top gear

JULY 1987

THOROUGHBRED SPORTS CAR Club

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NEWSLETTER OF THE THOROUGHBRED SPORTS CAR CLUB

OBJECTS OF THE CLUB

"Fostering better acquaintance and social spirit between the various owners of thoroughbred sports cars in Australia".

"To help and advance thoroughbred sports car owners and ownership".

"To establish and maintain by example a high standard of conduct and a respect of the laws of the road".

GENERAL MEETINGS OF THE CLUB

The General Meetings of the club are held on the second Wednesday of each month, commencing at 8.00 p.m. at the Sydney Rowing Club, Great North Rd., Abbotsford.

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THOROUGHBRED SPORTS CAR Club

COMMITTEE

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Committee:	LESTER GOUGH – (H) 799 3209 (W) 750 8188 LEN MADAR – (H) 652 2061 (W) 651 1812

presidents prose

Welcome to the July edition of your club magazine which should be a bumper addition if all our selected scribes have done the right thing by our editor.

After the past two months of rather hactic activities on the club scene July appears to be the month of recuperation of body and repair of car, both items required in our household. There have been some very good atten dances at our recent events of which you are about to read and occasions cannot go past without some vote of thanks to the various members involved.

Taken in date order firstly to David & Barbara Muir for the lend of their house for the annual 'Games Night'. Although not a raging financial success, socially it certainly was, thanks once again to our Social Committee led by Jim Peters.

Our second lot of thanks goes to Jim Peters, then to Vic Andrews who completerd the organisation of our driver training day at Oran Park.

Also well attended was ou last club meeting where our guest speaker was Peter Findlay from Nationwide Driving School who conducted our last driver training day. Peter spoke of his previous racing experience, both here and overseas, and educated us as to the hazards of correct braking. The vote of thanks was proposed by Grant Liddell who presented Peter with a bottle of our infamous port, another victim!

At the next meeting on July 8th club member John Burton will be showing a video of the recent Canberra weekend.

looking forward to seeing you soon,

Ray Ross.

Coming Events

JULY

8th Club Meeting - Ryde RSL Club

25/26th Mystery Weekend. "Murder At The Inn"
Bookings - Jim Peters (H) 922 6807

AUGUST

9th Super Sprint - Oran Park (South Circuit).
Bookings - Vic Andrews (H) 528 3227

12th Club Meeting - Ryde RSL Club
"Video Night"

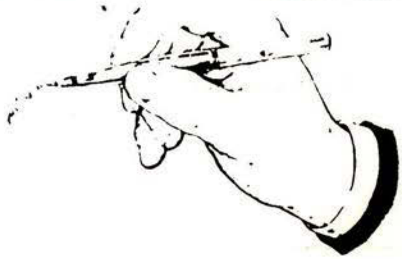
23rd Super Sprint - Amaroo Park.
Bookings - Vic Andrews (H) 528 3227

SEPTEMBER

9th Club Meeting - Ryde RSL Club.

27th Silverdale Hillclimb and Social Day.
Bookings - Lester Gough (H) 799 3209

MINUTES OF MEETING



JUNE MINUTES:

Apologies : Dreghorn, Adrian Walker, Gary Bruce, Gary McDonald, Lynda Du Cros.

Welcome to new member Bill Long and guest speaker Peter Finlay.

Correspondence : Invitation from CAMS to attend State council meeting, Vic Andrews will attend on our behalf.

Treasurer : Bank balance $1,965-00.

Editor : Seeking authors for various articles covering recent club events - Ray Ross duly volunteered some authors.

Social : Jim Peters recently attended 'Murder at Inn' and had a great night. Club has booked for the 25th July and it is important for all going to promptly forward their deposits.

Sporting : Driver training day was a great success, very informative with 100% attendance and perfect conditions.
Motorkhana - 13 drivers competed, Don taking out short wheelbase class, Ray the long. Two new members came along and everyone enjoyed themselves.

Canberra Weekend : We now hold 3 records; John Burton, Don McDonald and Vic Andrews. On the day 2 trophy winners, John Burton and Don McDonald, 3 seconds, Ray Ross, Piotr Fast and Vic Andrews.

