CONSERVAR PATRIMÓNIO

Conservation of industrial and technological heritage
Conservação de património tecnológico e industrial
NOTE / NOTA

Is historic working machinery up to 21st century sustainability demands or are we stuck in time?

Os equipamentos históricos em funcionamento estão à altura das exigências de sustentabilidade do século XXI ou estamos parados no tempo?

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Abstract

The Science and Industry Museum have embarked on an ambitious decarbonisation project to become net zero by 2030. As part of this plan, the Power Hall Gallery (historic working engines) is undergoing a redevelopment to improve and conserve the historic listed building and run the engines more efficiently, cutting carbon emissions by 60 %. The historic engines pinpoint a pivotal moment in history; the birth of the steam engine, when fossil fuel ruled. In the 21st century we are looking for ways to be more sustainable. The Science and Industry Museum have been working with external specialists and researching more efficient ways of running the historic engines. Looking at adapting and applying a different approach to running the historic engines. Will they be able to withstand the change and adapt to 21st century demands? Can the Museum balance sustainability with the care and preservation of the historic collection?

KEYWORDS
Historic engines
Sustainability
Running
Decarbonisation
Gallery

Resumo

O Museu da Ciência e da Indústria iniciou um projeto de descarbonização para atingir zero emissões líquidas até 2030. A remodelação da Galeria *Power Hall* (motores históricos em funcionamento) faz parte deste projeto, para conservar o edifício histórico classificado e fazer funcionar os motores de forma mais eficiente, reduzindo as emissões de carbono em 60 %. As locomotivas históricas assinalam um momento crucial da história: o nascimento da máquina a vapor, quando os combustíveis fósseis dominavam. No século XXI, procuramos formas de nos tornarmos mais sustentáveis. O Museu da Ciência e da Indústria está a trabalhar com especialistas externos e a investigar formas de funcionamento dos motores histórico mais eficientes, procurando adaptar e aplicar uma abordagem diferente ao seu funcionamento. Serão estes motores capazes de resistir à mudança e adaptar-se às exigências do século XXI? Poderá o Museu equilibrar a sustentabilidade com o cuidado e a preservação da coleção histórica?

PALAVRAS-CHAVE
Motores históricos
Sustentabilidade
Operacionalidade
Descarbonização
Galeria

Introduction

This paper discusses the decarbonisation work that the Science and Industry Museum's Power Hall redevelopment is undergoing to create a more sustainable gallery not only in its environmental control for the collection, but in the running of the historic engines that once stood proud in the birthplace of the Industrial Revolution. Running on fossil fuels to power a city of production and manufacture, can this historic collection evolve to still tell their story of where they came from and inspire wonder and curiosity amongst visitors whilst running more sustainably to meet the twenty first century demands on them?

Becoming net zero

The Science Museum Group is on a journey to decarbonise all areas by reducing the carbon emissions from its operations, procurement, and supply chain, and using resources more efficiently, while still investing in and developing the estate in a sustainable way.

The Science Museum Group collection reflects the scientific innovations which have made the world we have today. Intrinsic to these stories is the impact of innovation on the natural world, in particular climate change.

Fast forward the historically important collection to the twenty first century, where the world has warmed by 1 °C since the birth of the industrial revolution when the collections were built and changed industry forever. The Science Museum Group's Sustainability Strategy has set a net zero target and pathway, underpinned by science-based absolute emission carbon reduction targets that are consistent with limiting warming to 1.5 °C above pre-industrial levels.

One of the many ways in which the Science Museum Group is linking decarbonisation with the collection, is by reviewing and changing how the historic working machinery in the Power Hall Gallery at the Science and Industry Museum, Manchester is powered and maintained.

Site history

The site of the Science and Industry Museum, Manchester is the site of the world's oldest surviving passenger railway, dating back to 1830, and comprises of a series of four historic listed buildings deemed to be of significant historical importance (Figure 1).

Today, the historic site tells the story of an industrial city in the North West of England and the museum collection is just as significant, representing a varied cross section of world class firsts in science, technology, innovation, and industry. Through this world class collection, the museum aims to tell authentic stories, encourage visitors to think big, encourage exploration in science and innovative technology, to grow science capital, and to reveal the wonder.

