AERODYNAMICS TO SAVE ENERGY FOR RAIL FREIGHT WAGONS

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The following rather "newsy" description summarises the recent work that the Vehicle Aerodynamics Group at the Royal Melbourne Institute of Technology (RMIT) has been undertaking on rail freight wagons in association with the Railways of Australia (ROA).

Aerodynamic drag of rail freight wagons can be greatly reduced, making large energy savings possible. The wind-tunnel tests suggest that railway organisations ordering new wagons cannot afford to ignore the potential fuel savings and higher speeds.

RMIT and ROA has produced a design called the "Greenhouser" that predicts good aerodynamic savings. The State Rail Authority of New South Wales (SRA) has evaluated the RMIT results and recommended proceeding to the next stage of detailed design and evaluation.

The National Energy Research Development and Demonstration Council of the Australian Government Department of Primary Industries and Energy has funded the project.

The team first investigated hopper (bottom-dump) and tippler-type (gondola) wagons with features that represent a wide range of unit-train wagons used in Australia. Tippler wagons are bulk carriers that rotate to empty their contents, whereas the hopper-type dump their bulk load out the bottom, via opening doors.

RMIT built 1/10 scale models (see Figs). The model hopper wagon was based on a SRA "NHJF" coal wagon with Victoria's V/Line "VHGY" grain-wagon details for the bottom. The resultant "generic" model wagon would give results with wider application, whilst losing some data accuracy for specific wagons. The models could be easily modified. Once hopper tests were completed, the model was transformed into a tippler configuration based on the Queensland "GH" coal wagon.

The RMIT team has been investigating improvements in the aerodynamics of the two wagons in their wind tunnel for the last two years.

Bulk-haul trains carrying coal can be 100 cars long. RMIT measured the aerodynamic drag on the third wagon from the front in the configuration shown in Fig 1. It was found that the airflow environment of that wagon appeared to be representative of other wagons in a long train.

Test Results

Drag coefficient (C_D) is a measure of aerodynamic efficiency. Based on RMIT's train experience, a 24% reduction in C_D could be expected to reduce fuel use by between 6% and 4% as a first estimate, i.e., the percentage in C_D change is divided by between 4 and 6, depending on the operating conditions.

To calculate fuel saving more accurately on a specific operation, the C_D measured in the wind tunnel can be used in an Energy Calculator - a computer program developed by ROA and BHP Melbourne Research Laboratories.

The following C_D's apply to train operating speeds of about 70 km/h and an average annual Australian wind speed of about 11 km/h.

Generally, the tippler had a lower C_D (0.27) compared with the hopper (0.35). This may due in part to the poor aerodynamics of the brake gear at the ends of the hopper wagon.

Loading either empty wagon with coal to typical heights reduces the C_D by about 22%.

Flat covers reduced the C_D by about 30-40% depending on wind conditions, whereas 600 mm radius rounded tops shown in the photo reduced the C_D by 40% for average wind conditions.

(This highlighted why a train with open-top empty wagons travelling at high speed can use more fuel than a train loaded with coal.)

Bomb-bay doors gave a 10-15% lower C_D than standard hopper bottoms.

Top covers worked well, however there is a need for automatic loading without removing the covers. Hence the RMIT/ROA team has developed the "Greenhouser" (see Fig. 2). This consists of a partially-covered angled top with a curved aerodynamic fairing at each end.

This invention is shown in the Figure modelling a 1350 mm gap and permits a 1200 mm wide loading chute. (The connecting supports spanning the gap will not be used in full-scale operation.) In this configuration the Greenhouser reduces the drag by 28%. Even on a fully-laden wagon, RMIT found the Greenhouser reduced the drag by 13%.

Economic Analysis

SRA has investigated the cost-benefit of the Greenhouser.

SRA used the ROA Energy Calculator to predict fuel savings for the Ulan-Newcastle coal operation. The hilly terrain gives a low average speed of 56 km/h. This operation uses four locomotives with 84 wagons to transport 8400 tonnes of coal to the coast each day. Each of these trains consumes about 3.8 million litres per year or about $1.7 million per year at Australian prices.

SRA predicts a fuel saving of 4% representing about $70,000 p.a. on this route. If a constant 80 km/h were possible savings would rise to 6%. This would further increase on a flat route. These results reinforced the empirical rule explained above of dividing the average drag coefficient reduction by between 4 and 6.