Some bad luck - Chris Jackson rolled, however with some much appreciated help from Lester Gough was able to drive the car home. Lionel Walker had someone plough into the rear of the Aston enroute to Canberra.

Pointscore :-	Don & Vic	8
	Ray	7
	Len	5

Ray on behalf of the club thanked Lester and Vic for their efforts in making the Canberra Weekend a success - a great example of club spirit.

General Business : Lester has found a source for club car badges and cloth sew-on type badges - will give details to committee.

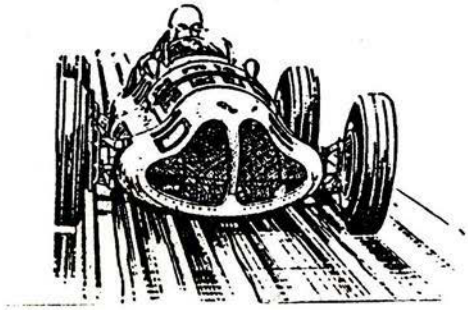
There followed an interesting talk from our guest speaker Peter Finlay.

POINT SCORE

Sporting Pointscore After Canberra.

Don McDonald; Vic Andrews	8
Gary McDonald; Ray Ross	7
Len Madar	5
John Burton; Chris Jackson	4
Piotr Fast	3
Adrian Walker; Angus McDonald	2
Grant Liddell; Dennis Mitchell	2
Dave Muir; Bill Long	1

sporting report



MOTORKHANA

SUNDAY 24th MAY.

On the 24th of May some of our club members and friends attensed a Motorkhans held at the Fiat Club Grounds. It was a fine sunny day for the events, although the night before was very cold, so there was still dew on the grass which made the first half of the morning, well ... fun.

The first couple of laps were in the high 40's and low 50's but as the morning went on and the grass got chewed up a bit, the times improved greatly. Micheal Lynch got the fastes time in my car with a time of 41.24 seconds, that is until Don McDonald turned up in his Cooper S and knocked off 3.5 seconds with a time of 37.74 seconds, while Judy Andrews clocked up the fastest time in the L.W.B. class with a time of 42.80 secondds in her Volvo 164 and although I didn't envt the job that Graham Thow and Brendon Walker each had on their hands, both in their 351 Falcons, it was great to watch these cars being thrown aroung in the dirt.

During the second part of the course Don McDonald got the best time in the S.W.B. class with a time of 40.04 seconds, although Ian Uregham (and dog) did quite well with a time of 43.60 seconds which I thought was quite funny because the dog was calmer than I was when I went around with him (the dog must be used to the way he drives), while Ray Ross got the best time in the L.W.B. class in his Commodore with a time of 43.62 seconds.

Don McDonald chalked up the best total result with a time of 77.78 seconds, while Ray Ross took the honours in the L.W.B. class with a time of 88.49 seconds.

The day ended a great success with no casualties for the day, well, except one, my accelerator cable snapped a couple of kilometres from home.

		Best total Dirt+Flag	FLAGS Best	Dirt circuit Best
1. Don McDonald	Mini	77,78	37.74	40.04
2. Ian Dreghorn	Fiat	82.54	38.94	43.60
3. Adrian Walker	Alfa	86.74	44.07	42.67
4. Val McDonald	Mini	88.29	41.59	46.70
5. Michael Lynch	Capri	88.39	41.24	47.15
6. Michael Graham	Capri	90.56	41.79	48.77
7. Mark Dilanian	Capri	92.29	43.50	48.79

Longwheel Base		Best Total Dirt +Flag	Flags Best	Dirt Circuit Best
1. Ray Ross	Commodore	88.49	44.87	43.62
2. Vic Andrews	Volvo 164	88.81	42.90	45.91
3. Judy Andrews	Volvo 164	89.28	42.80	46.48
4. Graham Thow	Falcon XD	91.02	46.63	44.39
5. Brendan Walker	Falcon XB	99.39	53.70	45.69
6. Lionel Walker	" "	---	50.57	---

ADVANCED DRIVING COURSE

subtitled

BACK TO SCHOOL !!

