a giant statue of the man himself, being moved with the aid of a liquid that controversially is believed to be either water or oil.

The painting, aptly known as "Colossus on a sledge", depicts many labourers dragging the statue along the ground, with one man standing on a sledge pouring a mystery liquid on the ground, presumably to reduce friction between the two surfaces.

Unfortunately, no traces of this colossus have ever been found, but this has not stopped archeo-tribologists from arguing over whether this depiction was ceremonial in nature or proof of ancient tribological prowess.

1800-ish BCE

Back to Mesopotamia and following hot on the heels of their Akkadian predecessors (the people who conquered the Sumerians), we find the Babylonian civilisation using bitumen to construct roads and bridges. Bitumen was applied to road surfaces to help bind gravel and create smoother, more durable roadways. (Which is not a million miles away from how we make roads today.)

More than a millennium later, the Greek historian Herodotus, often referred to as the father of history, told how bitumen was used as mortar to construct the famous walls of Babylon, and the world's first skyscraper – "Etemenanki", also known as the Tower of Babel.

780-ish BCE

Meanwhile in East Asia, during the reign of the Western Zhou Dynasty, the Chinese discover the friction-reducing properties of a concoction made with vegetable oil and lead, making this momentous event the first historical record of what would later become known as a compound lubricant.

680-ish BCE

The inaugural Olympic Games were held in Olympia, Greece, in 776 BCE, but by 680 BC our Zeus-loving Hellenes had added four-horse chariot racing to the momentous event, and with that, the requirement for high-speed wheel-axle lubrication in the form of animal fat, making this milestone the first historical record of racing lubricants.

200-ish CE (Common Era)

Still in the Mediterranean, but 879 years later and during the Roman Empire heyday - also known as Pax Romana (Roman peace) - we find a multitude of olive oil-based lubricants in everyday use.

Experimentation at the time led to the use of more sophisticated lubricants, including those from olive oil and other vegetable derivatives. The Romans discovered that some of these more viscous liquids not only dissipated heat better than tallow, but also allowed mechanisms to move more freely. Writings by Cato the Elder (famous Roman senator, and historian) recommend that wagon axles should be lubricated with the boiled, viscous by-products of olive oil production.

Greases made from calcium salts and olive oil (basically calcium grease) were used to lubricate axles in horse-drawn chariots used for travel and warfare, and different oils were used in various metalworking processes, to lubricate moving parts in water clocks and to keep door hinges from squeaking in temples.

It was even rumoured that Caligula (3rd Roman emperor and all-round whack job) had his engineers make up a concoction of beeswax and olive oil to lubricate the bronze bearings on the rotating platform of his palatial pleasure barge on Lake Nemi.

These early experimentations marked the dawn of machinery lubrication and the world's love of olive oil as a salad dressing.

THE MEDIEVAL PERIOD (AKA THE DARK AGES)

475 CE - 1400 CE:

Historical context

The medieval timeperiod falls between the fall of the Western Roman Empire and the beginning of the Renaissance, and was mainly characterised by economic, intellectual, and cultural stagnation with feudalism, Viking raids and the bubonic plague also thrown in for good measure.

Long story short, people became superstitious, were mostly illiterate, and there was plenty of violence to go around. Honourable mentions for this period include advancements in armour technology, gothic architecture, the Wells Cathedral Clock and guest appearances by Attila the Hun, Charlemagne, King Arthur and Beowulf.

500-ish CE

During the medieval period, lubrication techniques were less advanced compared to later periods, and likewise the availability of specific lubricants and their use varied by region and technological development. During this dark time, tallow was predominantly used as a lubricant in Northern Europe to lubricate items like pivots and bearings. The stuff was often thickened with agents like clay or lime to form grease that was mainly used to lubricate gearing mechanisms in vertical watermills and post mills, for opening the gates of castles and on carriage wheel axles.

600-ish CE

During the late 7th century, warfare took a nasty turn with the invention of a devastating incendiary weapon called Greek fire – this stuff was nothing less than the medieval equivalent of a napalm bomb. This formidable weapon was invented by a Jewish refugee from Syria called Callinicus of Heliopolis during the reign of Byzantine Emperor Constantine IV.

Greek fire, or liquid fire as it was also known, was used by the Byzantine Empire during naval warfare and sieges. It was a highly flammable and adhesive substance that could stick to targets and continue to burn – not even water could extinguish it. The stuff would be fired at enemy ships from siphons, or hurled in pots, or sprayed using a basic handheld flamethrower-like device, or even used to create fire arrows.

The recipe for Greek fire was a closely guarded secret that was lost to history, so its exact composition is still a matter of speculation and debate, but many historians believe that it was composed of liquid petroleum, bitumen, and quicklime.

