AST Trust

Advancing Steam Traction

NEWSLETTER No. 28 OCT 2025

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CHAIRMAN'S PIECE
John Hind

In writing this piece, I always look back at what I said in the last Newsletter. In the last one I was anticipating the Greatest Gathering. Later in the newsletter, I write about what it was really like!

Thanks to all the members who renewed after my appeal in the last newsletter and welcome to the 10 new members who have joined since June.

I am writing this just after the conference and after the deadline for submissions for the Newsletter, so here is a quick picture when we were packing away after the conference. It was too good, not include it in this edition with an appropriate humorous caption!

ASTT members re-create a Classic Scene from 'The Titfield Thunderbolt

THE GREATEST GATHERING
John Hind

1st to 3rd August – Derby, Litchurch Lane. There were 3 public days for the event itself, but behind the scenes, it was a 5 day event with 1 day of set up and 1 day to breakdown. The biggest contributors were Jamie and Richard, who supported over 5 days at the event.

Gwion Clark, Alex Powell, Richard Coleby, Jamie and I were present for the set up day and the 3 full days of the Gathering. As added help on the public days we were joined by Nigel Barnes, Owen Jordan, Chris Newman and Mike Stocksbridge. Jamie, Richard and I were supporting other stands as well, so having a big crew meant that our stand was continuously manned while others from the team were getting a chance to see the event or take refreshment breaks.

Part of the Revolution budget included publicity materials, which was spent on pull-up banners, handouts and brochures.

Over the 3 days there were 37,000 visitors, there were over 140 rail vehicles, plus many groups like our own. The site is 90 acres. The exhibits were in clusters round the site, which meant that some areas were crowded and other not. Fortunately, we were in area that had a large footfall. The pictures show the crowds.

With so much to see, the visitors were in a rush to get round and most would not linger. Other groups found the same. However, we did have sufficient people taking a closer look to keep the team busy giving explanations of what we were about. Anyone who showed an interest left with handouts whether they were about Revolution, ASTT or the conference.

Through Richard's Railway Challenge contacts, we had visits from the Institution of Mechanical Engineers, Railway Division's past chairmen - Professor Simon Iwnicki – Emeritus Professor at the University of Huddersfield, Andrew Skinner – Head of Engineering at Great Western Railway and Bill Reeve – Director of Rail at Transport Scotland.

From the media we had Steam Railway and Trackside stop, chat, have a look, take lots of pictures and leave with handouts, and then not publish anything!

I also showed Revolution to Tom Ingall, who is a presenter and reporter for BBC Look North in Sheffield. He is a railway enthusiast who has his own YouTube Channel https://www.youtube.com/@tomingall74 . When we run Revolution on air, we will invite him along to do a promotional video for us.

We had Paul Hibberd's donated books on sale and did manage to sell a few and at the end of the event accepted a lump sum from the Bury Standard 4 Group, who will sell them through their shop.

The 4 days went quickly and although we did not raise a lot of money or sell a lot of books, it was worthwhile from a networking and profile point of view.

Many thanks to all who were on the stand and especially to Nigel Barnes, Alex Powell and Gwion Clark for taking on the role of Chief Explainers. Neither should we forget thanking Chris producing the handouts. A final thanks to Jamie and Richard, without whose work over the last couple of years we would not have had a locomotive to show and thanks is due to them for getting Revolution to the Greatest Gathering, which meant extra trips to suppliers to collect parts and hours in the workshop.


ADVANCED STEAM TRACTION
AST
ASTT
ADVANCED STEAM TRACTION TRUST
Engineering Design
Book Sales
Annual Conference


ASTT


ASTT

MEMBERSHIP MATTERS

Chris Newman

Committee Members

ASTT's management committee :

John Hind	Chairman & Trustee	Jamie Keyte Trustee
Hendrik Kaptein	Secretary & Trustee	Alex Powell Trustee
Chris Newman	Treasurer & Trustee	Grant Soden Ex-officio
Mike Stockbridge	Ex-officio	

New Members:

Charlie Kallesø – railway technologist with mainline steam experience, from Denmark.

Nicholas May - from West Australia.

Richard Schurmann - electronics engineer and volunteer on the Puffing Billy Railway, from Victoria, Australia.

Ian Foot – retired railway engineer and project manager, now a volunteer and director of the North Yorks Moors Railway, from Yorkshire, UK.

Will Richardson – design engineer in the energy sector and volunteer on the Clan Project, from Northumberland, UK.

Dr. Gordon Keyte – retired aeronautical physicist (and father of Jamie Keyte), from Hampshire, UK.

Martin Greenland - retired geotechnical engineer now driving steam locomotives on the FR and WHR; from Lancashire, UK.

Alex Stackhouse - has completed a 4 year apprenticeship as a steam loco fitter & machinist, and has now embarked on a HNC Mech Eng South Devon College. He volunteers as steam driver at the 10¼" gauge Bickington Steam Railway. He lives in Newton Abbott in Devon.

Membership Numbers

We currently have 130 members after two past members failed to renew.

The current breakdown of these 130 members is as follows (in the hope that all resubscribe!):

Full Members:	39	UK Members:	81	Age Ranges	
Associate Members:	80	EU:	19	Over 60	Approx. 42%
Student Members:	11	North America:	14	30 to 60	Approx. 43%
		South America:	1	Under 30	Approx. 15%
		Australasia:	13	Av. age	Approx. 56
		Asia & Africa:	2		

PUBLICATIONS PAGE
Chris Newman

Book Sales

Book sales, like membership numbers, have risen dramatically since the last Newsletter, with 44 books sold and 88 brochures (Prospectuses) distributed. Publication of a 5th volume of Porta's papers has spearheaded the increase, but other sales have been quite buoyant compared to the spring. However, as noted previously, the prospect of no new titles in the pipeline renders it unlikely that this recent spike in sales will be repeated in the foreseeable future.

Books sales since April 2025 have been as follows:

Publisher	Author	Title	Sales since N/L 27	Total Sales
ASTT	L.D. Porta	Porta's Papers Vol 1	10	162
	L.D. Porta	Porta's Papers Vol 2	10	153
	L.D. Porta	Porta's Papers Vol 3	9	120
	Martyn Bane	Porta's Papers Vol 4	15	93
	L.D. Porta	Porta's Papers Vol 5	62	62
	C. Newman (Editor)	Porta's Centenary Compendium Vol 1	3	91
	C. Newman (Editor)	Porta's Centenary Compendium Vol 2	9	56
	Ian Gaylor	Lyn Design Calculations	3	114
	David Wardale	5AT FDCs	2	225
	David Wardale	Reminiscences of a Trainspotter	0	43
	Alan Fozard	5AT Feasibility Study	0	47
	Chris Newman	ASTT Prospectus¶	88	88
Camden*	*David Wardale*	*The Red Devil and Other Tales from the Age of Steam*	*0*	*260*
	Phil Girdlestone	*Here be Dragons*	*0*	*33*
	Jos Koopmans	*The Fire Burns Better …*	*0*	*11*
	L.D. Porta	*Advanced Steam Design*	*0*	*5*
Crimson Lake	Adrian Tester	Physiology of the Loco Boiler – Part 1	4	39
	Adrian Tester	A Defence of the MR/LMS 4F 0-6-0	0	44
	Adrian Tester	Introduction to Large Lap Valves	0	24
		Total sales	134	1674

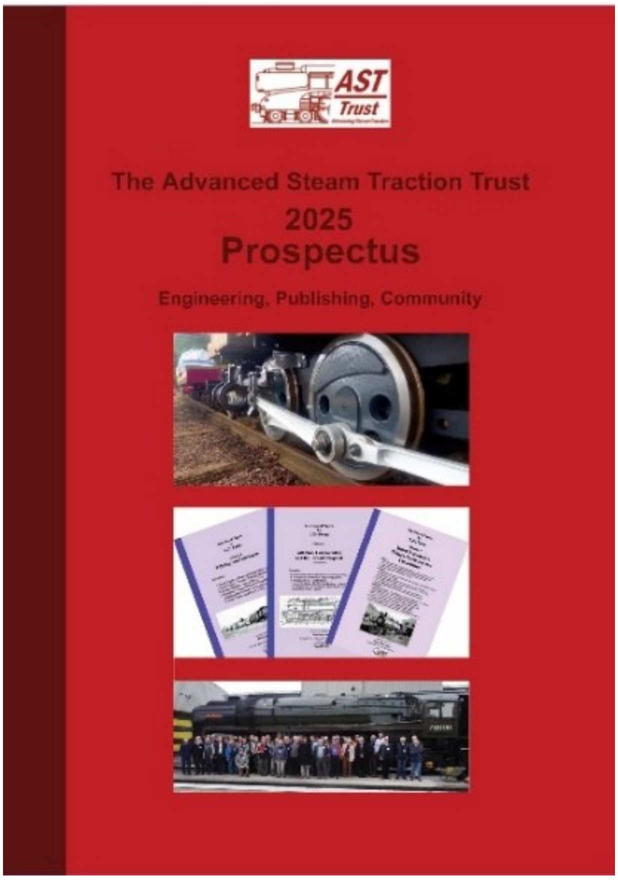
* Camden is now selling these titles in digital format and are no longer sold by ASTT.

¶ ASTT's "Prospectus" was produced for distribution at the Greatest Gathering event in Derby (August 2025). It is however available for sale "at cost" for £2 per copy.

Book sales provide a valuable source of income to ASTT which helps to fund activities, not least our *Revolution* project. **Members are urged to support our endeavours by purchasing books from us.**

Note: We'd like to expand our book selection, so we welcome any suggestions for additional titles that we might be able to sell, or new texts that we might publish under ASTT's logo.

ASTT Prospectus



A promotional "2025 Prospectus" has been prepared, and over 80 copies were printed for distribution to prospective members and donors at the Greatest Gathering event held in Derby in August. Remaining copies will be made available at our 2025 conference and other events. An A4 leaflet was also prepared for more widespread distribution at the event

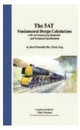
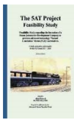
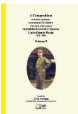
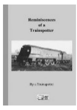
The Prospectus and leaflet are ASTT'S first attempt at producing printed promotional material for general distribution. The Prospectus covers 16 topics in its 22 pages, as below:

ASTT in Brief
Aims
Background
ASTT Management Committee
ASTT Membership
ASTT Conferences
Titles Published by ASTT
ASTT Studies and Projects
The "Revolution" Project
Electronic Performance Testing of Locomotives
Seeking Alternatives to Coal - Trials on the Bure Valley and Other Railways
Other Studies by ASTT
ASTT Website
Appendix 1 - Livio Dante Porta and his Legacy
Appendix 2 - Institution of Locomotive Engineers
Appendix 3 - The 5AT Project (and the birth of ASTT)

Members are encouraged to purchase copies of the Prospectus at an "at-cost" price of £2 each plus postage, to show (or give) to friends and colleagues who might be interested in joining ASTT. Costs will be reimbursed for each new member that they recruit. A PDF copy of the Prospectus can be downloaded from the website at http://advanced-steam.org/wp-content/uploads/2025/08/ASTT-Prospectus-Final.pdf.

Copies of the 2-page leaflet should now be being printed by Bookvault and distributed with each book order that they print and dispatch for ASTT.   A PDF copy can be downloaded at http://advanced-steam.org/wp-content/uploads/2025/08/ASTT-Leaflet-Rev-2b.pdf
It is anticipated that both leaflet and brochure will be updated as ASTT evolves.