Originally built in 1855 by the London & North Western Railway Company, the Power Hall Gallery was a former Shipping Shed for the purpose of processing goods and it was further developed in 1881 with the external gantry crane, also Grade 2 listed (Figure 2 and Figure 3).

In 1980 the London & North Western Railway Company sold the site to Manchester City Council and restoration of the building began. The plan for the Power Hall Gallery was to install several large exhibits including steam, gas, diesel, and electric engines, as well as locomotives, all with a strong Manchester connection in their history. Many of the engines were installed in full working order and are still in running condition. They were selected to show the pivotal moment when steam engines were first created and how they changed the world and our relationship with fossil fuels forever.

Figure 1. Former Liverpool Road Station, Science and Industry Museum (source: Board of Trustees of the Science Museum, London).

Figure 2. Former Liverpool Road Station view of the Shipping Shed, Science and Industry Museum (source: Board of Trustees of the Science Museum, London).

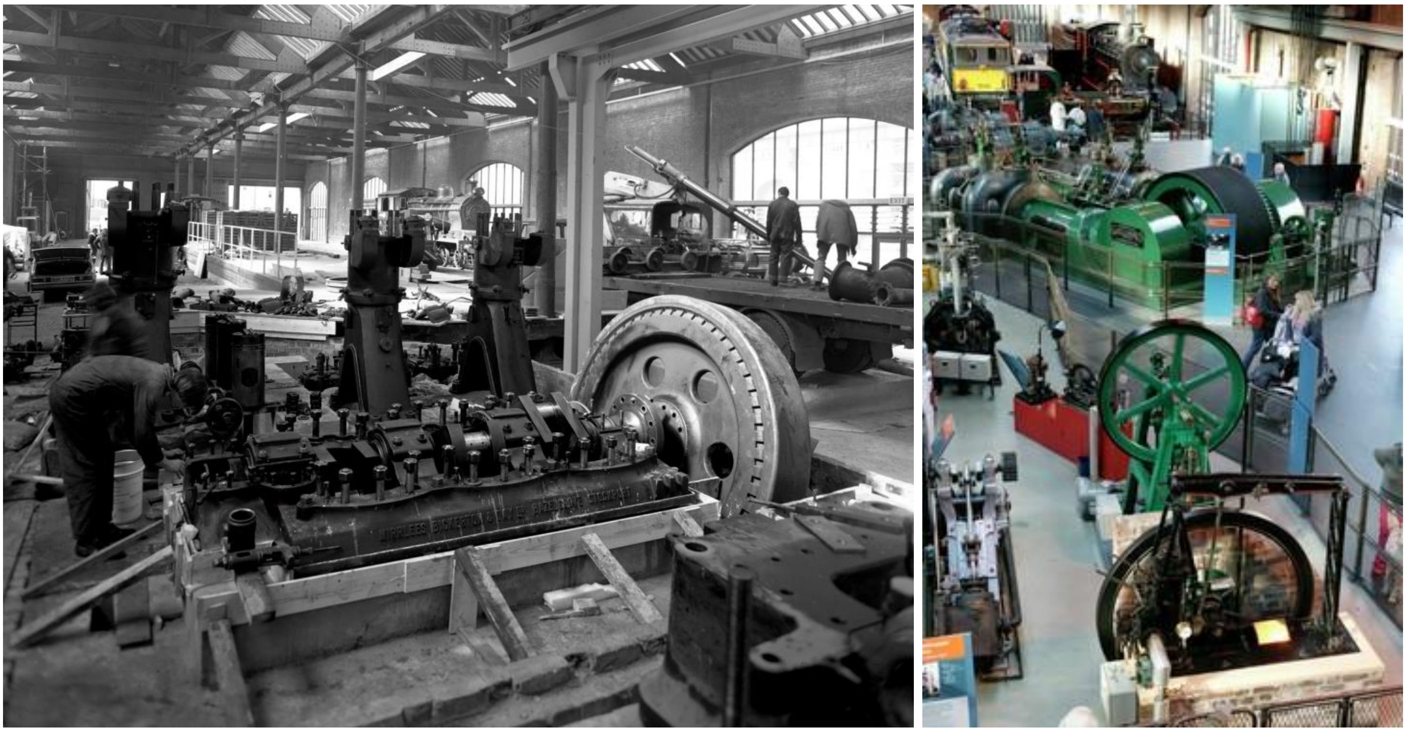

Figure 3. Former Liverpool Road Station: *a)* inside the former Shipping Shed during 1983 redevelopment; *b)* Science and Industry Museum, c. 2014 (source: Board of Trustees of the Science Museum, London).