On a fine but brisk morning on the 16th May, 20 members arrived at Oran Park with an assortment of cars, ranging from slicked wheeled sports sedans to the family shopping wagon.

We were met there by Peter Finlay and his team of instructors from Nationwide Defensive Driving School, who were going to give us lessons in advanced driving, and if we wished, to be observed for our CAMS license.

After the cars were scrutineered we were given a brief rundown on the days schedule. Then we walked the track where the apex of each corner and the unseen hazards were pointed out.

Following this we divided into small groups under each instructor, who drove our cars around the track in the correct manner and then sent us out to emulate them, with varying degrees of success.

Later we were instructed in braking techniques, that is, braking in a straight line and on a bend at various speeds without locking up the brakes, not so easy.

We were then demonstrated how to pick the apex of each corner at speed, and copy by example. This is where the fun began and the track became easier to handle, the driving more smooth.

Towards the end of a very full day we were timed in a lap dash and assembled on the grid according to our times for a simulated race. This is where the adreneline started really pumping and finished off a most enjoyable and instructive day !!

The day went off fairly smoothly, with only a few minor mishaps such as Dave Muir's rather erratic Anglia, Chris Jackson's unfortunate blown head gasket, and not the least Len Madar's not one but two rear wheels. Len was not driving at the time, our illustrious chief instructor was at the wheel. I, and I think it was Chris were following him down the straight at the time when the Triumph gave a few unusual side steps as it entered the corner as to confuse us to which way he was going, then surprise, surprise, wheels everywhere! In Peter's capable hands the car was driven on the drums off the side of the track and out of harms way. But not a good way to end the day.

I8m sure that everyone, including those with a few mishaps enjoyed the day, I know I was still smiling when I went to sleep that night.

BILL LONG

"Wallaby Lake? Get one rut over and you can't miss it."

CANBERRA WEEKEND - 6/7/8 JUNE

Considerable organising (thanks to Lester Gough and Vic Andrews) had gone into the preparations for a successful "Thoroughbred" assault on Canberra, and in particular, the "Cara" Hill climb. The Club had past successes, with members holding several class records and all were fired up to repeat the 1986 results.

Needless to say, the weather was lousy as we set off early Saturday morning. To our surprise, at the city limits, the inclement weather cleared and a pleasant trip ensued.

The trip down was uneventful for most, except Lionel Walker's beautiful DB6 Aston Martin. Lionel, without a second thought of the danger involved, leaped to the rescue of a fellow human being caught up in a life threatening situation. His reward was an out of control trailer slamming into the back of the Aston. To add insult to injury the Boys in Blue were not interested.

The circular streets of Canberra took their toll, causing several drivers to have words with their navigators. Eventually, the Ross', Andrews, MacDonalds, Walkers, Fasts, Longs, Goughs, Madars, Liddells, Muirs, Burtons and other singles met up at the Monaro Motel.

Several members took the opportunity Saturday afternoon to familiarise themselves with the cara circuit. David Muir was a little dizzy by the time Bill Long, Don MacDonald and John Burton arrived, having been circulating for some considerable time.

Saturday evening saw the masses assembled for dinner at the Kingston Hotel. The service was lousy but the company great. The majority turned in early but several members who shall remain nameless (I wasn't there to get their names actually) partied on until sometime past midnight.

Sunday morning dawned, weather fine and sunny, but a little cool! Most were to circuit by 9.30a.m.. The event was under way by 10.30a.m. with a variety of vehicles competing. (Porsche, Lancia, Morgan, Torana to name a few). About 38 competitors all up. Results involving our members follow this article.

Don MacDonald drove with skill and determination posting creditable times in the Magnum. Actually the announcer called Don's car a "tank". Don had his hands full at the time and couldn't respond. To add further insult, he called by Nissan "ugly". Piotr Fast improved by over a second on his 1986 result and probably wished I had remained in PNG. Piotr held the 2001-3000cc lap record until a certain Nissan driver eclipsed him by a mere .71 of a second.

