

### 3 - Modern Steam in Revenue Service

Roger Waller, Dipl. Ing. ETH

#### Abstract:

After an interval of 40 years the Swiss Locomotive- and Machine Works in Winterthur started to build new steam locomotives again. In 1992 three prototypes of an entirely new developed rack steam locomotive entered commercial service. In 1996 five identical production locomotives followed. Taking the Brienz Rothorn Railway as an example, this paper explains the way this at a first glance rather unconventional solution came to be. It also gives an idea what kind of innovations were necessary to bring the seemingly old-fashioned technology up to today's standards and make modern steam a commercially viable option. The aim was not to be just better than the old steam locomotives, but to be competitive against today's Diesels, which were about to eliminate steam operation. We can indeed claim that thanks to the modern steam locomotives, the ongoing dieselisation on both the Brienz Rothorn and the Schafberg line was stopped, more so even reversed, in that the percentage of steam operation has steadily increased since the arrival of the modern steam locomotives.

At the time a German standard gauge steam locomotive is being modernized in Winterthur along the lines of the modern steam technology implied on the rack tanks. The locomotive is destined mainly to pull the famous Orient-Express trains. It will prove that the modern steam technology can also be used for larger locomotives.

So far rationalizing a steam operated railway inevitably meant dieselisation or even electrification. In both cases the result is a considerable loss of attractiveness. Now modern steam locomotives offer an economical and ecological operation without the loss of attractiveness and we now can claim that modern steam is proven technology.

#### Diesels on the Brienzer Rothorn

Although a mere 99% of all railways in Switzerland are electrified, there is one remarkable exception, the Brienz Rothorn Railway. Electrification was discussed more than once but always considered too expensive. So the railway remained 100% steam operated until 1972. Up to then the rolling stock consisted of 5 steam locomotives built in 1891/92 and two more powerful ones built in 1933/36. The older locomotives push one coach seating 48 passengers, the newer ones transport up to 80 passengers in two coaches. Each train requires a staff of three (driver, fireman and guard). Due to the limited capacity of its trains the railway was unable to cope with the demand, especially on sunny days. Various solutions to increase the capacity and to reduce operating costs have been discussed. A report \*on these findings stated, that new steam locomotives would provide the most attractive solution. Unfortunately, at that time, no locomotive builder was prepared to offer them. The "second best" option was chosen: new diesel locomotives. The prototype, the Hm 2/2 No. 8 was not a real success, but nevertheless demonstrated what could be done. The locomotive entered service in 1973 and was allowed to push one coach only. But there was no fireman and short preparation times. Based on this prototype, two much improved Hm 2/2 (No. 9 and 10) were built and entered service in 1975. Pushing two lightweight coaches with up to 112 passengers and requiring a staff of only two per train, their economy was far superior to the one of the old steam locomotives. On top of their economy No. 9 and 10 were, unlike the prototype No. 8, quite reliable in service. Is it astonishing that the railway took full advantage of the diesels? When there was heavy traffic, diesel was used because steam was unable to cope with the demand. When traffic was low, diesel was used because steam was too expensive. Steam remained useful though, mainly for advertisement, less so for actual train service. The result of this traction policy was, that the majority of passengers were transported by diesel, whether they liked it or not. When the railway announced their intention to buy a

fourth diesel, I wrote a letter to the director pointing out the fact that already most passengers had no choice but to take a diesel train. Yet another diesel would make matters even worse and relegate steam definitely to advertisement purposes. I did not only complain though but proposed what I felt was a much better solution: a new, modern steam locomotive with an economy comparable to diesel, but much more attractive. Unfortunately, my proposal came too late to prevent No. 11, put in service in 1987. But it created interest and later turned out to be the start for modern steam locomotives. Table 1 shows the motive power of the Brienz Rothorn Railway in 1990, before the introduction of modern steam locomotives.

## The Shortcomings of old Steam Locomotives

Promising a modern steam locomotive that would be economically competitive against (modern) diesel was one thing, realizing it another. First a list of disadvantages of the traditional steam locomotives was produced:

- **Higher staff costs:** mainly due to the need for a fireman, but also because of longer hours for servicing and supervising the steam locomotives
- **Higher maintenance costs:** mainly due to the old age of design and material
- **Low thermal efficiency:** due to a generally low cycle efficiency but also due to various deficiencies in design and calculation
- **High stand-by losses:** steam locomotive boilers usually were not or only insufficiently insulated resulting in considerable radiation losses
- **Longer preparation times:** whilst diesel- and electric locomotives can (almost) be put in service by "pushing a button", traditional steam locomotives needed careful nursing before and after each trip, especially when coal-fired.
- **Environmental nuisance:** traditional steam locomotives are increasingly criticised for their environmental impact. Visible air pollution and dripping oil are not to everyone's liking. This is not helped by some rail fans, which not only ignore it but also contribute to strengthen the bad image by ordering black smoke for a "good" photograph. Thanks to the general popularity of steam locomotives, most people still tend to "overlook" these negative aspects, but I'm sure it will no longer be tolerated on tourist lines with regular steam trains.