In spite of its name, Greek fire was not a Greek invention. The etymology of the term, just like the recipe for the stuff, is also shrouded in mystery, but historical records dating back to this time period claim that the term was coined by western crusaders 100 years after the stuff had disappeared from historical records.

700-ish CE

While Vikings are often associated with raiding and warfare, they were also skilled traders and boat builders. In fact, Viking warriors were considered the quintessential shipwrights of the 8th century and built longships called Drakkars - a term believed to derive from the Old Norse words “dreki” and “kar,” meaning “dragon” and “ship,” respectively.

These ancient mariners are believed to have used whale oil to lubricate the sails’ hinge supports, rowlocks and the rudder axes. This ‘new’ type of oil was obtained from the blubber of whale stomachs.

With their Drakkars well lubricated, these seafaring Northmen could go about their business of exploring new territories and raiding coastal regions.

THE RENAISSANCE (AKA THE AGE OF REBIRTH)

1400 CE – 1600CE

Historical context

Whatever we lacked in the dark ages we made up for in the Renaissance – this incredible period in human history was a cultural, artistic, and intellectual movement that marked a profound transition from the medieval to the modern world and, just like Ferraris, good espresso and Luciano Pavarotti, this movement traces its origins to Bel Paese - otherwise known as Italy

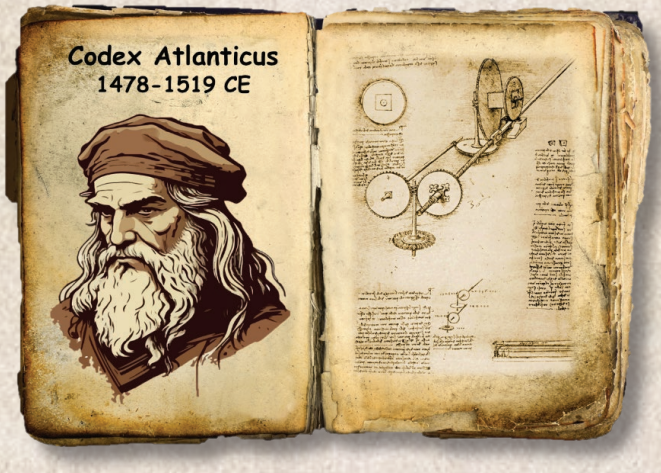
As civilisation continued to develop in Italy through the 15th and 16th centuries, some of the greatest revolutionary minds developed inventions and mechanical tools.

Honourable mentions of this era include astronomical discoveries, the development of artistic and scientific methods, and the invention of the printing press, microscope and barometer, to name a few.

As for guest appearances, the Renaissance was littered with the world's biggest ensemble of overachievers - Nicolaus Copernicus, Galileo Galilei, Johannes Gutenberg, Christopher Columbus, Dante, Andreas Vesalius, Michelangelo and, of course, Leonardo da Vinci.

1500-ish CE

With animal fats and primitive oily compounds in use throughout the world, the next true evolution in lubrication came from the father of invention, Leonardo da Vinci.



Signore da Vinci introduced the idea that the coefficient of friction is the ratio of its force to the weight or load applied. He made significant observations about friction and lubrication, including the concept of reducing friction by using a layer of lubricant between moving surfaces. To this end, he created a self-oiling lubrication system for wheel axles, using bearings, which he lubricated with animal fat and opium oil.

Da Vinci's mechanical inventions and designs, including those related to lubrication, reflected his deep understanding of engineering principles and his desire to improve various aspects of technology during his time. His creations laid the groundwork for many advancements in mechanical engineering and lubrication techniques that followed in the centuries to come.

'The noblest pleasure is the joy of understanding.' — Leonardo da Vinci

1600-ish CE

As iron and brass replaced wooden machine parts, animal fat fell short of our lubrication requirements. As a result, people in Europe began experimenting with mixtures of vegetable oil, including castor, peanut, rapeseed and canola oil. Whale oil, however, saw continued use throughout this century - not only as a lubricant, but also as a fuel in lamps, and for the manufacturing of candles.

Meanwhile on the other side of the pond in the new world, we find Seneca Indians in North America – upstate New York and Pennsylvania - using crude oil to waterproof baskets and wigwams, as a glue to make arrowheads, but mainly for medicinal purposes to cure a variety of ills.
Seneca Oil, as it became known, was traded by the Senaca tribe to European settlers as a tonic, insect repellent and salve that could treat anything from rheumatism to toothache.

THE AGE OF ENLIGHTENMENT (AKA THE AGE OF REASON)

Late 1600 - late 1700 CE

Historical context

The Age of Enlightenment was an intellectual and philosophical movement between the late 17th century and the 18th century, that emphasised reason, individualism, and the pursuit of knowledge and human rights. It played a crucial role in shaping modern thought, including political and scientific developments.