Angus MacDonald pushed his Lancer to the limit recording a best time of 49.13. Not bad from only 1.6 litres.

Grant Liddell had a "hair raising" experience which left him quite flat. Pun intended, with apology. He is actually a good bloke. You can get your own back Grant by penning the next Club adventure.

Ray Ross had four other Toranas to contend with but on cold slicks was unable to achieve the car's full potential. He did try though, several witnessed the "Blue and Yellow" hanging out the tail on a few corners. A second place in this Group was a good result.

Len Madar regretted not using the practice session Saturday afternoon and had to be content with third place in his class; won by a Formula Vee.

Bill Long is improving like a good champagne, given time. He certainly enjoys his motor sport but hasn't yet found the limits of his superbly prepared GTR Torana. By next year I'm tipping Bill as the driver to watch.

Chris Jackson was a different kettle of fish. He put in a relatively conservative run on the first occasion (his first time on the track) and perhaps opened up a little too much on his second. The announcer had been praising the safety of the track just prior to Chris' run. Chris must have taken him literally, but was unprepared for the double roll with pike (degree of difficulty on Cara Hill) the Torana displayed on the last corner. Chris emerged from the vehicle, pride a little hurt but body in tact (thankfully), to the delight of onwatchers. Sadly, it was his last run for the day. I'm sure Chris would like me to thank Lester Gough for his efforts in getting the Torana mobile again, to allow Chris to drive back to Sydney..

Dave Muir had the little Anglia humming, posting his best time on the last run. Unfortunately, the competition was a touch too quick.

Vic Andrews had the Viper flying in his efforts to break the 40 second barrier. He was just outclassed by one of my favourite cars, a Clubman, driven by John Ribic recording FTD of 38 odd seconds. Vic went all out on his last run skidding off with heaps of understeer on the corner which tripped Chris. Wife Robyn was a little concerned but all ended well with Vic smiling widely, perhaps a little embarrassed.

A brief presentation was held at the Kingston Hotel after the event with Don MacDonald and yours truly taking the Type 1 our 3 litre and 2 to 3 litre classes respectively, including the respective records.

To round off an excellent week-end the troop enjoyed a Vietnamese banquet followed by a drinking session in Grant and Robyn's unit. Even the kids behaved themselves.

Until next year.

JOHN BURTON

The state of the art

J N Randle
Jaguar Cars Limited

The motor industry survives through response to changing circumstances. The highly competitive nature of the industry has ensured that despite the great complexity of the product, its ability to respond is exceptional. That ability to respond has never been so evident than has been displayed during the past two to three years.

Industry in Europe has suffered three major shocks in recent years: the oil crisis, Japanese influence and environmental concerns. Those shocks have catalysed activity in the areas of fuel economy and improvement in quality and reliability. More recently the discovery of new oil resources has widened manufacturers' vision, so that performance and features have assumed a priority unexpected five years ago.

High performance derivatives of models in all sectors of the market now proliferate whereas a few years ago these would have been regarded as socially unacceptable. ABS, 4WD and turbocharging are typical of the feature levels available throughout the market.

This paper seeks to examine the state of the art in automotive engineering, to analyse, where appropriate, the value of various features presently available and to suggest where these developments may lead in the future. The areas of greatest interest are seen as: electrical and electronic developments, materials development, engine developments, transmissions development, aerodynamics, and suspensions systems.

The application of electronics to vehicle systems is on an accelerating trend. In 1982 Ford predicted that by 1985 the average car would contain some $550 worth of electronics. That target had been exceeded by 1984. The University of Delpht has estimated that by 1992 around $1350 worth of electronics will be common — an increase of around 2.5 times in only six years.

The present semiconductor content of the average vehicle is around $64. This is predicted to rise to $150 by the year 2000. The primary driving force behind this rapid assimilation of solid state technology is the growing conflict between the increased complexity demanded by both environmental conditions and customer requirement, coupled with the drive towards greater reliability and quality.