In total there are 11 steam engines, six gas engines, four diesel engines, and two hot air engines, and the museum intends to make running the engines, and their fuel source, more sustainable in the future.

To set the scene, the gallery is an impressive testament to engineering and to the passion behind the people who have built and maintained these machines. There is a 1/3 scale model of a Newcomen engine, lovingly constructed by the museum founders and an 1830 colliery beam engine which towers over the gallery. At the core of the narrative of the Manchester engines are three large mill engines; the Durn Mill engine is the oldest and simplest, the Firgrove mill engine is a standard type used in the Manchester cotton industry, and the Galloways is the most advanced steam mill engine.

In the central compound there is a group of five small steam engines, which show a variety of shapes and types, all with different purposes; a double diagonal, A=frame, grasshopper, a very small engine with dynamo and an engine with generator set.

There is also a Ferranti vertical steam engine with alternator and fly wheel, rare in its arrangement. This demonstrates the overlap of steam engines for motive power with early electricity generation. This engine is going to be the testbed and pilot engine for the museum to run engines oil-free and use more sustainable products and methods.

Together, these machines showcase engine design and their development from the nineteenth century and have been a staple of the museum's collection, inspiring visitors with the sights, smells and sound of the historic working engines since the early 1980s. It is essential to keep the wonder running moving forward for future visitors, to keep the history alive (Figure 4).

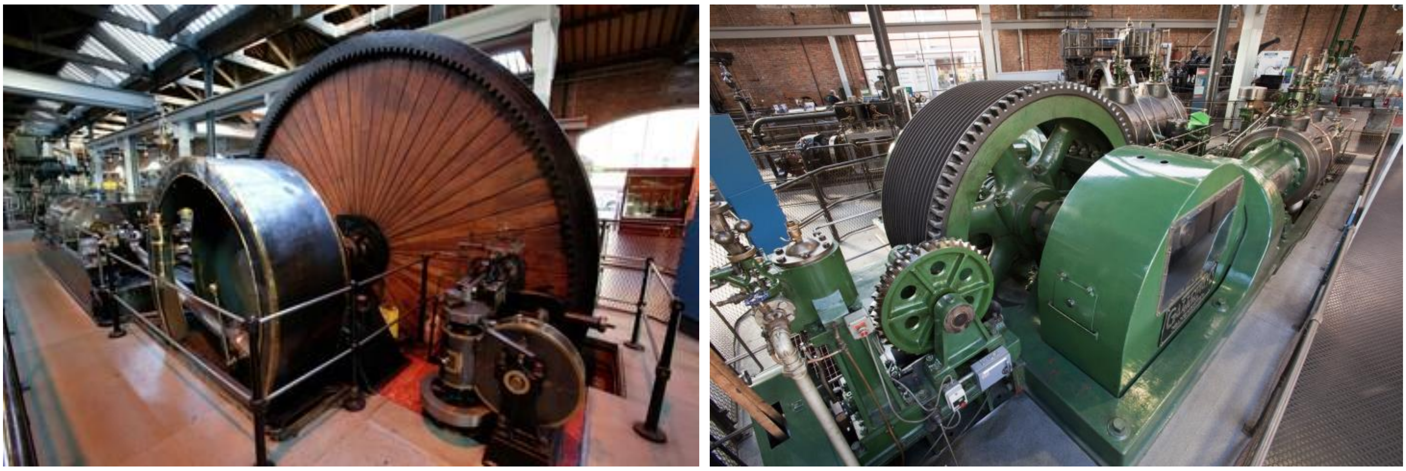

Figure 4. Firgrove Mill tandem compound condensing engine, made by J. & W. McNaught, Rochdale,1907 *(a)* and horizontal cross-compound condensing uniflow engine, made by Galloways Ltd, Manchester, for Elm Street Mill, Burnley, 1926, Science and Industry Museum *(b)* (source: Board of Trustees of the Science Museum, London).

Redevelopment

The Power Hall gallery has been under refurbishment since 2019. An opportunity to refresh the gallery and the narrative, with the idea to incorporate a more sustainable approach to energy efficiency, the materials used and how we operate the working historic machinery.