Titles published by the Advanced Steam Traction Trust

	Year	Author	Title	Pages	RRP*
	2015	David Wardale	The 5AT Fundamental Design Calculations	556 (b&w)	£49.00
	2016	Alan Fozard and others	The 5AT Feasibility Study edited	230 (colour)	£35.00
	2018	Ian Gaylor	Steam Locomotive Design Specifications and Calculations for New Build Baldwin 2-4-2T 'LYN'	604 (colour)	£52.00
	2018	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 1 - Tribology and Lubrication	250 (b&w)	£25.00
	2019	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 2 - Adhesion, Compounding and the Tornado Proposal	256 (b&w)	£25.00
	2021	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 3 - - Steam Locomotive Boilers, Fireboxes and Combustion	290 (b&w)	£25.00
	2024	L.D. Porta and others Compiled by Martyn Bane	Selection of Papers by L.D. Porta - Vol 4 - Locomotive Boiler Water – Treatment, Circulation and Preheating	513 (colour)	£40.00 (£48 hard cover)
	2025	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 5 - - Exhaust Systems and Other Aspects of Loco Design, Performance and Operation	340 (some colour)	£27.00
	2022	Compiled and edited by Chris Newman	A Compendium of Articles and Papers to celebrate the Centenary of the birth of Livio Dante Porta - Volume 1	226 (colour)	£25.00
	2023	Compiled and edited by Chris Newman	A Compendium of Articles and Papers to celebrate the Centenary of the birth of Livio Dante Porta – Volume 2	331 (colour)	£27.00
	2023	David Wardale	Reminiscences of a Trainspotter	67 (b&w)	£16.00
	2025	Chris Newman	ASTT 2025 Prospectus	22 (colour)	£2.00 (at cost)

* The RRPs (recommended retail prices) shown do not include postage. Paid-up members of ASTT are entitled to a 20% discount on these prices.

These books can be purchased through ASTT's website at http://advanced-steam.org/books-forsale/.

THE AST'S FACEBOOK PAGES
John Hind

We have two Facebook pages, which were set up by Iain Jack, who is the administrator for them. One page has 539 members and the other 354. We are now looking for someone who is willing to stimulate more interest in them by posting news items and follow up with new members of the Facebook group, to encourage them to become come paid up members.

If anyone would like to find out more, please contact me at johnhind@advanced-steam.org or DM me on Messenger – if you are on Facebook, you will know what I mean!

LETTER TO THE EDITOR
Richard Schurmann

The Volume 5 of Selection of Papers by L.D. Porta does contain some gems. One paper that interested me was "A Mechanical Anti-Slipping Device for Steam, Electric or Diesel Locomotives". The paper is dated 1977, but the idea was anticipated many years previously in the aircraft and motor car industry. The combined British Police forces ordered some special "pursuit" cars. One imagines that the idea was to have a faster car than the cars used by the crooks who were being pursued. A short run of cars were especially made by Ford, using a Zephyr as the basis. Whereas Porta used detection of the torque required to accelerate a flywheel when wheel slip instigated, in the motor car application, the acceleration, of opposite sign, when the wheels lock is the more critical matter. The special Zephyrs were four wheel drive with limited slip differentials in both axles and in the transfer case. This prevents the locking of a single wheel, or both wheels at one end on hard braking, but in the more extreme case, when wheel locking does occur, it will be at both front an rear, a serious out-of-control situation.

The flywheel was in a small housing mounted on the transfer case. If sudden deceleration was detected, the brakes were momentarily released. The system was known as the Dunlop Maxaret Anti-Lock Braking system. It was first developed for aircraft. I first read about it in a book about sports cars in the 1960s. A googling of "Maxaret" or look at https://www.jensenmuseum.org/dunlop-maxaret/ yields interesting details.

I am not writing to suggest that Porta copied the Maxaret work without acknowledgement. Perhaps it was an idea that would inevitably pop up in various fields.

COMMUNICATING WITH AI ON THE SUBJECT OF MODERN STEAM

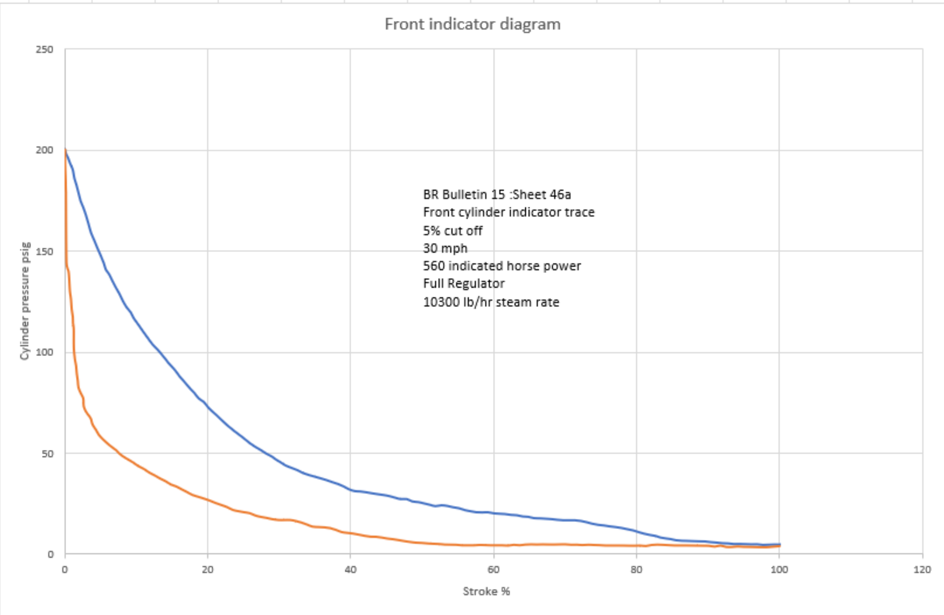
Graham Shirley

with foreword by Chris Newman

On 21st July (2025), ASTT member (and Caprotti valve expert) Graham Shirley wrote to me with some comments on my transcription of Porta's paper on the subject of the 1957 BR Bulletin No 15 on the tests carried out at Swindon on the then near-new Class 8 Pacific No 71000 "Duke of Gloucester". He enclosed with it a spreadsheet containing a table of numbers from which an indicator diagram had been drawn, to which he added a bland note saying "I forgot to say that I digitized the indicator diagrams using AI. See attached."

Data Ref The British transport commission Bulletin # 15 - Performance and efficiency test class 8 3 cyl 4-6-2 express passenger steam locomotive No. 71000
Sheet 46a
Front cylinder indicator trace
5% cut off
30 mph
560 indicated horse power
Full Regulator
10300 lb/hr steam rate

Expansion		Compression		Indicator diagram	
Stroke %	Exp. Cylinder pressure psig	Stroke %	Comp. Cylinder pressure psig	Stroke %	Cylinder pressure psig
0.013332	200.4422	0.021476	200	0.013332	200.4422
0.240541	197.8154	0.089684	199.9484	0.240541	197.8154
0.507273	195.8901	0.100705	193.2917	0.507273	195.8901
0.738767	193.6113	0.178888	184.5051	0.738767	193.6113
0.950522	191.8736	0.19077	181.2631	0.950522	191.8736
1.180038	189.8063	0.218551	178.9624	1.180038	189.8063
1.392233	185.7649	0.21971	176.0306	1.392233	185.7649
1.661909	182.6835	0.295307	144.0543	1.661909	182.6835
1.973268	178.4312	0.560728	140.1434	1.973268	178.4312
2.248881	174.6601	0.660186	136.7976	2.248881	174.6601
2.616118	171.4947	0.763568	130.3879	2.616118	171.4947
2.99621	167.6327	0.913283	126.2736	2.99621	167.6327
3.339488	163.5147	1.026609	121.0085	3.339488	163.5147
3.71037	158.8794	1.175653	117.4897	3.71037	158.8794
4.176822	154.9962	1.201406	114.3826	4.176822	154.9962
4.603553	151.2859	1.304672	111.2668	4.603553	151.2859
5.084697	147.4246	1.316968	102.4003	5.084697	147.4246
5.499719	143.8089	1.458055	96.69787	5.499719	143.8089
5.784551	140.6329	1.633197	93.23269	5.784551	140.6329
6.229448	138.4175	1.728761	89.42073	6.229448	138.4175
6.665613	135.2728	1.870368	85.7729	6.665613	135.2728
7.146453	131.9767	1.96767	82.43737	7.146453	131.9767



71000 Indicator Diagram as created by Microsoft's Co-Pilot AI software.

Not surprisingly, this revelation sparked my interest, prompting me to write back to ask:

> "I wonder if you'd be interested in telling the story behind it in the form of an article for our Newsletter. I think it might generate a lot of interest – how the steam movement might put AI to good use!"

He wrote back to say:

> "Happy to work with you on an Ai article for the newsletter. They say if you have a dog don't bark yourself! So, I asked Copilot to write it … see attached.
>
> I didn't manage to get a polished version to publish. It needs some more work from the editor."

His concluding comment might be right, but I think the unpolished version might be better in revealing the raw power (and perhaps, the limitations) of AI. Graham's communications with MS's Copilot also offers lessons in how best to communicate with AI.

Anyway, Graham's questions (and Copilot's answers) fall into two categories:

"The Art of Prompting — Making AI Your Engineering Companion", and

The article itself – "AI in Steam Engineering: Timing the Perfect Exhaust - How digital intelligence supports heritage locomotive design

Record of Graham Shirley's communication with Microsoft's "Copilot" AI software (July 2025).

Note: Graham's questions appear in regular font. MS Copilot's responses are in *italics.*

Graham Shirley: Good afternoon, can you help me today?
***Copilot AI**: I'm ready whenever you are — whether you're diving into something technical, exploring solar energy, or taking a nostalgic trip along the Clun Castle's tracks. What are we tackling today: a tangled bit of Python, a historic mystery, or maybe troubleshooting a scanner that's being cheeky again?*
I have been asked to write an article for the Advanced Steam Traction Trust's next Newsletter. The title of the article will be "The use of AI for modern steam locomotive engineering." I would like to discuss the art of making a good prompt to assist with the AI generation of the best response.
That sounds like a brilliant and timely article, — blending the heritage and hands-on craftsmanship of steam engineering with the modern magic of artificial intelligence. You could absolutely turn this into an engaging piece for readers who want to preserve tradition without missing out on the benefits of today's technology.
I would like examples to cover some questions that might be asked.
An engineer wants to make a threaded hole for a 3/8-inch British standard Whitworth Stainless steel 304 bolt. Help with the instructions to make the hole; size of the tapping drill, tap purchase, thread cutting fluid to use, instructions for tapping action and the recommended tightening torque for the bolt.
Let's break it into two parts: first, how to craft good prompts when asking an AI for technical guidance, and then use your engineer's threaded hole question as a real-world example.

The Art of Prompting Part 1 — Making AI Your Engineering Companion

To harness AI effectively for modern steam locomotive engineering, engineers must know how to talk to it. A well-formed prompt:
*Is **specific**: It clearly states the engineering task.*
*Is **context-rich**: It includes material type, standards (e.g. BSW), machine constraints.*
*Has a **goal-oriented tone**: Whether seeking step-by-step instructions or optimization recommendations.*
*Uses **real-world framing**: As if explaining to a skilled apprentice.*

Example of a weak prompt:
"Tell me about drilling for bolts."
Example of a strong prompt:
"I need to drill and tap a hole for a 3/8-inch BSW stainless steel 304 bolt. What tapping drill size, cutting fluid, tapping method, and torque should I use?"
Think of prompting like drafting a spec: the more precise, the better the AI can respond with actionable insight.