The first impact has been in the area of fuelling and emission controls where environmental pressures have demanded greater and more accurate control on all areas affecting engine performance and emissions. The greater and greater accuracy required to meet the stringent market pressures are leading the industry towards air mass measurement, programmed ignition systems, knock sensing and sequential fuel injection. Additionally, the introduction of electronics has been apparent in the widespread introduction of ABS, but elsewhere it has been relatively minor, being limited to stand-alone systems such as service predictors, suspension height controllers and cruise control systems.

However, the development of electronics is moving very quickly. The reductions in size and cost that are imminent will bring about a further revolution in the application of electronics to the automobile.

The feature size of a semiconductor is the key factor in determining the number of transistors that can be fabricated onto a fixed area of silicon. The size reduction that is taking place is such that it is estimated that sub-micron devices will be in volume production by the year 1990.

Areas of particular interest are as follows:

Complementary metal oxide semiconductor: CMOS systems are rapidly replacing NMOS systems, having the advantages of high-speed operation, reduced heat dissipation, reduced supply current and higher noise immunity, bringing in their train higher reliability and lower quiescent drain for systems requiring a constant timing function.

Microprocessors: The cost of microprocessors is reducing rapidly. The latest systems provide a comprehensive range of chip peripherals. Their greater flexibility is greatly simplifying interfacing to sensors and actuators. The move towards integration of all systems into large central microprocessors will reduce connections and hence increase reliability. The greatly increased power that is now available has allowed the introduction of watchdogging and limp-home facilities, such that the latest systems are extremely tolerant of a wide range of failure modes.

Memory: Memory densities and the cost per bit of Read Only Memory (ROM) used for program code and Random Access Memory (RAM) used for data storage, has now reached such a level that it is no longer a significant issue in system costs. New developments in terms of Electrically one shot Programmable Read Only Memory devices are expected to have significant impact on the automotive systems, particularly in engine management where they will rapidly replace EPROMs.

Packaging: A major development in the field of systems packaging is the introduction of Surface Mounted Devices (SMD). These are now less than half the size and a third of the weight of the components they replace, with the result that some large ICs are now only 70 per cent of the surface area of the pre-SMD devices, leading to reduced costs and easier underbonnet and bulkhead area packaging.

Power devices: Currently power switching is predominantly mechanical, usually bipolar up to 6A and relays beyond. High current semiconductor switching is still expensive and the reduced costs of relays following recent developments, combined with improved relay reliability, has delayed the introduction of solid state power switching devices.

However, small and medium power MOS switches (Metal Oxide Silicon) has meant that suitable devices for automotive use are now appearing. These devices, with improved thermal stability, reduced power dissipation and with the reducing cost of peripherals, coupled with their ability to be interfaced directly with microprocessors, has made them almost cost effective.

Smart power devices are also appearing which combine switching with interface circuitry, current protection and load monitoring, and are becoming very attractive in multiplex-wired systems.

Multiplexing: The rising cost of conventional electrics with the increasing complexity of modern motor cars, coupled with the need to improve reliability, is driving the cost of electric devices upwards, and the gap between an electric and a complete electronic system is now closing. In fact, with very complex vehicles it is probably now cost-effective to introduce multiplexing. One can expect to see the introduction of selected multiplexed areas such as door systems by 1987 in Europe.

Meanwhile, hybrid systems are being developed involving signal wire switching which will appear during 1986. The introduction of multiplexing will lead to a revolution with regard to on-board diagnostics and dealer servicing.

The servicing and diagnostics of electrical and electronic systems will be too complex to be handled conventionally and will require the development of computer-based testing and diagnostic systems. Within a very short period it will be necessary to design both the system and the servicing software at the same time, leading to greater reliability and customer satisfaction.

In the wake of this development new driver information systems will appear with a move towards flexible displays capable of delivering enormous amounts of information to the driver. Navigation systems and voice control systems are also being rapidly developed. During 1986 vehicles will appear which will be almost totally microprocessor-controlled, leading to full multiplexing within the next five years.

The movement away from traditional materials has been slow due to the relatively high cost of the new materials and the inadequacy of the new materials to fully satisfy the performance parameters satisfied by traditional materials.

