6 - Steam Locomotive Components for Museum and Tourist Railways

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Abstract: The construction of the new SLM rack tank steam locomotives was accompanied by the simultaneous development of numerous components and by-products, detailed below:

- external electric pre-heater for fireless, gentle and unattended steaming-up
- electronic measurement of the indicated power, which makes a precise and continuous monitoring of the steam engine possible
- fully welded replacement boilers
- insulation techniques to reduce heat-loss and energy consumption
- light-oil firing system for smokeless combustion even in small fireboxes
- compound-regulator for simultaneous oil/atomizing steam flow control
- low-maintenance and leakage-free bearings for axles and rods

All these developments are also ideal for use in museum locomotives to improve reliability and to reduce running costs and pollution.

1 Introduction

The construction of the new SLM rack tank steam locomotives was accompanied by the simultaneous development of numerous components. Most of these can be used to improve the steam locomotives of museum and tourist railways. Of special interest in this context are:

- light-oil firing systems
- electric preheating devices
- insulation technology
- electronic indicating and testing equipment
- sealed bearings
- all-welded boilers

All-welded boilers are more or less common technology and will therefore not be dealt with in this paper.

2 Light-oil firing

The basic advantages of light-oil firing systems are:

- One-man operation is possible. This is most important to achieve economies comparable to diesel or electric traction.

- No fire cleaning is necessary. There are no ashes and no cinders. Modern oil-firing makes the preparation of a locomotive easy, and after terminating the service you can put the engine immediately in the shed without any further attention.
- Cleanest combustion without smoke – not less smoke: **no** smoke. This is most important nowadays if we want to continue and increase steam services.
- Higher efficiency due to superior combustion. Unburnt fuel losses, a big issue with coal firing, are virtually non-existant in modern oil firing systems.
- No sparks and hence no lineside fires. This has become important now even in Britain. Due to the greenhouse effect, the weather is not as it used to be. Ten years ago, you could not go to Britain without an umbrella because it was raining in the morning, followed by rain in the afternoon and completed by rain during the night. So any sparks would immediately be drowned, and there was no danger of lineside fires. But nowadays England can have more sun than the Caribbean Islands, and you may find dry weather conditions for two or three months. As a result of several lineside fires, steam operation has been banned during the summer months. The inherent danger of lineside fires also provides a good excuse for those who don't like to see steam trains operating on their railways. Oil firing is the right answer in both cases (Let me open a bracket here: There **is** a solution for coal firing. Dr. Giesl of Austria invented a micro-spark arrestor in combination with his ejector. In field tests he found that sparks which pass a mesh width of 1.7 mm do not have the ignition power to start a fire. He introduced his system on the old rack locomotives (999.0 and 999.1) of the Schafberg und Schneeberg lines in Austria. Both lines run through forest. The micro-spark arrestor solves the problem of spark throwing, provided the mesh is carefully maintained. In 1992, there was nevertheless a huge forest fire on the Schneeberg line. With the money spent for fire fighting, they could have bought one of our new rack tanks. A rather large hole was found in the mesh of the spark arrestor, but it was decided to blame a cigarette, and since then smoking is prohibited aboard these trains.).
- Modern oil firing is easily adjustable. It can be turned off immediately. The problem on coal fired locomotives is well known: the fireman prepares a big fire whilst approaching a gradient, but operating decides to keep the signal on red for some reason. Where to put the steam? Turning the oil firing system off prevents the safety valves from blowing off.
- Last but not least, a modern oil firing system is much easier to operate. Coal firing requires a skilled fireman, but nowadays it's not easy to get the necessary experience with the limited number of operating days. With today's traffic density on the main lines, one cannot afford to stop for raising steam.