A new roof offering better insulation, and the addition of modern glazing with built in UV filters offering better thermal properties, with well-sealed new doors are all ways in which the gallery will improve environmental performance for the collection and reduce 515 tonnes of carbon emissions per year for the museum (the equivalent of 30 UK households).

The Science Museum Group's environmental control on gallery is based on the Bizot Green Protocol. For most classes of objects housed in the Power Hall Gallery, passive environmental control will suffice in offering a stable environment for the metal-based engines. Air conditioning and other high-energy mechanical ventilation are not required.

Powering the engines

To help accomplish the group's bid to be carbon neutral by 2033 and to provide power to the engines, technology such as the introduction of a ground source heat pump network across the site has been implemented. The existing steam infrastructure to run the machinery dates to the 1980's refurbishment and has been out of service since 2018. A whole new steam system is being installed to bring the engines back to life once more, but with a more energy efficient sustainable approach. The new boiler to power the engines is powered by electricity, removing the old inefficient gas boiler.

The new electric boiler will sit inside the gallery (the previous boiler was housed in its own building, hidden away) and fit the industrial appeal of the gallery with its own interpretation linking to the sustainability strategy.

Rather than using external heat dissipaters to condensate the returned steam from the engines (previously there were external cooling towers), a similar system will be installed internally on gallery which will use water from bore holes created for the heat pumps. Being located inside the gallery the heat dissipated by the condensing system will be used in the new gallery heating system.

Part of the sustainability plan is to run the steam engines on a closed-loop water system to reduce the amount of water being used and discharged to foul drainage. Even with filtration in place the water could not be returned successfully fully clean if oils were used for lubricating internal cylinders, pistons and valve gear.

Method

The use of wet steam to lubricate the historic working machinery internal moving parts that encounter steam under pressure was first suggested to the museum by external conservation consultant *Industrial Heritage Consultants*. IHC have a breadth of knowledge and experience working with engines, and notably with paddle steamers P.S Waverly and P.S Kingswear, where this is usual practice as fresh water is in short supply and the engines are required to run on a closed-loop system. External lubrication can still go-ahead but needs to be minimised as a tendency to over-oil comes with its own set of issues for the object. “In engines using saturated steam, the particles of moisture in the steam plus what cylinder oil enters the cylinders and steam chests of the piston rods and valve stems are generally sufficient lubrication for the piston rings and valves” [1].

Saturated steam occurs when liquid and gas phases of water exist simultaneously at a given temperature and pressure. The rate which water is vaporised is equal to the rate condensed.

This approach sparked an interest in the museum, and we have been looking into if this could successfully be translated to our historic mill engines. Are the different engines so different after all? The key benefits of wet steam lubrication are that this resolves the problem of oil contamination in the water and the subsequent damage to the systems boiler. Also, if steam condensate cannot be returned to the boiler because of the oil content, it would need to be discharged to foul drains instead, therefore increasing water consumption.

Research beyond working with IHC and looking at steam ship engines as models was broadened out. A nearby museum, Bolton Steam Museum, uses a hybrid model of running via external electrical power drive and the option to run on steam with very low oil consumption, not entirely oil free. Their decision is based on running time and costs versus resource and found that this model works best with no notable issues for the engines being created by the choice of operation.

My research and discussions also took me to a discussion seminar hosted by the *Big Stuff Network*, where I had reached out to the global community on the subject, this helped me to understand the science of engines and potential associated risks in the change of running.

This work is still in its infancy, and we are working with external specialists and Tribologist to see what is possible with either oil-free running or minimal oil/different lubricants such as natural products. We know that vertical engines (as a pose to horizontal operating ones) are similar to the diagonal engines of steam ships. There is less load applied to the cylinder walls and piston in the vertical position. So, this seems like the logical place to start. If the trial is successful, the museum will look to roll out trials on the horizontal engines. There is less load applied to the cylinder walls and piston in the vertical position.

The museum created a wish list for running the engines and their priority order, each engine was then assessed for suitability to run/made recommendations for running. For some of the engines this means a change in method of running. We are looking at a bold mixture of steam, externally run by electric drive, and a hybrid of the two, and the decommissioning of some engines to preserve them as they are.