The need to replace traditional materials has been initially driven by the need to improve economy. However,

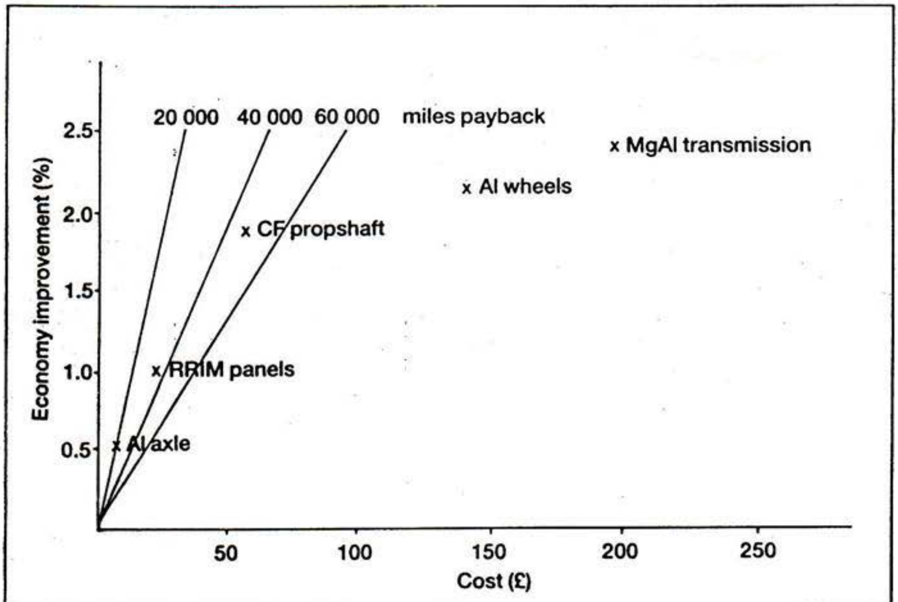


Figure 1. Materials cost effectiveness.

weight reduction is a relatively inefficient means of improving economy, the general rule being that a 10 per cent reduction in weight will only bring about a 3 per cent reduction in economy.

Cost-effective gains can be demonstrated with the adoption of aluminium in place of cast iron for engine blocks and so on, but the use of more exotic materials is extremely difficult to justify on straight economic grounds. Improvements in vehicle economy are much more readily obtained by attention to improvements in efficiency. However, there is movement towards more exotic materials which is being driven by a number of pressures, namely:

Gains in overall manufacturing efficiency brought about by the ability to produce in one item what had been an assembly of many when using conventional materials. This gives improvements in quality and reliability, damage resistance, improved performance, corrosion resistance and ease of manufacturing complex forms.

Traditionally plastic materials have been used in interior trim construction — at present around 75 per cent of all inside materials are plastic.

Exterior use of plastic is limited to only around 14 per cent by weight while mechanically there is only around 11 per cent plastic used. However, with greatly improved materials there is now a movement towards the use of plastics in cosmetically critical areas where previously the use of plastic for body panels had been limited to cosmetically uncritical items such as spoilers and bumpers. It can now be expected that larger panels such as doors, bonnets and boots will be constructed from plastic materials by the end of the decade.

Presently, around 8 to 9 per cent of total vehicle weight is plastic, distributed 75 per cent interior, 14 per cent exterior, 11 per cent mechanical and electrical components. When examining the

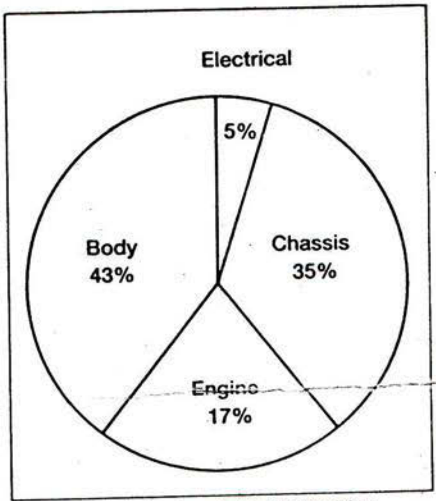


Figure 2. Typical weight distribution.

weight analysis of a typical vehicle it is clear that if weight reduction is the principal aim, then the area of greatest interest is the body. Introduction of plastic body panels does, however, require a significant change in the construction of vehicle main structure, where much greater accuracy of mounting surfaces is required than with conventional construction and a move towards the sort of construction that was employed with the Rover 2000 in the early 1960s becomes necessary.