As already mentioned in my previous paper "Modern Steam Locomotives in Revenue Service", the SLM light oil firing system is successfully used on the steam rack locomotives H 2/3. Even at full load, these locomotives work with a perfectly clean exhaust. Now let me briefly explain how the system works. From the oiltank, mounted on the rear of the cab, the oil flows to the burners by gravity. Instead of the grate we have our oil firing system. It contains 5 burners. There is a small pilot burner in the middle and 4 main burners near the corners of the firebox. All burners fire vertically up and the flames do not touch the walls. This is most important to achieve a good combustion with excellent emission values. The oil is atomized by superheated steam. Because of the one-man operation, the engine driver has to drive **and** to fire. To make life easier for him, we developed a one-lever control which automatically adjusts the atomizing steam pressure to the oil flow rate.

It is quite easy to find pictures of old diesel locomotives belching smoke like coal fired steam locomotives. This type of pictures would illustrate what can be "proved" by comparing **old** technology with **new** technology. One of the fundamental faults of the past was to compare **old steam** locomotives with **new diesel** and **new electric** locomotives. As a kind of revenge, we could now do the opposite and compare **new steam** locomotives with **old diesels**. But being serious engineers, we made a serious comparison. We compared the latest diesel locomotive of the Brienz-Rothorn Railway, No. 11, built in

1987, and the new prototype steam locomotive No. 12, built in 1992. In order to make up for the age difference, we upgraded No. 11 in theory with the latest MTU diesel engine. The comparison, based on test results both for steam and diesel, was between 1992 diesel technology and 1992 steam technology. We also calculated the emission values to the power at the cogwheel rim which includes the total thermal efficiency of both locomotives. The results showed very low NO_X-values for modern steam, and Mr. Serchinger calculated that these are very near the theoretical minimum. CO-emissions are also much lower than those of the diesel locomotive; only the SO_2-emissions are a bit higher due to the lower efficiency of the steam cycle.

3 Electric preheater

In Alpine regions the weather is not very predictable. Nevertheless, most people believe in weather forecasts and do not plan a trip when bad weather is announced. If the weather is unexpectedly clearing up, people rush to the station to get up the mountain. Steam railways, also believing in weather forecasts, often had not enough engines in steam to cope with the sudden demand. In order to prevent this, we invented the electric preheating device with which a cold boiler can be put in steam overnight or be kept at any desired temperature, in both cases without supervision.

The function is simple. The electric preheating device is connected to the boiler by means of two flexible hoses. A hot-water pump enforces permanent circulation from the boiler to the electric preheater and back to the boiler. The comparetively low energy input per time and the continuous flow ensure a slow and very gentle heating up. Unlike the conventional method of raising steam with heat transfer from the gas side, all parts of the boiler are warmed up simultaneously. Maximum steam pressure is 10 bar. Control is by means of two thermostats, allowing to keep any set temperature. There are no emissions, of course, allowing to raise steam even in a shed without a chimney. With steam up to 10 bar in the boiler, the engine can easily be moved outside the shed to light the fire, be it an oil- or coal-fired locomotive. Connecting and disconnecting the two flexible hoses each takes about 5 minutes, compared to a couple of hours with the traditional method. Thus the electric preheater saves a lot of man-hours.

4 Insulation

Insulation is most important. At full power, radiation losses are quite small, say 2 to 5 %. This was leading, or rather misleading, many engineers to believe that it is not worthwhile to tackle these losses. But it is clear that the losses become relatively bigger at low powers, and when the engine is standing there are more or less only radiation losses. Now most locomotives usually work only 5 to 10 % of the time at full power, but radiation losses occur 100 % of the time when the engine is in steam. Even a small 0-4-0 locomotive has radiation losses in the order of 20 kW if the boiler is not insulated. On large mainline engines, radiation losses amount to between 100 and 150 kW. By multiplying the radiation losses times the hours the engine is in steam, one can easily realize how much energy = fuel = money is wasted. Insulation material is not expensive anymore. Therefore it is a good option to improve the service of the locomotive and to save energy.