The museum has the bold decision not to run any engines on diesel or gas, and to remove the fossil fuels from scope when the engines are brought back to working life. This will instead be replicated through an external electrical drive.

The first engine selected to move to oil free running or low oil/different lubrication is the S. Z de Ferranti inverted vertical cross-compound engine, made in Hollinwood 1900 (Figure 5).

Figure 5. Ferranti inverted vertical cross-compound engine, Science and Industry Museum (source: Board of Trustees of the Science Museum, London).

Now that we have a plan of action for each individual engine and know which engines are more suited to different methods of running, it is key to prevent any future damage. The first treatment is to apply colloidal graphite to the internal working, this is an embedded lubricant to reduce friction on moving parts and to act as a barrier to the moisture in the steam from settling on metal surface and causing internal corrosion.

Colloidal Graphite is a liquid suspension of graphitic carbon in either water or various organic solvents used as a conductive coating and an industrial lubricant. It creates a quick drying film that provides long-lasting lubrication. It's recommended as a general maintenance lubricant on moving parts like gaskets, transfer belts, rollers, wheels and gears.

The piston rings and pads will be replaced with a modern heat resistant material such as Polytetrafluoroethylene (PTFE). These will be fitted without intrusion and original parts (the parts removed as part of this work) will be documented and kept within the collection.

To measure the success of the proposed method of running, all engines will be condition reported and documented, measurements recorded to measure wear and photographs taken before work commences. All changes will be reviewed periodically, and this will act as a benchmarking exercise to monitor this trial.

After an agreed number of running hours, the engines will be reassessed. The museum will also document and compile daily activity such as logging start and stop times, warm-up times, hours run, oil consumption and any maintenance issues.

All this combined information will be the indicator of if this pilot of different running and changes to the engine's running life has been successful. If things work well, we will look to move on the next engine the following year.

Cultural preservation balanced with physical preservation

There is an argument to say that the atmosphere of the engines running is lost if not run in an authentic way, using the authentic fuels. The sights, the sounds, the smells are not quite the same. But the engines are already in a replicated environment of the museum, and run at slower speeds, rather than running at top speed in a Manchester cotton mill during the Industrial Revolution. Equally, none of the engines are housed in its original location; all the engines were brought to the Power Hall in the 1980s. The object output has already been changed from production performance to engagement performance.

Scholte discusses the experience of immersive art in a 2011 paper but translates to any kind of operating art or operating historic machinery in museums and galleries "as a spectator, one physically enters the space of the installation and undergoes a combination of sensory, aesthetic, and psychological experiences. Inside that space anything can happen: projections, machines making noises and motions, an accumulation of countless objects, smells or other sensations" [2].

The task of a conservator can be a tricky one, the balance of preserving original material with preserving the function and narrative of the object, ensuring the object history and the skills to operate is not lost. It is important to consider the whole history, not what is just in front of our eyes. When looking at changing materials such as the piston ring material and the way we approach running the engines, a large consideration has been what percentage of the object is original versus the replacement parts and the significance of those parts. Also understanding what knowledge and skills might be lost if engines were mothballed and the impact of this, we are using this balanced approach across Science Museum Group working machinery,

> *For both changeable artworks and machines, change is fundamental to understanding their meaning and to sustaining their social value. Preventing change in these objects causes immediate loss of the intangible experience of their movement and function, and in machines it also causes rapid loss of the intangible and embodied knowledge of how to maintain and operate the object, as well as the cultural practices based around the understanding and maintenance of the objects ability to change. This creates a dilemma for people caring for changeable objects; if the objects are not kept active, the intangible heritage that is a major part of their identity and significance will be lost. If they are kept active, however, their original components and material will become worn, requiring interventions such as restoration or replacements that are frequently identified as unprofessional conservation practice.* [3]

Conclusions

It is the responsibility of the heritage sector to preserve both the material of historical objects and the authenticity of the story it is charged with for future generations. The object and its story need to be considered in its entirety to reach successful conclusions and compromises. In the twenty first century this responsibility is further complicated by the responsibility of sustainability, which is everyone's task to try to slow global warming. This paper demonstrates how museums can strike the balance of preserving its national heritage along with responding to contemporary change and action that is needed. Museums are not just history; they can embrace new thinking and still preserve history successfully.

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