Unless significant pressures are placed on the automobile through fuel crises it is unlikely that the structure will move away from conventional steel construction, although bonded aluminium structures are particularly attractive if the ultimate lightweight vehicle is desired. It is predicted that there will be an increase in the weight of plastics in motor cars to around 12 per cent by 1990, a doubling since 1980.

Alternative materials to mild steel for body construction: In the short term high strength steels are attractive but require modified tooling and extended try-out to compensate for the additional spring-back experienced with these steels.

Rephosphorised steel will probably remain the first choice where minimum body panel strength is critical, such as in the main floor and so on, but bake hardening steels can be used to advantage where form fidelity is required.

High-strength low-alloy steels will continue to find wide use in structural components. Development of steel bonding can be expected to improve the torsional rigidity of the structure thus allowing thinner gauges to be used, but much work is yet to be done to clarify fatigue and impact properties of thinner structures.

As the thickness of steels is progressively reduced, the need for additional protection is greater. Coated steels are likely to be widely adopted for underbonnet applications and other problem areas such as door clinches. The types of protection currently available include: electrozinc coating, modified electrogalvanising, hot dip galvanising and zinc primer coatings. The present trend in the USA is towards two-sided electrogalvanising.

Aluminium is generally unlikely to be used in place of steel pressed panels, since although it halves the weight, the cost is doubled. It has a number of problems in terms of damage resistance and becomes much more attractive as a main structural material rather than for skins.

Plastics, whether reinforced or not, are showing increasing worldwide use, perhaps the most successful example of which is the GM Pontiac Fiero sports car introduced in 1984, the success of which has led them to declare their intention to produce their F-series cars in 1988 to the same format. Other US manufacturers are likely to follow suit now that the viability of this technology has been established.

RIM polyurethanes not only meet the requirements of body panels but also offer advantages such as resilience and corrosion resistance. Polyurethanes exhibit excellent green strength and allow broad latitudes in process conditions, such as mould temperature and injection rate. They have excellent fuel resistance and dimensional stability when exposed to humid conditions. It has now been established that Class A surfaces can be obtained and the low specific gravity will reduce the component weight to approximately half that of a metal component.

These manufacturing processes employ low temperatures and pressures resulting in significant changes in capital investment and energy costs, coupled to which significant styling freedoms are possible.

Developments are currently taking place in Detroit for 1986 vehicles in which it is expected that fully oven-compatible thermoplastics will be available to enable the manufacture of large horizontal exterior panels coupled with new, high performance RIM systems. These include a range of materials called polyureas which have been developed from polyurethane/urea material incorporating an aromatic amines chain extruder. Their advantages over currently available RIM materials include faster cycle times and the elimination of post-curing. In-line paint temperatures of 163°C are possible.

GM, having introduced such systems on the Fiero, are claiming up to 30 per cent reduction in manufacturing costs.

Structural materials: At present the use of exotic materials in such components as engines has been very limited, due to the very high cost of such materials. However, this may not always be a constraint and some very interesting developments are taking place.

Materials of considerable interest are continuous fibre reinforced aluminium and carbon fibre reinforced plastics. the former exhibits physical properties similar to steel at normal engine operating temperatures except that its density is about 60 per cent lower. Carbon reinforced plastics have properties which are an order of magnitude better than those of conventional plastics and have been used successfully for major components in experimental engines.

Another material of considerable interest is defect-free cement which has great potential for use in engines, particularly for cylinder blocks and rocker covers, the main advantages of which would be reduced weight, cost and noise emission. There are instances of some of these new materials being used in race engines, as for instance by the Polymotor Research Corporation, on a project undertaken with Lola.