Of course, the full benefit can only be gained with a firing system that can be turned off completely like the oil firing. On a coal fired engine, some of the energy saved by the better insulation will be blown off the safety valves. However, there is still a tremendous gain when the boiler presssure is not on the red mark.

5 Modern measuring technology

Measuring technology made big progress during recent years, and it pays to take full advantage of it. Let's look at indicating as an example. With an indicator diagram, one can determine how much work the engine is doing and, in combination with the speed, how much indicated power is being produced. The indicating diagrams also allow to check the accuracy of the motion as well as the valve timings.

Traditionally indicating used to be done mechanically. I gained experience with that method in South Africa. Under the direction of David Wardale, I was responsible for the mechanical indicating of the famous "Red Devil" (SAR class 26 3450). I had to sit in front on the buffer beam, protected by a provisional shelter only, at speeds up to 100 kph. This was quite an adventure. The feeling was comparable to the one on a rollercoaster. Fortunately, there was no lorry on the track. Sitting next to the smokebox, there was no way to hear anything but the roar of the exhaust, so communication was by hand signals. For each pair of diagrams, new paper had to be wrapped and fixed on the indicating drum, which was time-consuming. So it was difficult to take enough diagrams and at the right time. And there was hardly a chance to record something unpredicted like slipping of the engine.

Already on the "Red Devil" we tried the electronic indicating method. David Wardale's other assistant at that time, Dr. Peter Le Sueur, was responsible for this method. It was soon clear that the electronic indicating was far superior. The whole test trip could be recorded on tape, allowing to draw diagrams of any point of the trip.

Today electronic indicating has been refined by SLM to the point that the results are immediately calculated and printed by the computer for quick analyses.

6 Sealed bearings

Plain bearings commonly used on steam engines have several disadvantages. They are not very reliable. They need a lot of maintenence and – very important nowadays – they loose litres of oil. And who knows how long the environmentalists will close both eyes to overlook this! It is in any case better to have a technical solution ready now. As a matter of fact, two solutions already exist:

- roller bearings
- floating bushes

Both principles have some advantages in common. Both types can be grease-lubricated and fully sealed. If properly designed, there is no leakage. They need less maintenance. Longer service intervals save man hours – you do not have to walk around the engine with the grease- or oil-gun every day or every trip any more. Roller bearings have less rolling resistance, giving a slight gain on tractive effort. And – most important – they are environmentally friendly.

SLM is currently equipping a 52.80 class locomotive with that technology. The idea is to apply most of the modern technology used on the rack locomotives to a standard gauge locomotive. Unfortunately the budget did not allow for a new locomotive, but it will be extensively rebuilt. New axles, axleboxes, pins, rods, pistons, piston-rods, crossheads and crosshead-guides will give the rebuilt engine a smoother ride with less maintenance.

The floating bushes need less radial space than the roller bearings. We successfully use bearings with floating bushes on the connecting rods of the new rack locomotives.

7 New orders

SLM is going to build steam engines too. Lake Geneva has eight paddle ships, four of which are genuine steamers. The other four were converted to diesel-electric drives about 40 years ago. The steam engines are still going strong, whilst the diesel-electric drives have reached the end of their economic lives. SLM proposed to replace the diesel-electric drives with genuine new steam engines. In order to reach a comparable economy, the new steam engines will be operated from the bridge, thus not requiring additional staff as compared to a motor ship. The first of the "re-steamized" paddlers will re-enter service in 2001.

8 Postscript (November 2000)

All of the modern steam technology developed by Swiss Locomotive and Machine Works (SLM) is now entirely in the hands of a new company named

Dampflokomotiv- und Maschinenfabrik DLM Ltd.

DLM Ltd. is active since July 2000. It was founded by the members of the SLM steam team and the Swiss firm "Hug Engineering". DLM Ltd. exclusively purchased all SLM know-how of modern steam technology as from 1950 and intends to continue production and development of new steam locomotives as well as steam engines for ships.

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