The above is by no means a complete list of the shortcomings of the traditional steam locomotives but reflects the main reasons why most railways were dieselised or electrified. If we wanted to reverse that process on at least some of the railways, we would have to rectify the above deficiencies of the steam locomotive. Much brainstorming was necessary but out came a proposal, which should do the job. The appearance of the locomotive was not much different from the older ones, which seems to be an advantage rather than a disadvantage, at least on tourist lines.

## New Steam Locomotives: a Dream Comes True

The proposal, including a first design drawing, was presented to the director of the Brienz Rothorn Railway in 1987. The following advantages were claimed for the new locomotives:

- **One man operation:** the new steam locomotives do not need a fireman, thus bringing staff costs of steam to the same level as for diesel or electric traction
- **Light-oil-firing:** thanks to a modern oil-firing system, the problem of air pollution would be solved. The oil-firing would also eliminate problems like line-side fires, fire cleaning, clinkering, ash disposal and additional working hours
- **Fully insulated boiler and cylinder:** to reduce stand-by losses and to improve the efficiency, insulation quality of stationary boilers was envisaged. Good insulation not only saves energy, it is also

essential to keep an engine in steam overnight unattended. If there is still steam pressure in the boiler, the oil firing can immediately be turned on (almost by "pushing a button").

- **Streamlined steam passages:** the BRB locomotives No. 6 and 7 have their cylinders in the middle underneath the boiler and the gear in front underneath the smoke box. This arrangement was to be reversed for the new locomotives by placing the cylinder underneath the smoke box to give better streamlining of steam and exhaust pipes. The steam passages inside the cylinder were to be improved too.
- **Roller bearings:** One of the main expenditures for the maintenance of traditional steam locomotives is related to plain bearings. Replacing these by correctly designed, sealed roller bearings would save a lot of servicing and maintenance. No oil would be lost, making new steam locomotives environmentally friendly also in this respect.
- **Interchangeable parts:** traditional steam locomotives used to be different even if built to the same drawings, which made it difficult to have spare parts on stock. Today's philosophy requires interchangeable parts to ensure that the engines are back in service as soon as possible. Thanks to today's CNC manufacturing methods, the interchangeability of parts on new locomotives is not much of a headache.
- **Electric preheating device:** with the electric preheating device a cold boiler can be put in steam overnight or be kept at any desired temperature, in both cases without supervision. (A more detailed description of the function is given in the paper "Steam Locomotive Components for Museum and Tourist Railways".)

With this information on the proposed new steam locomotives, enough interest was created to obtain a request for an offer. Now convincing SLM to actually offer these new steam locomotives was real hard work. In the end it was decided to do a market survey to see if there is enough potential for more than one new steam rack locomotive. SLM decided that at least six locomotives would have to be ordered otherwise the proposal was dead. The result was quite astonishing and showed a potential for no less than 15 new locomotives. Main customer would be the Austrian Federal Railway, which asked for 12 locomotives for their two rack lines on the Schafberg and the Schneeberg. Now the risk of building 15 locomotives to an entirely new design, restarting after an interval of 40 years with a team that has never built a new steam locomotive before seemed too high a risk for SLM. Subsequently it was decided to build a prototype. The negotiations with possible customers resulted in three orders for prototype locomotives, one each for Brienz Rothorn Railway, Montreux - Glion - Rochers-de-Naye (both in Switzerland) and Austrian Federal Railway.

All three new locomotives have been thoroughly tested in SLM before delivery. In 1992 all were commissioned and entered commercial service soon afterwards. The good experience gained with these locomotives in daily service lead to an order of five production locomotives, virtually to the same design. A few details have been modified of course following the experience in revenue service, but otherwise the basic design features remained unchanged. Table 2 shows the rolling stock of the Brienz Rothorn Railway in 1996 with now three new locomotives, No. 12, 14 and 15. No. 13 was painted on a mock-up of the cab and is not used for a locomotive. The prototype diesel no. 8 was sold. Table 3 shows the development of mileages done by each locomotive since the introduction of the new steam locomotives. It can clearly be seen that the new steam locomotives took away kilometres not only from the old steam locomotives but mainly from the diesels. Whilst from 1973 to 1992 there was a strong tendency to diesel, this trend was reversed by the new steam locomotives.

We can indeed claim that thanks to the modern steam locomotives, the ongoing dieselisation on both the Brienz Rothorn and the Schafberg line was stopped, more so even reversed in that the percentage of steam has steadily increased since the modern steam locomotives began to operate.