The Art of Prompting Part 2 — Example Response to an Engineering Prompt

Here's the AI-generated guidance for your example:
Engineering Task
Create a threaded hole for a 3/8-inch British Standard Whitworth (BSW) bolt in Stainless Steel 304.
Tapping Drill Size
- ***Drill size required**: ~7.90 mm Whitworth threads are based on thread depth and pitch. For 3/8" BSW (16 threads per inch), subtract the thread depth from the bolt's major diameter:*
- *BSW Major Diameter: 0.375 inch (9.525 mm)*

Recommended tapping drill: 7.90 mm (can vary slightly depending on thread engagement needs)

Tap Purchase

- *Choose a **3/8-inch BSW tap set** (typically taper, second, and bottom taps if full-depth threads are required)*
- ***Material**: HSS (High Speed Steel) or cobalt-alloyed for stainless applications*

Look for brands rated for hard metals—Dormer, Presto, or RS Pro are common choices

Thread Cutting Fluid

- *Use **high-performance tapping fluid suitable for stainless steel**, such as:*
  - *Rocol RTD Liquid*

Trefolex CDT Cutting Compound These reduce galling and extend tap life significantly.

Tapping Instructions

1. ***Secure the workpiece** in a vice or jig*
2. ***Apply cutting fluid** liberally to the hole and tap*
3. *Start with a **taper tap**, aligning it perpendicular to the surface*
4. ***Turn slowly** with steady pressure — ¼ turn in, then ⅛ turn back to break chips*
5. *Follow with second and bottoming taps if full depth is required*

***Clear chips** frequently, reapply cutting fluid as needed*

Bolt Tightening Torque

- *For **3/8" BSW in stainless steel 304**, a general guideline: **Torque**: ~25–30 Nm (This depends on thread engagement, lubrication, and application — verify against engineering standards if used in pressure-bearing components.)*

An Engineering Prompt from Graham Shirley

An engineer wants a review of an archive Institute of Locomotive engineers' paper 403 G. DA COSTA, B.E. (Associate), on the 31st of October 1938, in Bombay titled "THE INDICATOR DIAGRAM AND THE EFFICIENCY OF THE NON-CONDENSING SIMPLE EXPANSION STEAM LOCOMOTIVE."
Can I upload a file for you to review?

Thanks for uploading that,— what a treasure trove of locomotive wisdom. C. Da Costa certainly didn't shy away from depth! There's plenty here that could enrich your newsletter article, especially around how AI could support the engineering principles laid out in that 1938 paper.

Would you like to explore how specific concepts from the paper — like optimizing valve timing, improving steam circuit efficiency, or comparing indicator diagrams — could be reimagined with AI today? I can also help you weave historical references from the document into your article's narrative, perhaps juxtaposing the idealized engine cycle with AI-assisted simulation and design techniques.

Another Engineering Prompt from Graham Shirley

Tell me when the exhaust valve of a poppet valve system should close depending on the cut off set on the engine?

*Great question, — and one that gets right to the heart of efficient steam cycle design. In a poppet valve system, especially one with **independent inlet and exhaust cams** (like the Franklin or Caprotti types), the **exhaust valve closure timing** can be finely tuned to match the cut-off setting and optimize both power and economy.*

Here's a general guide based on theoretical and practical insights:

Exhaust Valve Closure vs. Cut-Off Setting

Cut	***Recommended Exhaust Valve***	***Purpose***
10	*~50–54%*	*High-speed running; early compression for cushioning*
20	*~43–47%*	*Efficient steam use with moderate compression*
30	*~35–39%*	*Balanced economy and power*
40	*~25–29%*	*Late cut-off, low-speed heavy load; min. compression*
50	*~10–20%*	*Max tractive effort; compression less critical*

These values are approximate and depend on:

Clearance volume *(smaller clearance = earlier compression)*

Boiler pressure and superheat

Desired final compression pressure *(ideally ~90% of boiler pressure at high speeds)*

Why It Matters

Early cut-offs *(used at high speeds) need* ***earlier exhaust valve closure*** *to allow enough time for compression and avoid shock at admission.*

Late cut-offs *(used at low speeds or heavy loads) benefit from* ***later exhaust closure****, maximizing expansion and tractive effort.*

In cam-operated systems, this timing can be ***varied continuously****, unlike Walschaert gear which has interdependent valve events. That's one reason poppet systems shine at early cut-offs — they allow* ***precise control*** *over each event.*

Would you like to include a diagram or table like this in your newsletter article? I can help format it for print or even draft a section explaining how AI could assist engineers in optimizing these timings dynamically.
Just let me know how you'd like to approach it, and we'll get drafting.
If you'd like, I can help you polish this into full newsletter article format — even with an opening paragraph that ties AI into the legacy of Clun Castle or similar heritage icons. Shall we draft that next?
Can I have the document in word format?
I can't create or export Word documents, but I can absolutely help you format everything so it's ready to paste directly into one — complete with headings, spacing, and layout cues.
Here's your formatted newsletter section, ready for copy-paste (see overleaf)

Title: AI in Steam Engineering: Timing the Perfect Exhaust
Subtitle: How digital intelligence supports heritage locomotive design

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Poppet Valves and Steam Timing

Poppet valve systems offer something rare in locomotive engineering: independence. Unlike traditional Walschaert gear, cam-operated valves allow inlet and exhaust events to be tuned separately — empowering engineers to match valve behavior precisely to operating conditions.

But when should the exhaust valve close?

It all depends on the cut-off setting and the desired compression for the stroke. With AI, these calculations become both faster and more accurate.

Prompting for Precision

Engineers today can use AI tools like Copilot to generate exact recommendations based on a short input. For example:

Prompt:

"What exhaust valve closure timing is recommended for a poppet valve steam locomotive operating at 180 psi boiler pressure, using early cut-offs at high speed, with 8% cylinder clearance?"

This unlocks targeted data — like the chart below — and can also return simulated indicator diagrams and recommended cam profiles.

Exhaust Valve Closure Timing Table

Cut	*Exh*	*Compression Purpose*
10	*50–*	*High-speed cushioning; avoids shock*
20	*43–*	*Smooth running with efficient steam use*
30	*35–*	*Balancing fuel use and mechanical efficiency*
40	*25–*	*Suitable for heavier loads; extended expansion*
50	*18–*	*Moderate compression; tractive effort focus*
60	*14–*	*Extensive expansion at lower speeds*
70	*10–*	*Minimal compression; high steam throughput*
80	*5–*	*Quick exhaust; short cushioning phase*

How AI Assists

AI can:

- *Simulate steam cycles across speeds and cut-off points*
- *Recommend cam profiles for precise valve events*

Optimize power vs. fuel usage dynamically per locomotive duty

As Da Costa wrote in 1938, the ideal steam cycle was largely a theoretical pursuit. With AI today, that ideal can be approached — and refined — in real time.

To simulate a steam cycle — especially one relevant to locomotive engineering — you can use modern tools that combine thermodynamic modelling with AI-assisted optimization. Here's a breakdown of how it works and what's available:

What a Steam Cycle Simulation Involves

A typical simulation models the flow of steam through:

Boiler*: Generates steam at a set pressure and temperature*

Steam Circuit*: Includes pipes, valves, and superheaters*

Cylinder or Turbine*: Converts thermal energy into mechanical work*

Exhaust System*: Releases spent steam, possibly with compression*

The simulation calculates:

Pressure and temperature at each stage

Work done per cycle

Steam consumption per indicated horsepower-hour

- *Efficiency compared to ideal cycles (Carnot, Rankine, or Da Costa's)*

AI-Enhanced Simulation Tools

Here are some standout platforms that support steam cycle modeling:

Tool	***Features***	***Use Case***
i-Steam™	*Non-linear modeling of steam and power systems; hydraulic modeling of headers*	*Ideal for optimizing locomotive steam circuits*
IPSE GO	*Graphical interface; step-by-step steam cycle setup; composition control*	*Educational and industrial process simulation*
Cycle-Tempo	*Thermodynamic and exergy analysis; supports complex integrated systems*	*Advanced design and performance evaluation*
STEAM MASTER	*Predicts plant performance under varying loads and conditions*	*Simulation of conventional steam power plants*
PyRankine	*Open-source Python-based Rankine cycle simulator*	*Customizable for locomotive-scale modeling*

These tools allow engineers to:

- *Simulate real-world steam behavior*
- *Compare actual vs. ideal performance*
- *Optimize valve timing, boiler pressure, and cut-off settings*
- *Visualize indicator diagrams and steam rate curves*

Would you like help setting up a simulation using one of these tools — perhaps a Da Costa-style locomotive cycle with early cut-off and cam-operated valves? I can walk you through the parameters or even help you write a Python script using PyRankine. Let's bring steam into the digital age.

Let me know if you'd like me to help polish your full article for flow, tone, or print-readiness — or if you want help adding illustrations, diagrams, or historical footnotes. We can make this one a standout piece.

Example 3 – Steam Table calculations. ASTT example FDC 1.3

Steam expands from 21.39 bar with 450 degrees superheat with an isentropic efficiency on 0.85 to 1.5 bar. What will be the steam temperature when the poppet valve opens?

*To estimate the **steam temperature at the point of exhaust valve opening** (after expansion from 21.39 bar and 450 °C to 1.5 bar with an isentropic efficiency of 0.85), we'll walk through the thermodynamic steps using the **Mollier diagram method** and steam tables.*

Step-by-Step Thermodynamic Estimation

1. Initial Steam Conditions

- ***Pressure (P_1)***: *21.39 bar (absolute)*
- ***Temperature (T_1)***: *450 °C*
- *From steam tables:*
  - ***Enthalpy (h_1)*** *≈ 3270 kJ/kg*

Entropy (s_1) *≈ 7.254 kJ/kg·K*

2. Isentropic Expansion to 1.5 bar

- ***Isentropic efficiency (η_s)***: *0.85*
- *From steam tables at 1.5 bar:*
  - ***Isentropic enthalpy (h_2s)*** *≈ 2680 kJ/kg (from constant entropy line)*
  - ***Actual enthalpy after expansion (h_2)***:
  - *(h_2 = h_1 - \eta_s \cdot (h_1 - h_{2s}))*

(h_2 = 3270 - 0.85 \cdot (3270 - 2680) = 2779 kJ/kg)

3. Determine Temperature at 1.5 bar and h_2 = 2779 kJ/kg

- *At 1.5 bar, saturation temperature ≈ 111.4 °C*
- *Since h_2 > h_g (saturated vapor enthalpy ≈ 2706 kJ/kg), steam is* ***still superheated***
- *From superheated steam tables:*
  - *At 1.5 bar and h ≈ 2779 kJ/kg →* ***T ≈ 180–190 °C***

Final Answer

Estimated steam temperature when the poppet valve opens:

≈ 185 °C*, assuming expansion ends at 1.5 bar with 85% isentropic efficiency.*

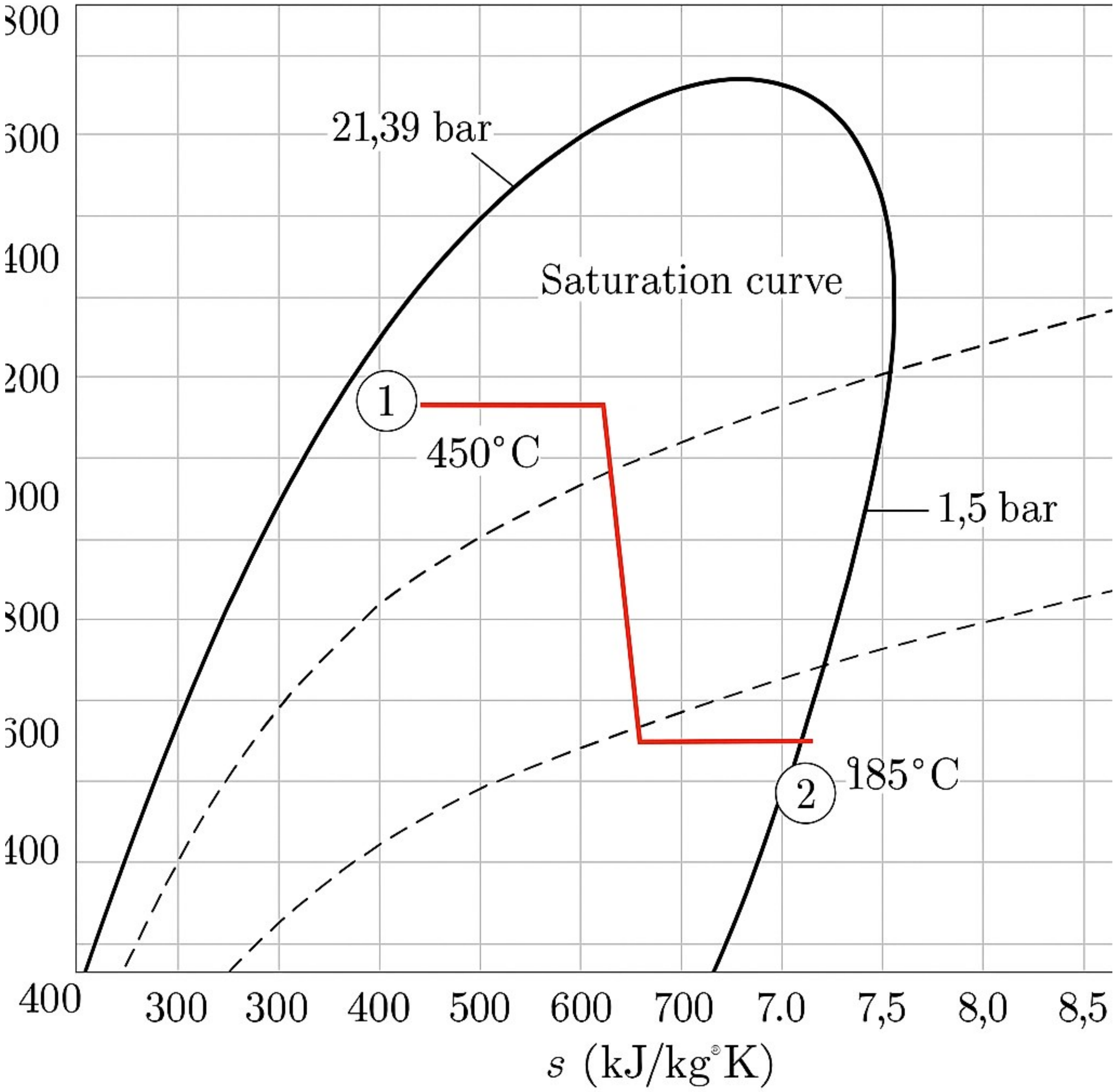
Would you like to see this visualized on a Mollier diagram or plotted as part of a simulated indicator diagram? I can help sketch that out or guide you through a Python-based simulation.

Yes on a Mollier diagram please.

Here's your Mollier diagram with the steam expansion path illustrated — including the isentropic and actual trajectories. It captures the transition from high-pressure, high-superheat to low-pressure exhaust conditions, showing how the efficiency affects final enthalpy and temperature.

Let me know if you'd like to overlay additional working cycles or highlight locomotive-specific steam conditions.

Well, the Mollier diagram is artistically correct but technically not there yet!



Final Thought: Why It Matters

In the realm of modern steam engineering, where restoration meets innovation, AI is the draughtsman's assistant, the toolroom encyclopaedia, and even the virtual apprentice. By mastering the way we ask, we master the quality of what AI gives in return.

Postscript by Chris Newman

I followed Graham's advice and asked MS Copilot "How did L.D. Porta contribute to steam development?". I was gratified to receive an answer derived entirely from a single reference: https://advanced-steam.org! Copilot's response was as follows:

Livio Dante Porta was a visionary Argentine engineer who revolutionized steam locomotive technology long after most had written it off. His contributions spanned nearly five decades and reshaped how engineers thought about steam power.

Key Innovations

- ***Gas Producer Combustion System (GPCS)****: Porta pioneered this method to reduce smoke and improve combustion efficiency by introducing over-fire air and controlling firebed conditions.*
- ***Advanced Exhaust Systems****: He developed the* ***Lempor*** *and* ***Kylpor*** *exhausts, which improved draughting and reduced back pressure, boosting locomotive performance.*
- ***Water Treatment & Boiler Efficiency****: Porta emphasized proper water chemistry and insulation to extend boiler life and reduce maintenance.*

Thermodynamic Optimization*: He applied rigorous scientific principles to steam design, improving thermal efficiency and power output dramatically.*

Practical Applications

- ***Rebuilding Locomotives****: Rather than designing new engines, Porta focused on upgrading existing ones. His rebuilds in* ***Argentina, Cuba, Brazil, and Paraguay*** *often outperformed diesel counterparts*
- ***Rio Turbio Railway****: As general manager, he modified 2-10-2 locomotives to haul 2,000-ton coal trains over 255 km of narrow-gauge track—an astonishing feat.*
- ***ACE 3000 Project (USA)****: Porta was tapped as VP of R&D for this ambitious automated steam locomotive initiative in the 1980s.*

Cuban State Railways*: He designed the* ***LVM 800****, a new steam locomotive for shunting and branch lines, though it was never built due to political shifts*

Global Influence

- *Porta mentored and inspired modern steam engineers like* ***David Wardale****,* ***Phil Girdlestone****, and* ***Roger Waller****, who carried his principles into new designs like the* ***5AT Project.***

His work extended to the UK, where he helped retrofit National Coal Board locomotives with cleaner-burning fireboxes and exhausts

Porta didn't just keep steam alive—he made it smarter, cleaner, and more competitive.

Following Graham's line of thought, I also asked Copilot to review ASTT's website, which generated an equally pleasing result:

The Advanced Steam Traction Trust (ASTT) website is a well-organized hub for anyone interested in modern steam locomotive development and the legacy of engineers like L.D. Porta.

What You'll Find

- ***Mission & Background****: Clear explanation of ASTT's goals—promoting advanced steam traction and supporting research and development.*
- ***Technical Resources****: Includes detailed papers, diagrams, and updates on steam technology projects, especially those influenced by Porta's work.*
- ***News & Updates****: Regular posts about steam developments, events, and engineering milestones.*

Membership Info*: Offers ways to get involved, including joining the trust or donating to support ongoing work.*

Highlights

- ***Clean layout****: Easy to navigate with logical sections.*
- ***Depth of content****: Rich technical insights for enthusiasts and engineers alike.*

Historical context*: Connects past innovations with future possibilities.*

Areas for Improvement

- *Some pages could benefit from more visuals or interactive elements to engage newer audiences.*

A few technical documents might be dense for casual readers—perhaps summaries or explainer videos could help.

Overall, it's a solid resource for anyone passionate about keeping steam technology alive and evolving.

A DIFFERENT APPROACH TO FRONT END DESIGN RAISES SOME TRICKY QUESTIONS

Martin Johnson

1. INTRODUCTION

This article describes some work I have been doing subsequent to working with Chris Newman and David Fryer on the transcription of Porta's papers on Lempor and Kylpor design. See Ref. 6.1 . Part of this work involved setting Porta's theory in the context of more recent design methods for predicting the performance of jet pumps as summarised for example in Ref. 6.2 . All of the well known theories of jet pumps and locomotive front ends utilise conservation of mass, momentum and energy to develop equations describing the performance of the device. They may vary in how they develop the equations and which losses might be accounted for but they are similar in fundamental approach. The modern approach expresses performance of a jet pump in terms of a mass flow ratio M (in our context, flow of exhaust gas / flow of steam and sometimes known as entrainment ratio) against a pressure ratio N (in our context, draught / exhaust back pressure). If the calculations for both M and N use consistent units, then the efficiency of the front end considered as a pumping machine becomes M.N. The advantage of working in terms of M and N rather than steam flow, gas flow, draught and back pressure is that it reduces 4 variables to 2 which would have greatly simplified Porta's work, for example.

I am strongly in favour of the N - M approach as it is a summary of the available theory which has been widely applied with success across a wide range of industries. The approach predicts a performance curve stretching from zero M to zero N (See Figure 1), which looks similar to a centrifugal pump performance curve. That is not surprising since centrifugal and jet pumps are both momentum exchange devices, but it gives us a fresh way of thinking about how the resistance of the locomotive gas circuit comprising ashpan, grate, firebed, firebox, tube bank and smokebox interact with the performance of the front end.

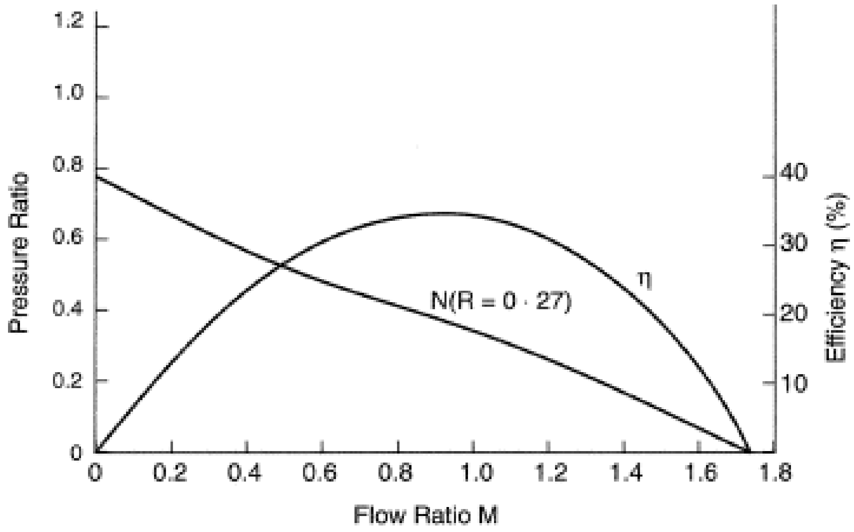


Figure 1: A typical jet pump performance curve.

With pumps of any sort the operating point is where the curve of resistance from the system (measured as draught required in our case) against gas flow intersects with the graph of pressure provided by the pump (smokebox vaccum in our case) plotted against gas flow. The key question that started this current line of thought is "What does the resistance of the boiler look like if plotted on non-dimensional N - M axes?" This article summarises progress so far along with some intriguing questions thrown up by the work.

2. CALCULATING M & N

Before going further, it is important to state the assumptions made in deriving M & N:

2.1 M

Steam flow is the feed water as measured plus any benefit from exhaust steam injectors. This is exactly as David Pawson and Derby calculated steam flow.

