The 5AT Group

Richard Coleby
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L.D. Porta – Argentinean Engineer (1922-2003)

- Took over steam development when Chapelon retired
- Aged 24, rebuilt a locomotive that equalled Chapelon’s best power/weight ratio
- Director of Argentine’s National Technology Institute from 1960 to 1982
- Pioneered several important advancements in the late 20th century
Porta’s Legacy

Porta’s theories were adopted in South Africa by David Wardale

The 3300 kW (4,400HP) “Red Devil” Class 26 achieved
37% increase in power
60% reduction in specific coal consumption
45% reduction in water consumption
Origin of the 5AT Project

1998 - David Wardale suggests a “super class 5” locomotive that will deliver outstanding performance.
2000 - 2012

2000 – Article in ‘Locomotive International’ outlined concept and main features

2002 - Fundamental Design Calculations started

2004 – Completed Fundamental Design Calculations, which show that it will deliver the performance

2007 – Costs & Timescale Established

2008 – Indonesian Coal Railway Study

2010 – Feasibility Study Published

2012 – Public announcement suspension of work on 5AT
What we achieved

- Completed Fundamental Design Calculations
  - 5AT - Second Generation Steam Locomotive
- Know how to deliver a project
  - Cost & timescale
- Feasibility Study for the 5AT
- Feasibility Study for coal haulage railway in Indonesia
  - Established that SGS steam is cheaper than diesel
Feasibility Study

- Design
  - Fundamental Design Calculations
  - Tools & Techniques
  - Skills
  - Organisation
- Manufacture
- Acceptance
  - Engineering Acceptance
  - Network Rail
  - HMRI
- Project Management
  - Processes
  - Timing
  - Risk analysis
- Costs
- Economics of Operation
- Environmental Impact
The 5AT – Second Generation Steam

- First new steam loco design to incorporate all of Porta’s developments
- Design for high speed operation - 180 kph (112.5 mph) continuous operation
- Intended to operate tourist trains on UK and European railways
Fundamental Design Calculations (FDCs)

- Applicable to any locomotive style both existing and new
- 18 Subject Areas
- 356 pages of calculations
  - Over 6000 lines of calculations
  - Over 100 diagrams
- Defines Characteristics of all the Main Components
- Defines Performance of the locomotive
5AT Cylinder Assembly
5AT FEA - RH Cylinder
5AT Frame and Suspension
5AT CAD – Front Crumple Zone
5AT Frame and Suspension
Lempor Exhaust - section

- Twin Chimney’s
- Convergent Divergent Nozzles
- Will require tuning
  - Not possible to accurately calculate total boiler vacuum
- Triple Chimney considered
Lempor Exhaust – Blast cap
Future Strategy

- Apply what we have learnt
  - Modifications to existing locomotives
  - Other new build opportunities

Survey ➔ Concept Phase ➔ Feasibility Phase ➔ Delivery Phase
Heritage Steam improvements

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Porta’s Advancements

- Improved coal combustion (reducing fuel consumption and emissions)
- Improved exhaust systems
- Increased steam temperatures
- Improved lubrication
- Improved water treatment
- Reduced steam leakage
- Improved insulation
- Improved adhesion
- Reduction in maintenance costs
FDC areas

- Pistons
- Crossheads & Slidebars
- Connecting Rods
- Crankpins
- Coupling Rods
- Driving & Coupled Axles
- Piston Valves
- Boiler
- Exhaust System

- Valve Gear
- Cylinders & Cylinder Liners
- Mainframes
- Springs & Spring Rigging
- Brake gear
- Balancing & Engine Stability
- Auxiliaries
Applying the FDCs

- Applicable to any existing locomotive style
- Defines characteristics of all the main components
- Defines the performance of the locomotive
- Problem areas with existing locomotives can be analysed using the FDCs
- Solutions to problems can be designed using the FDCs
FDCs for heritage steam

- Limitations exist in applying the FDCs to existing locomotives
- Locomotive appearance must not be visibly changed
- This may require some level of compromise in the design
- The resulting improvement in performance will not be to 5AT levels but will be significant and can be measured
FDCs for new steam

- When applied to new designs the full range of benefits become available
- Locomotive appearance can be radically different
- There is a lower level of compromise in the design
- The resulting improvement in performance will be significantly better
New locomotive design