SRA concluded that the cost of incorporating the Greenhouser in new wagon designs would be minimal. It appears likely that it will produce a nett saving almost immediately on new wagons. SRA has recommended detailed design of the proposal.

Incorporating the invention into a "tubular-type" monocoque construction should permit a higher strength-to-weight ratio and increased carrying-capacity. RMIT is patenting the Greenhouser internationally.

The Future

RMIT anticipate that these results will be tested in actual rail operations to provide not only fuel-savings information but also scientific data to further enhance prediction techniques.

The aerodynamic benefits shown in this study have been high. However, these C_D reductions will vary with the actual wagon geometry and the incident wind environment. Fuel savings will vary with route and the ROA Energy Calculator can be used to estimate the fuel savings. This technology offers an opportunity for reassessment of existing designs.

A test chassis and accompanying test facilities now exist to permit designers easy evaluation of other wagon designs. EPT, a major Australian supplier of wagons, and RMIT are currently undertaking a Finite Element Stress Analysis of a proposed hopper design incorporating the Greenhouser.

The energy efficiency of rail compared with road transport prove interesting. For one wagon configuration, a C_D of 0.10 was measured for a modified tippler wagon in still-wind conditions. It was noted that each wagon can carry 100 tonnes. This is equivalent to five road-trucks, which normally each have a much higher drag coefficient of 0.6-0.8. When road safety, damage and road cost are considered and added to the considerable potential energy savings, rail should be the heavy-freight carrier of the future!

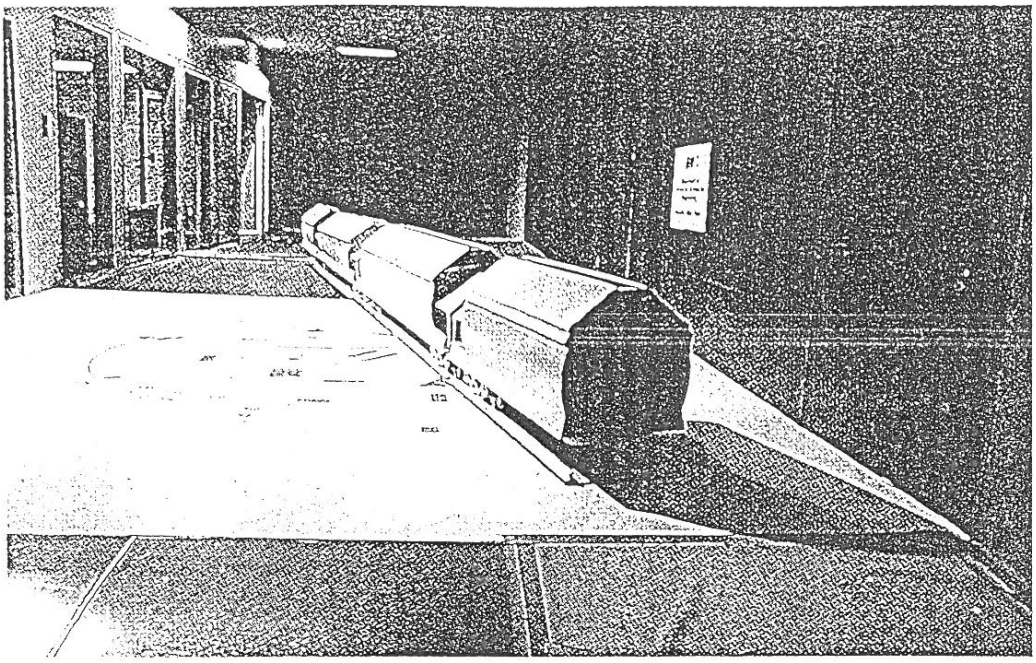

Fig. 1.
Model wagons in the RMIT wind tunnel, looking downstream.