The exhaust products are deduced from David Pawson's transcribed data using methods as set out in Ref. 6.3 as I believe this to be a better estimate of gas flow than the Derby or Lawford Fry methods. My method is similar to Lawford Fry's improved method as described in Ref. 6.4 , page 49 et. seq.

Exhaust products are assumed to comprise:

- Dry products of combustion
- Moisture sequestered in the coal
- Moisture produced from hydrogen in the fuel
- Unburnt carbon ejected as soot & cinders.

I have not included fly ash in exhaust products; in reality some ash will be ejected and some unburnt carbon lost to the ashpan but the above assumptions are reasonable and simple to apply

2.2 N

I have taken the exhaust back pressure as that measured by Derby. There should be a correction to include velocity energy within the exhaust pipework. However, there seems to be no record of the precise point where pressure tappings were placed and hence the diameter and velocity are not precisely known. Therefore, the correction is assumed to be insignificant. However, it is acknowledged that some Swindon tests are significantly affected by the absence of this correction.

The smokebox vacuum is that measured in tests. This should similarly have a correction for velocity energy within the smokebox but as with the steam pressure measurements, precise details of tapping points are not available. Therefore, the correction is assumed to be insignificant.

Both components that make up N are widely oscillating - varying with every exhaust pulse - and were measured using highly damped instruments that record a time averaged value. That is a potential source of systematic errors into the experimental data.

3. SOME TYPICAL BOILER PERFORMANCE DATA VIEWED AS N Vs. M DATA

For illustration of how the N - M method can be useful two examples are discussed below:

3.1 JUBILEE CLASS 45722

The problems with getting the Jubilee class to deliver their full potential are well documented. Figure 2 shows the Derby test results split into two groups, which I have called "single chimney" and "double chimney". Within those groups there are variations in dimensions which are summarised along with the relevant non dimensional parameters as follows:

Chimneys	Blast pipe dia. Dbp Inches	Choke dia. Dch Inches	Chimney exit dia. Inches	Nozzle to choke height h Inches	Chimney height H Inches
1	4.75	14.25	17.125	36.375	25.5
1	5.5	14.5	16.5	33.875	28
2	4.0	11.25	13.5938	23.688	32.875
2	4.25	11.25	13.5938	23.688	32.875

	Area ratio of Jet Pump R	Area ratio of Diffuser	Ratio h/Dbp	Ratio H/Dch	
1	0.11	1.44	7.66	1.79	
1	0.14	1.29	6.16	1.93	
2	0.13	1.46	5.92	2.92	
2	0.14	1.46	5.57	2.92	

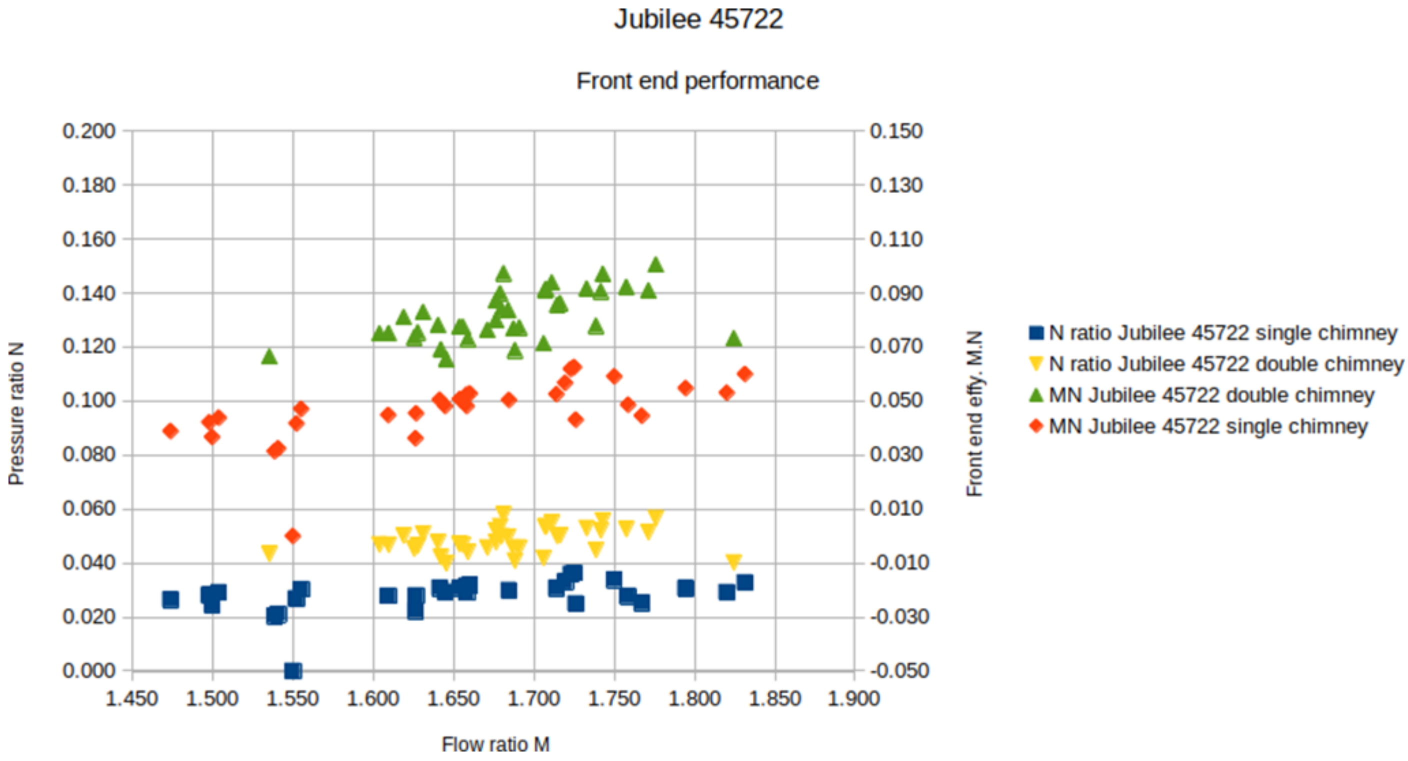


Figure 2: Front end tests shown as N Vs. M and M.N Vs. M

Figure 2 shows the Pressure ratio N on the left hand axis and Efficiency M.N on the right hand axis. Both groups of N data form a cluster with a slight rising gradient over a small range of M. Similarly the efficiency data shows a more marked rising gradient. The advantage of the double chimney design is clearly shown, whereas variations in geometry of the single chimney clearly have little effect and are lost in the experimental scatter.

The level of efficiency is interesting, being around 5% for the single chimney design, and from 7 to 10% for the double chimney. Most of the Rugby data shows front efficiency values around 7.5%, so the single chimney performance is particularly poor.

3.2 BR Class 9 - Double chimney and Giesl compared

Of all the Derby data, only one draughting system stands out from the various single and double chimney designs. Figure 3 below shows the extent of the difference.

The N data for the Giesl ejector is significantly higher than that for the double chimney. This is because the exhaust back pressure (the denominator in N) is lower for the Giesl, but one would expect the boiler resistance to be identical for both cases.

The efficiency of the Giesl (12 to 19%) is much better than Swindon's best practice for a double chimney (7 to 11%).

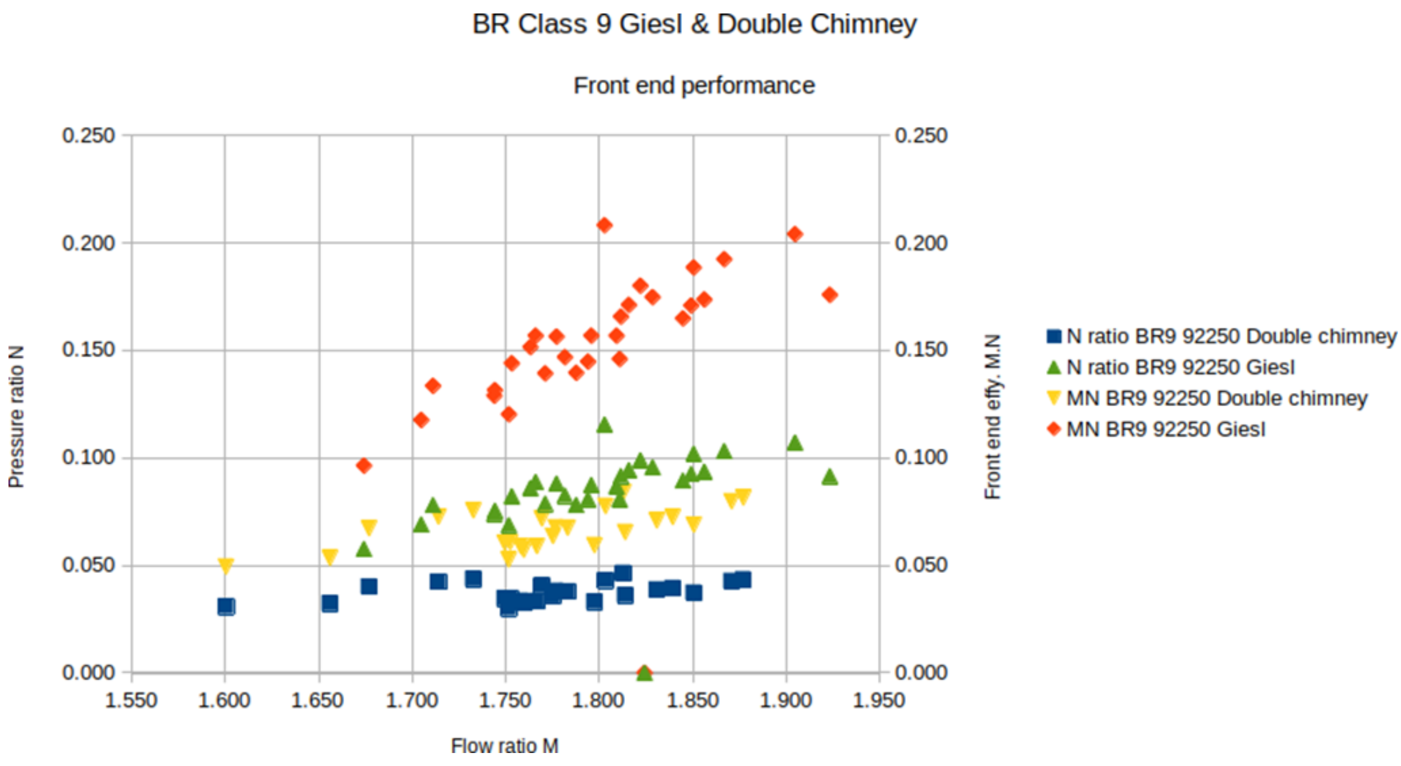


Figure 3: Performance of a double chimney compared with a Giesl chimney.

That does raise the question about what defines a good front end since the double chimney 9F is widely recognised as a good design. Sadly, Derby seemed to be fixated on fuel saving which in my opinion is only part of the answer. However, that is a discussion for another day.

4. DISCUSSION

All of the Derby data shows similar characteristics to the above two examples. The N data represents the draught resistance imposed by the boiler divided by the exhaust back pressure, but the problem of how that interacts with the jet pump performance still remains. I therefore went into more detailed analysis of the data for the BR 9F (92013 & 92050) single chimney with 5.25" blast pipe, mainly because the original data includes detail of damper settings which was a variable I wanted to be able to eliminate.