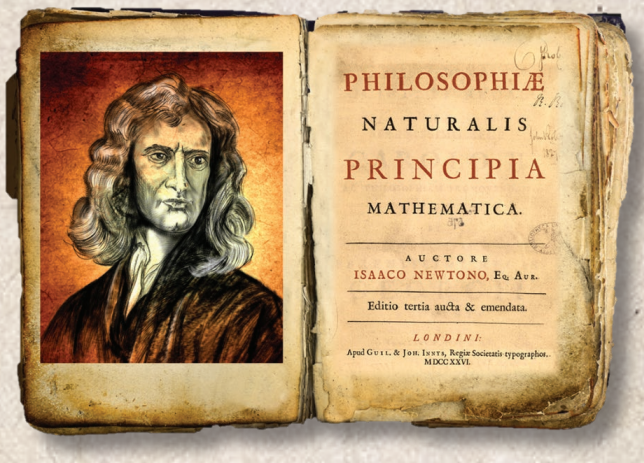
Honourable mentions for this period include René Descarte's first principle of "I think therefore I am", the invention of the steam engine, telegraph, lightning rod, the mechanical calculator and the hot air balloon.

Apart from a think tank of philosophers and engineers, this movement gave us some heavyweights in the natural science fields of zoology, physics and chemistry, with guest appearances by Carl Linnaeus, Daniel Bernoulli, Benjamin Franklin, Anders Celsius and Alessandro Volta, Charles-Augustin de Coulomb and the father of modern chemistry, Antoine Lavoisier.

1687 CE

Sir Isaac Newton was an intellectual giant of his time and one of the most influential scientists and mathematicians in history. He made groundbreaking contributions to physics, mathematics and astronomy, laying the foundation for many scientific principles that are still in use today.

Newton's most famous work, Philosophiæ Naturalis Principia Mathematica, commonly referred to as the Principia, was published in 1687. In this monumental book, he outlined his laws of motion and universal gravitation, providing a mathematical structure for understanding the physical world around us. He also formulated the mathematical framework for understanding viscosity and its relationship to the flow of fluids.



Newton's work in the Principia laid the groundwork for the study of viscosity and a fluid's resistance to flow. While he did not provide a comprehensive theory of viscosity or use the term itself, his contributions to the mathematical description of fluid motion and forces within fluids were foundational for later developments in fluid mechanics and our understanding of viscosity in the modern sense.

Isaac Newton's work had a profound and enduring impact on science and mathematics, ushering in a new era of scientific understanding. His work provided the framework for classical physics, and paved the way for subsequent scientific discoveries by geniuses like Albert Einstein, Niels Bohr, Werner Heisenberg and Erwin Schrödinger – the famous theoretical physicist who lost his cat in a box.

1699 CE

Guillaume Amontons was a self-taught French physicist and engineer known for his pioneering work in the field of friction and thermodynamics.

Illustration of Guillaume Amontons showing off one of his inventions in 1690

In 1699, Guillaume presented a paper to the Royal Academy of Sciences in Paris, France titled "De la résistance causée dans les machines" (On the Resistance Encountered in Machines), which discussed various aspects of friction and the resistance generated in machines.

Expanding upon the earlier works of Leonardo da Vinci, Amontons' paper explored the frictional forces that occur when surfaces come into contact with each other. This groundbreaking research laid the foundation for subsequent developments in the study of friction and the laws governing it, namely Amontons' first and second laws of friction.

But that's not all! In addition to his work on friction, he also made contributions to the field of thermodynamics. He discovered a relationship between the pressure and temperature of gases, that became known as "Amontons' first law of gas." Not bad for a deaf guy who never went to university.

Be sure to catch the next instalment of our timeline in *Technical Bulletin 89*, where we will brave the age of revolution and take you on a journey through the events that defined one of the most incredible periods of human progress and spawned the modern petroleum industry.

We will recount how the invention of kerosene saved a species of majestic sea titans from extinction and how a small antique shop in London evolved into one of the most prominent multinational energy companies in the world. We will live vicariously through a retired train conductor as he goes wildcatting for oil in Pennsylvania, learn how Rockefeller rose to prominence and discover who the real McCoy was.

About the author...

Steven Lara-Lee Lumley is in charge of technical development and training for WearCheck. She holds an N6 mechanical engineering diploma (HND N6) as well as Honeywell aerospace and ICML III accreditations.

Steven joined WearCheck in 2008 as a diagnostician and worked her way up to the position of senior diagnostician, during which time she diagnosed her millionth used oil sample, in addition to running oil analysis training courses for customers in several countries. In 2015, Steven was promoted to the position of technical manager.

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