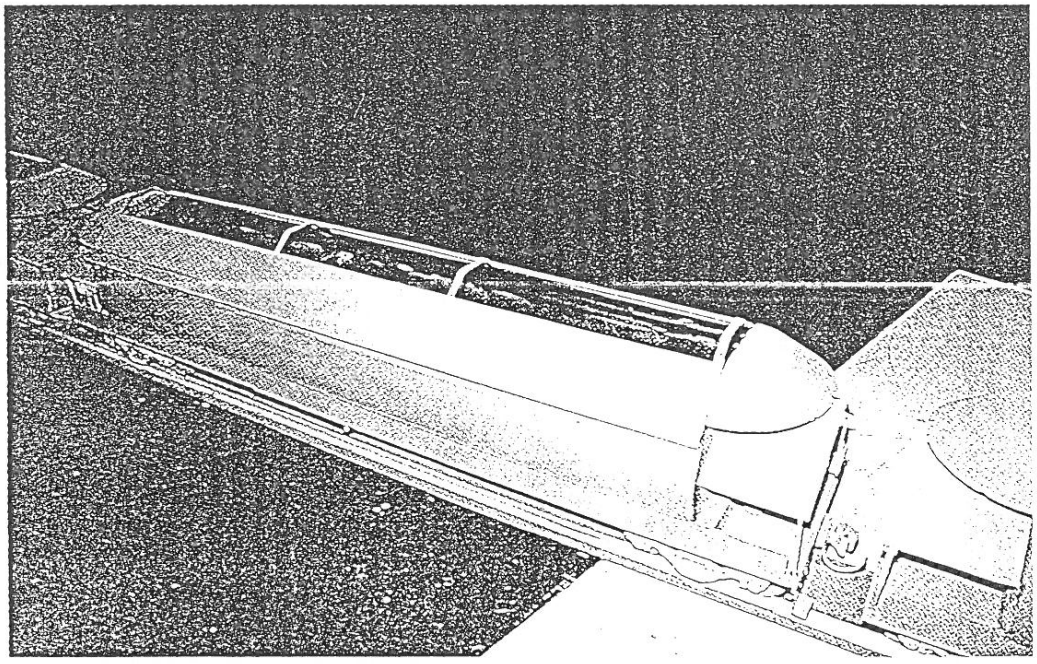

Fig. 2.
The RMIT Greenhouser.

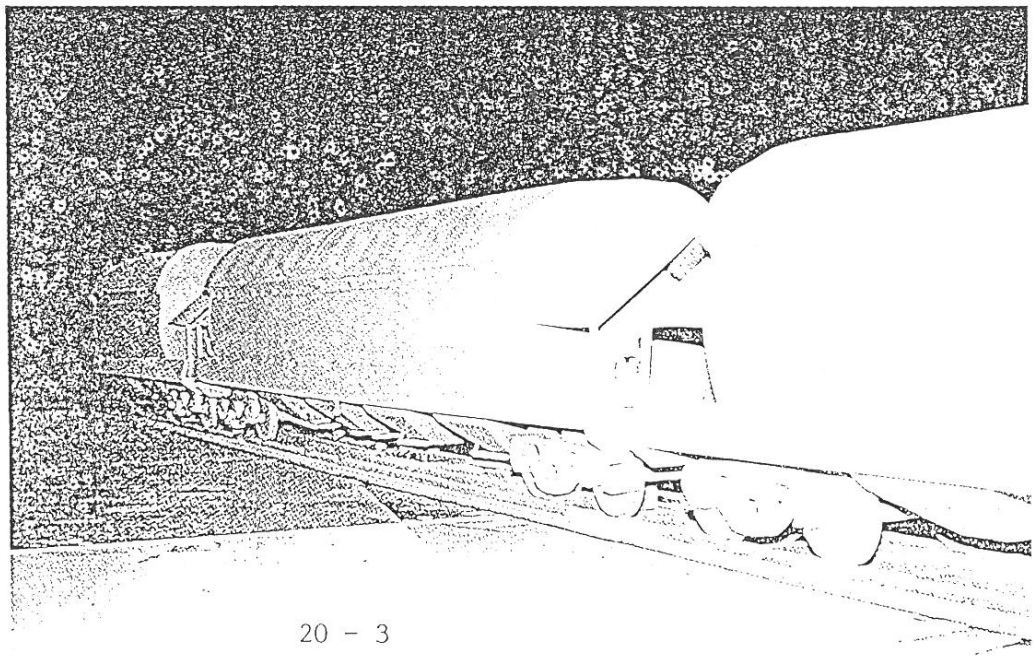

Fig. 3.
Model wagons with 600 mm radius rounded tops.