4.1. THE BOILER RESISTANCE CURVE

The first step in seeing how this appears on N Vs. M axes was to correlate the basic data for the following:

1. Steam production against flue gas flow. As is well known, this closely approximates to a straight line with zero intercept and in this case steam flow was 0.5799 x gas flow with a correlation coefficient of 0.998.

2. Exhaust back pressure against flue gas flow. This fitted a power law model with a correlation coefficient of 0.963.

3. Boiler draught requirement against flue gas flow. I used only data that was noted as both ashpan dampers full open in deriving the correlation although the difference between data where the dampers were in use was minimal. This fitted a power law model with a correlation coefficient of 0.940

The correlation graph for items 2 & 3 above is shown in Figure 4. Exhaust back pressure is shown in inches water gauge to be compatible with the draught measurement. The derived equations are clearly a good fit to the observed data.

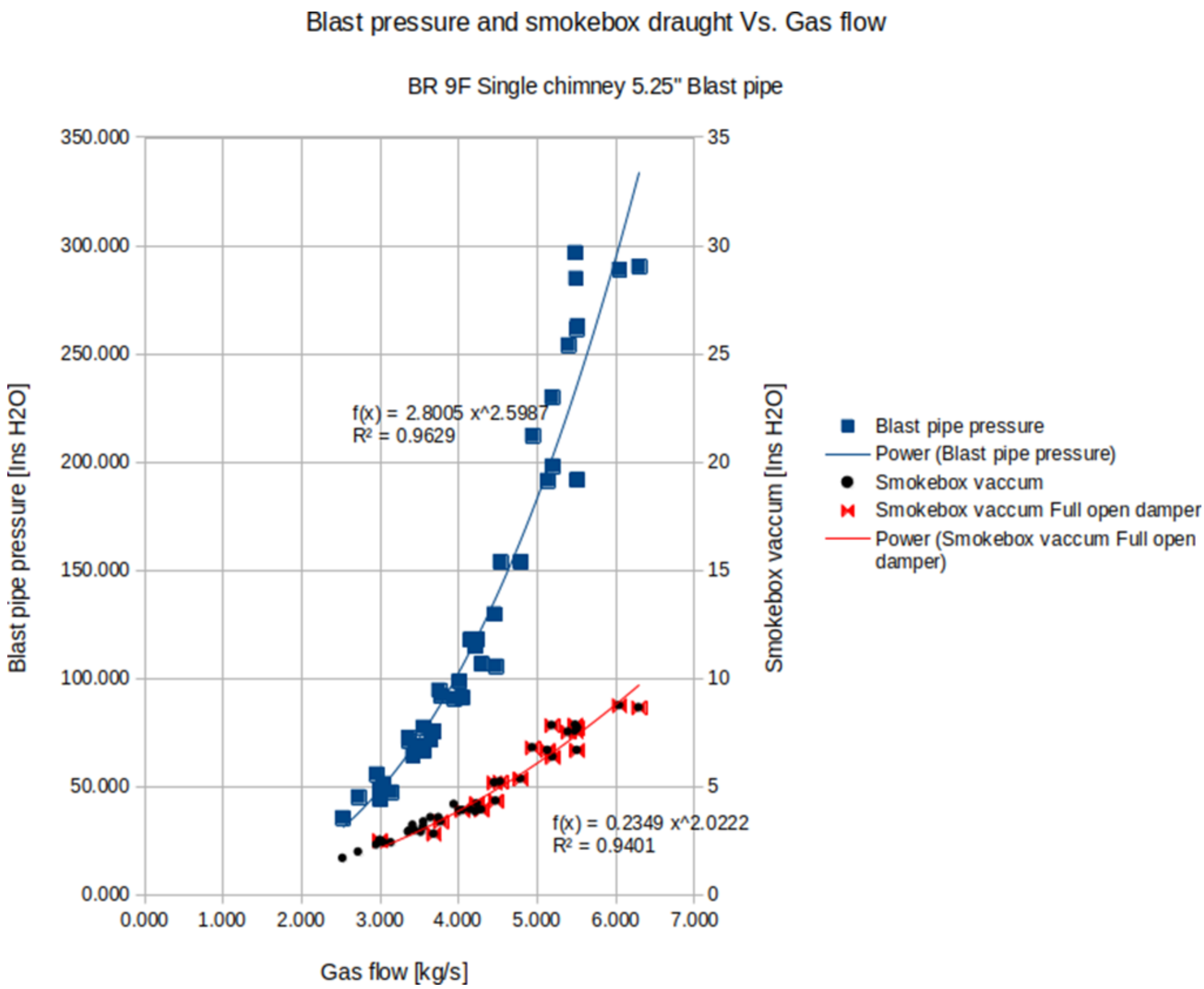


Figure 4: Correlation of draught and back pressure against flue gas flow.

Using the above correlations, the curve fitted data for M and N can be generated as follows:

Gas Flow kg/s	Steam flow kg/s	M	EBP ins H2O	Draught ins H2O	N
1.500	0.870	1.724	8.032	0.533	0.066
2.500	1.450	1.724	30.294	1.498	0.049
3.500	2.030	1.724	72.628	2.959	0.041
4.500	2.610	1.724	139.553	4.918	0.035
5.500	3.189	1.724	235.080	7.380	0.031
6.500	3.769	1.724	362.872	10.346	0.029

M is the reciprocal of the gradient of the graph of steam flow Vs. gas flow and thus stays constant. N varies because the indices of the two power law models for exhaust back pressure and draught are not the same. The system curve is shown to be a vertical straight line when viewed on N Vs. M axes. Interestingly, the highest value for N occurs at the lowest value of gas flow. The front end therefore has to work harder at low steaming rates because the exhaust back pressure which provides the motive power is lower relative to the requirement for draught. **So the worst design case for the exhaust system is actually at low steaming rates.** The required N value would continue to rise until zero gas flow according to the above correlations, although natural draught and the ability to use the blower would be mitigating factors at very low work rates. The vertical extent of the N line is proportional to the difference in power index between the blast pipe pressure and smokebox vacuum indices as show in Figure 4 and the range of gas flows required to be achieved.

The above observations gives a hint as to why locomotive performance is so sensitive to draughting; if it is not possible to overcome the low steaming rate case, then the locomotive will be limited to very low steaming rates. However, once the front end is sufficiently improved to overcome the low steaming rate case, the remainder of the performance up to high steaming rates is suddenly accessible and the apparent change in performance is miraculous.

4.2. INTERACTION OF FRONT END AND BOILER DRAUGHT DEMAND

The next step was to construct the expected front end performance. This can be done using Porta's formula ,for example, as published for Lempor exhausts or the online calculator at Ref.

6.5 run repeatedly at differing gas and steam flows. I chose to use the formula quoted in Ref.

since I am working in N and M terms and already have a spreadsheet version of the formula. My spreadsheet is available for those interested, emails via. the editor or Chris Newman, please.

My input data for the jet pump formula was:

Jet pump Area ratio R See note *	0.1185165	Calculated from (5.25"/15.25") ^ 2
Density ratio C	1.06	Calculated from average densities of smoke and steam.
Kp	0.01	Equivalent to a Cd of 0.99 for a well designed nozzle
Ks	0.05	Typical value for a bellmouth style inlet.
Km	0.05	Pessimistic value for skin friction loss in chimney.
Kd	0.9	As described below.
M ranges over	0.8 to 2.0	To encompass the range of interest.

* - Note there is an error in Ref 6.2 which refers to R being a ratio of diameters. It is the ratio blast nozzle area / chimney choke **area**.

Using the known geometry of the diffuser part of the chimney, published data such as Porta predicts a Kd = 0.67. However, all the published theory (Zeuner, Strahl, Cox, Porta, ESDU etc.) makes the assumption that the diffuser outlet velocity profile is flat. Young (1933) and subsequent CFD analyses have shown that it is far from flat, which results in excess kinetic energy being lost from the system. By increasing the Kd value to 0.9, one can correct for the extra lost energy and match the observed test results. From which it can be inferred that the outlet kinetic energy is about 134% (i.e. 0.9/0.67) of that for a flat exit profile in this case.

Figure 5 shows results of the above calculation along with the test data and the smoothed boiler resistance curve of Section 4.1 . The experimental N data is shown as blue symbols, while the predicted front end performance for N is shown as a blue line and both should be read on the left axis. In addition the vertical black line shows a smoothed boiler resistance curve and should also be read on the left axis. The obseved N.M data is shown as orange symbols and the predicted front end efficiency is shown as an orange line.

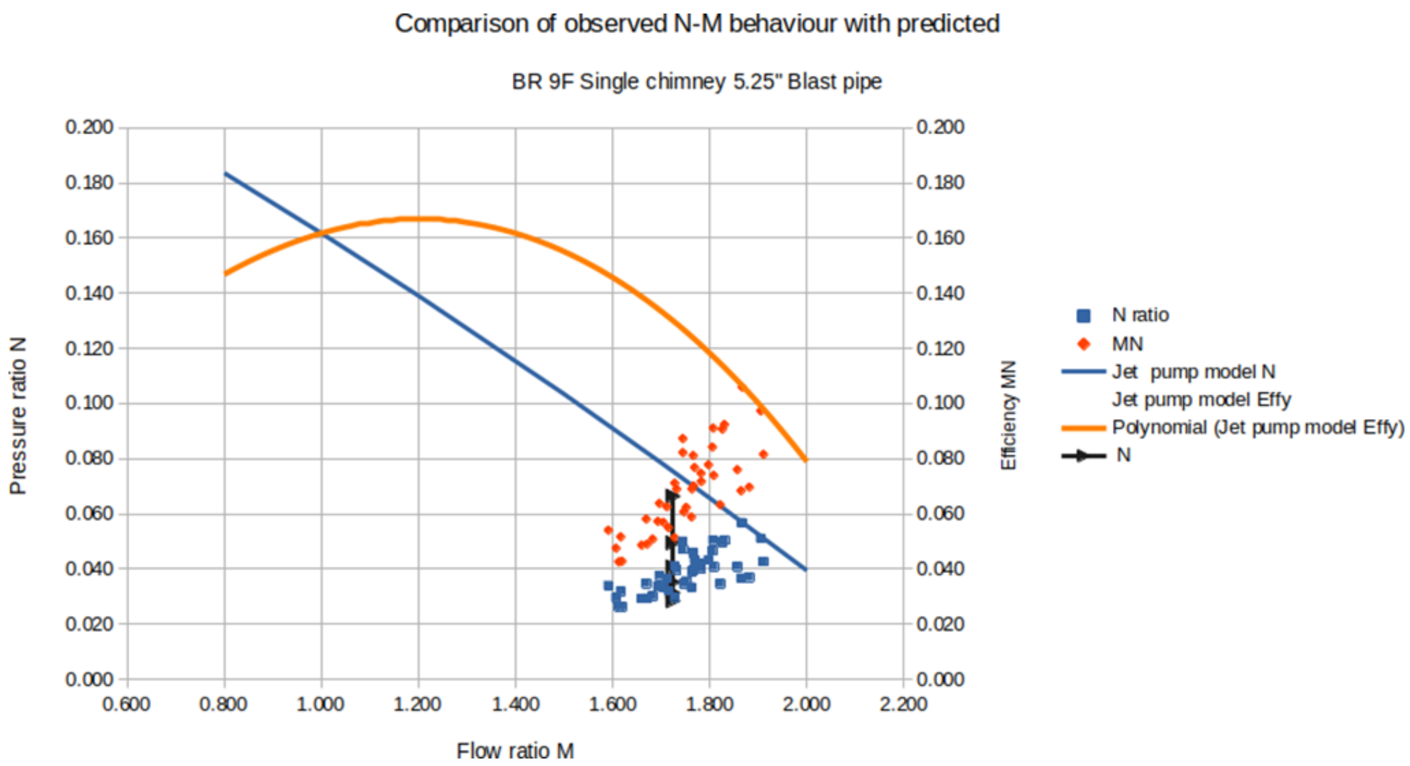


Figure 5: Experimental results for N and efficiency N.M plotted with predicted front end performance.