- Significant improvements
  - Environmental impact
  - Economy
  - Reliability
- To keep steam locomotive design skills alive with a new generation of engineers
- Design out known faults
- Proven new design features
  - Exhausts
  - Bearings
  - Pistons & Valves
- 21st Century design tools & techniques
21st Century Steam

5AT Group
21st Century Steam

Must haves

- ‘Greener’ credentials
- Sight, sound, smell of a Stephensonian locomotive
- Reliability and servicing closer to contemporary traction
21st Century Steam
A modular concept

- Base engine with standardised boiler, valve gear, cylinder and running gear

- Base engine adaptable to tender or tank
- Body ends are “bolt-on”
21st Century Steam
A Modular Concept
21st Century Steam
A Modular Concept
21st Century Steam

- Design in features which give efficiency and reliability
  - Higher efficiency – lower emissions
  - Reliability – keep it simple

- Keeping build costs low
  - Batch build
  - Design – lower component count
  - Build – Use modern materials and techniques
    - Corrosion resistant steels
    - High component accuracy
21st Century Steam

- Attention to detail
  - Do simple things well!
- Design out known problems, for example
  - Frame cracking
  - Laminated springs
  - Piston & piston valve sealing
  - Better gland packing
  - Pipe joints over rails
  - Improve pipe supports & joints
  - Pay attention to lubrication
- Improve crew conditions
21st Century Steam

- Use ‘off shelf’ proven components
  - Steam & Water Valves
  - Pipe Fittings
  - Roller Bearings
- Design in Quality
  - Advances in engineering knowledge
  - Materials of known specifications
- Features proven on today’s railway
  - Fabricated Structures
  - Freight bogies for tenders
21st Century Steam

- Reliability improved by rational approach to design
  - Adopt features of existing locomotives which are very reliable
  - Query *everything* which is “just good enough”
- Adopt technology from other industries
- Analyse all aspects of the design with the best tools
- Thermodynamic design based on science not guesswork
21st Century Steam
Across Industry Involvement

- Participation in survey
- Development of specification
- Styling of their locomotive
- Design reviews
- Training opportunities
  - Design
  - Manufacture
- Assembly of their locomotive
Steam has the potential to burn a variety of bio fuels:
- Compressed wood pellets
- Bio-diesel
- Compressed Biomass briquettes
- Process waste product
- Torrefied biomass
Torrefied Biomass has great potential
- Calorific value close to coal
- Can be co fired with coal

Have obtained a small quantity for trials
## Torrefied Biomass

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Introduction to the Survey

- Some railways are already starting to question the future direction of the industry
- Looking at the current situation will not provide the way forwards
- Need to look at the long term future of steam locomotives
- Need to find out what the railways themselves actually want and need for the future
Purpose of the Survey

- To define the best way forwards to utilise the technology that the Group owns
  - A Heritage Railway survey should be conducted
  - A Main Line operators survey should be conducted
- Can we help railways with improvements that could be made to existing locomotive stock?
- Can we define a new general purpose locomotive design and style to ensure steam locomotive operation for the future?
Background to the Survey

- Identify actions that can be taken to ensure the industry is not to suffer a lack of locomotives and the increased costs of maintaining them
- Need to keep steam locomotive technology alive with a new design of locomotive
- Foster a new generation of engineers who understand the technology and can develop it and take it forwards in the future
Survey content areas

- About your railway
- The future of steam in 2021 and beyond
- Railway operating environment
- Locomotive ownership
- Locomotive format
- Locomotive operation
- New locomotive design features
- Reducing the Environmental impact
How to conduct the survey

1) When was your railway formed?

2) What is the constitution of the railway?
   - Charity
   - Trust
   - Private
   - Limited Company

3) How many full time staff does the railway employ?
   - Footplate staff
   - Workshop Staff
   - Permanent way staff
   - Station staff
   - Administration staff
   - Other staff

4) How many months of the year do you operate a full service?
The software package provides full online analysis of the survey results.

- The biggest challenge will be to get consensus across the industry due to the variable operating conditions.
The 5AT Group understands Second Generation Steam

The challenge now is how best to apply this knowledge for the benefit of the Heritage Railway industry

- lower costs
- improve performance
- provide locomotives that satisfy environmental requirements that will ensure the industry survives well into the future