\* BRIENZ ROTHORN-BAHN: Erneuerung des Rollmaterials, November 1975, unpublished

<b>Rolling Stock of the Brienz-Rothorn Railway 1990</b>						
<b>Engine No.</b>	<b>Type</b>	<b>built</b>	<b>Coaches</b>	<b>Capacity</b>	<b>Crew</b>	<b>Productivity</b>
<b>1.....5</b>	<b>Old Steam</b>	<b>1891/92</b>	<b>1</b>	<b>48</b>	<b>3</b>	<b>100%</b>
<b>6 + 7</b>	<b>Old Steam</b>	<b>1933/36</b>	<b>2</b>	<b>80</b>	<b>3</b>	<b>167%</b>
<b>8</b>	<b>Diesel</b>	<b>1973</b>	<b>1</b>	<b>48</b>	<b>2</b>	<b>150%</b>
<b>9 + 10</b>	<b>Diesel</b>	<b>1975</b>	<b>2</b>	<b>112</b>	<b>2</b>	<b>350%</b>
<b>11</b>	<b>Diesel</b>	<b>1987</b>	<b>2</b>	<b>112</b>	<b>2</b>	<b>350%</b>
<b>Remarks:</b> <i>Capacity:</i> Number of passengers per train <i>Crew per Train:</i> Driver, (Fireman), Conductor <i>Productivity:</i> Number of passengers per train crew member as compared to old steam of 1891/92						

BRB2.xls / R. Waller / 25.05.98

Table 1

<b>Rolling Stock of the Brienz Rothorn Railway 1997</b>						
<b>Engine No.</b>	<b>Type</b>	<b>built</b>	<b>Coaches</b>	<b>Capacity</b>	<b>Crew</b>	<b>Productivity</b>
<b>1.....5</b>	<b>Old Steam</b>	<b>1891/92</b>	<b>1</b>	<b>48</b>	<b>3</b>	<b>100%</b>
<b>6 + 7</b>	<b>Old Steam</b>	<b>1933/36</b>	<b>2</b>	<b>80</b>	<b>3</b>	<b>167%</b>
<b>9 + 10</b>	<b>Diesel</b>	<b>1975</b>	<b>2</b>	<b>112</b>	<b>2</b>	<b>350%</b>
<b>11</b>	<b>Diesel</b>	<b>1987</b>	<b>2</b>	<b>112</b>	<b>2</b>	<b>350%</b>
<b>12</b>	<b>New Steam</b>	<b>1992</b>	<b>2</b>	<b>120</b>	<b>2</b>	<b>375%</b>
<b>14 + 15</b>	<b>New Steam</b>	<b>1996</b>	<b>2</b>	<b>120</b>	<b>2</b>	<b>375%</b>
<p><b>Remarks:</b> <i>Capacity:</i> Number of passengers per train  <i>Crew:</i> Driver, (Fireman), Conductor  <i>Productivity:</i> Number of passengers per train crew member as compared to old steam of 1891/92</p>						

BRB3.xls / R. Waller / 25.05.98

Table 2

<b>Engine Performance on the Brienz Rothorn Railway 1992-99 (km)</b>										
<b>Engine</b>	<b>Type</b>	<b>built</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
1	Old Steam	1891	2606	1056	1458	158	468	1250	568	0
2	Old Steam	1891	1641	1916	2161	2030	1834	1607	1598	1873
3	Old Steam	1892	2084	1292	0	0	0	0	0	0
4	Old Steam	1892	0	0	0	0	0	0	0	0
5	Old Steam	1891	2387	0	1208	1850	0	0	962	1309
6	Old Steam	1933	3346	2304	3088	2604	1972	2541	2204	2643
7	Old Steam	1936	3560	2672	3221	2618	1992	2160	2162	2648
8	Diesel	1973	2421	688	1232	1150				
9	Diesel	1975	6100	4586	5450	3453	3621	3124	2172	1213
10	Diesel	1975	6263	4135	4138	3948	2438	2758	2679	2579
11	Diesel	1987	6923	5501	5188	5691	3929	5018	5341	4938
12	New Steam	1992	1675	4609	5637	5513	3969	4762	4058	5319
14	New Steam	1996					4033	4101	4182	4638
15	New Steam	1996					4386	4488	3980	5184
<b>% Steam Traction</b>			44%	48%	51%	51%	65%	66%	66%	73%
<b>% New Steam Traction</b>			4%	16%	17%	19%	43%	42%	41%	47%
<i>Remarks:</i> Engine No.8 is a prototype Diesel locomotive; it pushes only one coach; it was sold in 1996 Engine No.12 is a prototype steam locomotive, commissioned 28 / 07 / 1992; 1992 was not a full season for her										

BRB1Da.xls / R. Waller / 16.12.99

Table 3 (updated)