There are several points of note in Figure 5:

1. The observed (blue) N data points are clustered around the smoothed N boiler resistance curve (black). This is to be expected since the latter is calculated from curve fits to the former.
2. The experimental data for N shows a positive slope rather than the vertical line of the smoothed resistance line or the falling slope of the predicted front end performance.
3. Similarly, the observed N.M data has a rising slope in contrast to the falling slope of the predicted front end efficiency curve.
4. Both the predicted N curve and jet pump efficiency curve just include the uppermost points of the observed data because the Kd value has been chosen to achieve that.
5. The maximum efficiency of the predicted front end performance ocurrs at an M value of 1.2 which is well below the required value of around 1.74. That suggests that the jet pump area ratio (actually 0.118) should have been made smaller by reducing the chimney choke size along with enlarging the blast pipe orifice. The choice of optimum area ratio is a complex problem and is a topic that I may return to in a future article. I believe it to be more complex than Porta's iterative approach to the Lempor exhaust suggests.

The scatter in the observed efficiency values was surprising so Figure 6 was produced to investigate if there was a pattern to the change in efficiency.

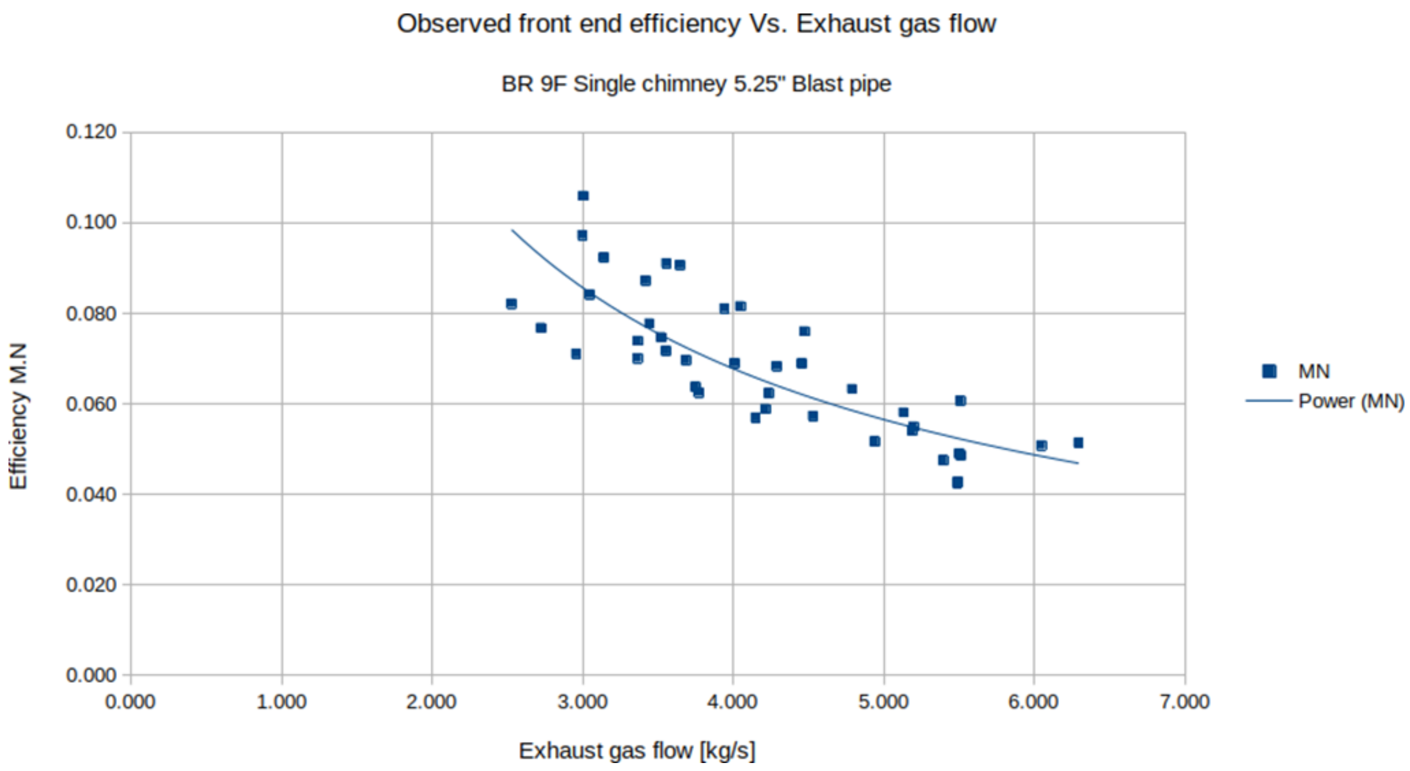


Figure 6: Observed jet pump efficiency values plotted against exhaust gas flow.

There clearly is a pattern of falling efficiency with increasing exhaust gas flow. However, since exhaust gas flow correlates closely with steam flow, exhaust steam temperature, smokebox gas temperature and to some degree with locomotive speed and cut off setting, Figure 6 does not provide any conclusive evidence of what is causing the effect.

An investigation of the remainder of the Derby data and two BR Bulletins confirms that every locomotive examined exhibits a falling efficiency similar to that shown in Figure 6, exhibiting a 75% to 50% reduction from peak efficiency across the gas flow range tested.. A similar pattern is also seen in the N data when plotted against gas flow. So referring to Figure 5, the points toward the top right of each cluster of data points are associated with low gas flows, and those at the bottom left with high gas flows.

Four points arise from the above:

1. The operating range for M is relatively small due to good proportionality between evaporation and exhaust gas flow.

2. The worst design case for a locomotive front end arises at low gas flows, due to the blast pipe pressure being proportional to the gas flow raised to an index usually 2 or above while the draught requirement is proportional to gas flow raised to an index of approximately 2 or less. This results in N increasing at low gas flows. The design methods of which I am aware are all applied at maximum gas flow conditions.

3. If point 2 is true, then there would be no possibility of a front end limit. However, the efficiency of the front end falls with increasing gas flow due to reasons that have not yet been identified. Such a fall would impose a front end limit, but if we do not understand what is causing the fall, we have no control over front end limit.

4. The Jet Pump model and by extension, any other model based on conservation of mass, momentum and energy assumptions do not fit observed front end performances very well. There appears to be an unknown factor at work influencing front end energy losses.

Some possible reasons for the fall in efficiency with increasing gas flow might be:

- The density ratio between the motive fluid (steam) and entrained fluid (exhaust gas) is not constant and ranges from 1 to 1.14 for the 9F tests. This does affect the performance and according to the formula quoted in Ref. 6.2 would cause N to increase by 25% range from 0.064 to 0.08 at an M value of 1.7. That is insufficient to explain the observed drop in N and N.M. of over 50%.

- The jet pump theory generally refers to devices where the blast pipe is at the base of the choke section (As in the Lempor exhaust) so there might be some effect associated with the gap between blast pipe and chimney choke on the 9F and similar designs. However, the derivation of the theory does not rely on an assumption of where the mixing section and choke are placed in relation to the blast pipe. Bill Hall (Ref. 6.6) put forward an alternative based on free jet theory which would predict a dependence of M upon gap between blast pipe and chimney.

- None of the available theories for locomotive front ends take account of the pulsating nature of both the steam and gas flow.

- Choking flow might be affecting the performance. Some theory is available for sonic flow jet pumps, but is not generally used for locomotives. The 9F exhaust back pressures examined here ranged from 1.2 to 10.7 psi with an average of 4.7 psi as measured by an averaging instrument, so when the pulsations are accounted for it is likely that well over half the data has at least some part of the exhaust cycle when choking flow takes place.

- The use of heavily damped instruments to measure the highly cyclic exhaust back pressures and smokebox vaccums may be distorting the data, leading to false conclusions here.

The author would welcome any other suggestions or data that might help with this problem.

5. CONCLUSIONS

By using the N Vs. M plots it has been shown that the only draughting system tested by British Railways that showed significant advantage over 2 chimney designs was the Giesl. The advantage of 2 chimneys over 1 is modest, but could be more marked as in the case of the Jubilee class, for example, where the single chimney design was unusually poor.

This work has shown that the worst design condition for a locomotive front end is actually at low steam and gas flows. Therefore, the design methods for front ends should account for that case. The available test data does not cover sufficiently low steaming rates to determine whether the effect continues at very low flows.

It has been shown that the design of the 9F single chimney locomotive resulted in a front end that gave it's best performance at an M value of around 1.2 - a long way below the 1.7 to 2 range typically required for a coal fired boiler. This appears to be due to the low diffuser efficiencies actually observed in locomotive practice, compared to "book" values, which tends to push the optimum efficiency point to lower M values than conventional theory would predict.

A significant fall in front end efficiency and pressure ratio N with increasing gas flow has been identified. The cause of this is not known but it is a factor that is not accounted for in commonly available design methods.

This line of research has further to go but it is clear that there is still much to learn about locomotive exhausts. One way forward might be to analyse E.G. Young's test data using methods described above. Since that data was obtained mostly with steady flow it might confirm or eliminate pulsating flow as a possible cause of the efficiency changes.

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A DEBATE ABOUT THE MERITS OF SUPERHEATING - PART I

compiled by Chris Newman

I've had the privilege of being copied into correspondence between Joe Cliffe and other members of ASTT on the "hot" topic of superheating. I'd always thought that the benefits of superheating had been established 100+ years ago, however Joe challenges the commonly-held belief that superheating is necessary for the prevention, or minimization, of condensation in the cylinder. He suggests instead that such beliefs derive from the promotional hype of Schmidt and his acolytes.

At 94 coming 95, Joe is ASTT's oldest member. However, he retains a razor-sharp mind and has regaled several of our recent conferences with presentations on a range of challenging subjects including:

- In 2018, on the Anderson Condenser;
- In 2018 (again), on Sir William Stanier;
- In 2019, on Wood Fired Steam Locomotives;
- In 2021, on Turbine Locomotives, Condensing and Non-Condensing, 1910- 1960;
- In 2023, on Bulleid's Irish Turf Burner.

By way f background, Joe retired from engineering some years ago but he developed a deep interest in steam traction when serving an apprenticeship at Doncaster under Edward Thompson, which he has never lost. After leaving the LNER, he joined Powerjets Ltd. to work on gas turbines, where he became acquainted with William Stanier who was then a director of the company.

Joe's Challenge:

When Joe purchased a copy of our recent publication "A selection of papers by Livio Dante Porta – Volume 5", he wrote to me to report the safe arrival of the book. In so doing, he added the following comment:

> "I was disappointed to read that even higher superheat temperatures are required for more advanced steam locos. Now, I am always looking at first principles and that Carnot law applies, but only for continuous flow machines like turbines, but not for reciprocating engines with heating and cooling events. The original purpose of superheat was to prevent condensation inside cylinders, known in as the "missing quantity" in 1896 re Callender & Nicholson. Superheating steam is a very inefficient way to heat cylinder walls due to its poor heat transfer coefficient and the lack of turbulence in a large cylinder.
>
> "Chapelon in his later writings found superheating to be unnecessary with steam jackets".

In response, I brought others into the discussion, mentioning that I recalled recent communications with Hendrik Kaptein concerning Chapelon's use of steam jacketing on his 160A1 and how effective it had proved as a substitute for superheating of its low-pressure cylinders.[1,2] I also mentioned that *Revolution* has been fitted with steam-jacketed cylinders with the idea of testing its performance with and without steam-heating, and questioned whether it would be possible to compare its performance with steam-heated cylinders both and without superheat.
I also recalled Doug Landau's idea of heat-jacketing the cylinders using combustion gas from the smokebox – the obvious problem being the need to prevent fuel particles from entering the jacket space, but offering the benefit of saving steam enthalpy.

Richard Coleby replied to say that "if we want to experiment with a 'superheatless' *Revolution* it is definitely within the realms of possibility to do so".

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1. Hendrik Kaptein has written an article on this topic which has been published in the October 2025 edition of "Back Track" magazine.
2. Hendrik has also published English translations of Chapelon's correspondence about the testing of 160A1. His translations are available to ASTT members in Newsletter No 22 (August 2023), page 37 - see https://advanced-steam.org/members/newsletter-archive/.

Jamie Keyte replied with a comprehensive view of the advantages of superheating, saying:

"Chapelon's comments on steam jacketing are very interesting (I've been fortunate to have seen Joe's thoughts on this before) and it'll be interesting to see how we get on with trials on *Revolution* since condensation in smaller sizes of loco is more of an issue than in large ones.

"I'm in no position to comment on whether the origins of superheating was a means of combating condensation or as a means of improving efficiency, perhaps both.

"The theoretical gains in efficiency from superheating – in thermodynamic terms – are very simple:

- Firstly, at typical locomotive working pressures roughly ¾ of the energy input is tied up in the latent heat of evaporation and cannot be recovered (in a conventional locomotive). Therefore, anything which can be done to reduce the water consumption (i.e. the steam mass flow rate) will reap dividends.
- Secondly, the general relationship for gases states: pV=mRT where:

p = pressure (the mean effective pressure in the cylinder)
V = volume (the volume of the cylinder)
m = mass (the mass flow rate of water / steam through the engine)
R = constant
T = temperature of the working fluid (steam)

- On the left-hand side of the equation pV = work done. If the work done by the engine remains constant then the balancing half of the equation, "mRT" must also remain constant. Therefore, if the temperature of the working fluid (T) is increased by means of superheat then - as R is constant - the mass flow rate "m" must reduce in order for the equation to remain in balance.
- From this is it clear that superheat causes a direct and positive impact on water consumption. Furthermore, the first statement shows that any sensible heat input in the form of superheat is repaid roughly threefold in the reduction in energy wasted as latent heat in the exhaust simply because you need to boil less water to get the same amount of work.
- It is also clear that superheat is about efficiency only. It does not increase the TE of the locomotive - the pV term – and only increases power in terms of the amount of energy which can be realised at the cylinders for a given heat input.

It also shows that the more energy per kg of working fluid the more efficient the engine. Which is why compounds which have effective reheat (or re-superheat) should – in theory – be the most efficient of all.

"The steam locomotive is a complex bit of kit and rarely works at anything approaching steady conditions, so inevitably I don't think it is a clear-cut case of steam jackets versus superheat. Condensation losses from the cylinders would affect the output (i.e. TE) from a "cold" locomotive (both perceived and real) and steam jackets and superheat would both help combat this. I sometimes wonder whether the oft-heard observation that the "superheater kicked in" (or warmed up) actually refers to the point at which the condensation in the cylinders has finally been overcome – which isn't really the same thing. Hopefully, *Revolution* will help us understand this more fully.

"But unless I have missed something, I cannot see how steam jacketing can result in a significant improvement in efficiency (other than combating condensation) since it does nothing to reduce the all-important water mass flow rate. Chapelon may have found something new and very interesting on 160A1 which I'd love to understand better.

"Said my bit, happy to be shot down in flames!"

Joe responded in response to my mention of Doug Landau's idea of preheating the cylinders with combustion gases, to say that

"I had thought of using hot oil circulating in the jackets, such as Dowtherm widely used in the petrochemical industry for this purpose, but it would need a heat-transfer mechanism from the smokebox, possibly a 'heat pipe' system or just heat conducting bars to the cylinder walls

"Superheating certainly reduces water consumption, but water is a lot cheaper than the coal required to produce it.

"Heat drop measurements involves very accurate measurement of steam temperature and sampling errors it is only used when there is no other way."

Meanwhile, **Hendrik Kaptein** came in with the following observation:

"The (originally expected) efficiency of superheating is curtailed by the rather limited amount of steam available for heating up cylinder walls, superheated steam being a no better heat conductor than air! This, combined with relative lack of cylinder steam turbulence, explains why superheating, though undoubtedly effective, falls short of original theoretical expectations.

"With steam jacketing the conduction issue is done away with. This may well be a part of the explanation of its unexpected efficiency (easily outdoing superheating at slow speeds offering more "condensation time").

“Concerning *Revolution*, I'd suggest testing it with the superheater removed as well, leaving the work against condensation to the steam jackets.

“No superheater in an otherwise identical boiler decreases combustion gas flow resistance & thus decreases the need for back pressure, (further) improving engine efficiency. It also reduces steam flow resistance from the boiler to the cylinders, and thus pressure loss on the way to the steam chest is reduced as well. Other media for heating up the cylinders may be less attractive, though Joe's suggestion on oil heating may be a good idea (apart from more complication).”

Richard Coleby responded as follows:

“What a fascinating read and thank you for this Hendrik.

“As the designer of Revolution's cylinder layout, this immediately begs the question as to whether at some time in the future it could be re-configured for the live steam feed to include the cylinder steam jacket - so I have a question - unsuprisingly!

“Did Chapelon take his in-feed steam directly to the steam jacket *and thence* to the steamchest or did the jacket and the steamchest work as a combined volume fed from some convenient location?

“It is obvious to me that whatever the route taken by the live steam, the absence of any strangulation of the steamchest is extremely important and therefore any design should revolve around this major requirement.

“Thanks to Jamie's important work on evolving a weldment design for the cylinder, it would certainly be possible to 'add' components to the existing structure.

“However, being an outside admission engine this would add some complexity to arranging pathways to the steamchest if the cylinder jacket was to be the first port of call for the steam.

“I look forward to your replies.”

Hendrik replied to Richard as follows:

“Yes, in the 160A1 all inlet steam went from the boiler into the HP steam jackets and next to the cylinders. LP cylinders were heated & fed the same way, by HP exhaust steam. Some throttling must have been unavoidable but the potential absence of a superheater may well have made up for this. Though I'm not aware of all *Revolution* cylinder construction details, it may be not too hard to "jacket" the cylinders and cylinder covers, with provision for ample steam passages in as far as fitting the 10¾” gauge profile. (Some pressure reduction from the boiler to the cylinders is not totally harmful for engine efficiency, optimal cylinder design being related to lower than full boiler pressure anyway.)

Meanwhile, **Joe Cliffe** came back to me regarding early claims about superheating:

“I know the old texts of the ”missing quantity” c 1906 and Schmidt’s salesmanship which mentioned the false claims of increased fluidity.[3] Leakage was a big factor then, eventually cured by multi-ring valves, not high superheat I stand by Chapelon who originally was the arch “high superheat” man for compounds. I accept Chapelon’s later views

“Regarding my hot oil opinion raised by Doug, there is a lot to say on all this. Smokebox heating and heat pipes etc.”

And in response to Jamie’s observations, Joe offered:

“Yes. Superheat undoubtably reduces water consumption. Once condensation is eliminated the thermal gains are very limited, but water is cheaper than the coal needed to superheat.

“A turbine is completely different.”

In a separate message, he added:

“Steam is a vapour not a gas It can only be regarded as a gas in its high superheat form where it has a very poor heat transfer coefficient in heating cylinder walls above the saturation temperature - or as in a turbine where it expands continuously to its saturation point. Perusal of the literature c 1906 shows that it was hoped to be a means of avoiding cylinder wall condensation, but then with only a poor knowledge of heat transfer mechanisms. Steam jackets of the time were based only on partial admission of steam which condensed in the jackets.

“ Chapelon made the breakthrough with 160A1 in this respect-delayed by the war, - too late.

“The only example of steam jackets on a British locomotive was on the L&Y Aspinall Atlantics of 1899, where the gains were a modest 2 to 3%, aided by the cylinders being inside the frames. They were never superheated even in LMS days.

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3. A quick glance at the Steam Tables shows that superheated steam is more viscous than saturated steam, and that the higher the superheat, the higher its viscosity.

"The base case also rests on an optimum all-saturated boiler drafted against a less efficient superheated version, which was never done because the false belief in superheating was so strongly held.

"The heating of cylinder walls by hot oil 'Dowtherm 'and 'heat pipe' is an alternative solution yet to come in an advanced steam locomotive. Note: I don't know too much about Heat Pipe technology but is widely used in the petrochemical industry using Dowtherm as heat transfer medium."

Later, he added "With *Revolution* there are likely to be adverse scaling factors which may make condensation worse with such small cylinders."

A concluding comment from Hendrik Kaptein

"Just a small comment on superheating, with apologies for repetitions:

"In small cylinders like *Revolution's* superheating will be more effective than in larger ones due to the aforementioned "layer effect" (see more extensively on this my contribution on scaling published in our Newsletter No 17, Oct 2017, page 50).

"Yes at least in terms of less harmful heat transfer, poppet valves (used on a large scale in France, from about 1930) are superior. Leakage seems to have been an issue at times, due to deformation caused by high steam temperatures. So, no superheat may lead to less leakage as well (see my contribution to forthcoming *Back Track* magazine)."

Conclusion

I offer no apologies for the fact that the above discussion is inconclusive and unresolved. The questions raised are complex and opinions differ. It is also clear that there remain a number of unknowns that may be difficult to resolve without practical experimentation.

Readers are invited to enter the discussion with their own thoughts and opinions, in the hope that it will lead to further debate (s) in future Newsletters. Either way, it may be expected that answers will be found by *Revolution* when it begins its career as a test-bed – the career for which it was always intended.

Happily, *Revolution*'s designers had the foresight to incorporate cavities around the cylinders to allow steam heating to be tried and tested on it, this being just one of many of its features that will be subject to scrutiny when it finds its feet on the rails.

I believe it may be safely predicted that *Revolution* will offer many opportunities for researchers and practitioners to test out novel ideas that will progress our knowledge of steam locomotive engineering, and do so at a cost that would be unaffordable on a larger scale machine. Let us hope that we will find the money and resources to exploit it to the full.

Post Script

Dr David Pawson was out of contact during the correspondence that is summarised in the foregoing article. Having received a draft copy of the article, David finds himself in fundamental disagreement with some of the opinions expressed in it.

David has promised to write an article of his own for publication in the next Newsletter, which may attract rejoinders from Joe Cliffe and other contributors to the debate.

We may therefore look forward to an ongoing discussion in Part 2 of this article in the next Newsletter.