The material used in this case was a high-strength, high-temperature polymer capable of producing tensile strengths greater than 2900ps (20Mpa) and withstanding temperatures in excess of 260°C.

By carefully using metals in areas above 260°C and plastics below this, they created a power unit with a weight reduction of approximately 50 per cent while producing 330hp at 9500rpm from a 2.3 litre engine.

It is unlikely that the use of such materials will be cost-effective in the near future, but in the longer term we may well see their introduction.

The aerodynamic behaviour of a motor vehicle affects its performance and acceptability in many ways, and in varying degrees. The parameter that has captured the greatest attention in recent years has been the drag coefficient and its effect upon fuel economy. It is conventionally accepted that for the average car usage pattern the percentage improvement in fuel economy achieved as the result of reduced aerodynamic drag is roughly 0.1 of the percentage reduction in drag. This conventional wisdom, however, neglects the effects that crosswind conditions have on fuel consumption.

Gino Sovran analysed the affects of wind and found that over a period of time the energy expended, and therefore the fuel consumed, in overcoming the aerodynamic drag of a vehicle in the presence of natural winds of varying strengths and directions was increased by a factor very dependent upon the cycle and the aerodynamic characteristics of the car, of between 1 and 6.

The reasons for this are twofold. First, the aerodynamic drag depends upon the square of the velocity relative to the car so that the averaging affect of driving a vehicle upwind and then directly downwind consumes more energy than covering the same distance in still air because of the square law effect of the component of wind velocity, and second, the drag force itself will increase in the presence of a crosswind component due to the increasing Cd with increasing yaw.

The overall effect is that the aerodynamic drag has a greater effect upon fuel economy than still air predictions would suggest, but underlines the necessity to establish the yawed drag coefficient, since this represents the more normal case.

Future developments require a clear understanding of the aerodynamics of bodies in close proximity to the ground plus greater attention to the reduction of drag producing protuberances. This involves attention to underbody smoothness, glazing details, mirrors, door handles, bumpers, wheel arch designs and so on.

Proper exploitation of low-drag, high-stability body shapes will require control of vehicle ride height and pitch attitudes, particularly at high speeds. It will also be necessary to pay attention to cooling system design, which again has significant effects upon drag and lift.

The reduction of aerodynamic noise requires that the general level of turbulence in the air flow around the car has to be reduced as much as possible, so that body panels and glasses are not excited to radiate noise into the car.

In order to tackle these problems it will be necessary to advance on a broad front, through investigation of basic shapes in wind tunnels, development of aerodynamic theories of ground proximity, and application of computational fluid dynamics. There will be a need to design shapes which, when close to the ground, yield low drag with desirable lift, side force and centre of pressure characteristics.

These are difficult problems to resolve due to the complex interaction between vehicle and ground, involving highly sensitive boundary layer interactions and associated flow separations which are greatly exacerbated by the presence of wheels, acting as major disrupting influences.

The second impact that aerodynamics have on a vehicle is on stability, particularly in the case of gusting winds. Here the most important requirements are that the aerodynamic forces acting upon the vehicle should not seriously reduce the tyre cornering stiffness by introducing lifting effects. An ideal case would be to produce aerodynamic downforce but this is only achieved in racing vehicles, and would, of course adversely affect fuel consumption.

In order to reduce the sideforce effects it is essential that the lateral centre of pressure should be kept as near as possible to the neutral steer point. However, this is often in conflict with designs produced to create low drag, particularly when substantially greater slopes are designed into the front of the vehicle, which has the effect of bringing the centre of pressure forward and thereby increasing the vehicle yaw response.

A second destabilising factor associated with aerodynamic drag of cars is the fact that a lower aerodynamic drag force reduces the weight transfer to the rear axle, which reduces the critical speed and hence introduces greater instability. The foregoing, coupled with the need to reduce weight to improve economy and performance, means that greater and greater attention must be paid to the aerodynamic stability and lift of modern car designs.

The trends in engine development have been, and continue to be governed by a combination of pressures on economy and emissions. Of the technologies presently being applied to meet the newly determined emission objectives in Europe, it is expected that a combination of the systems outlined

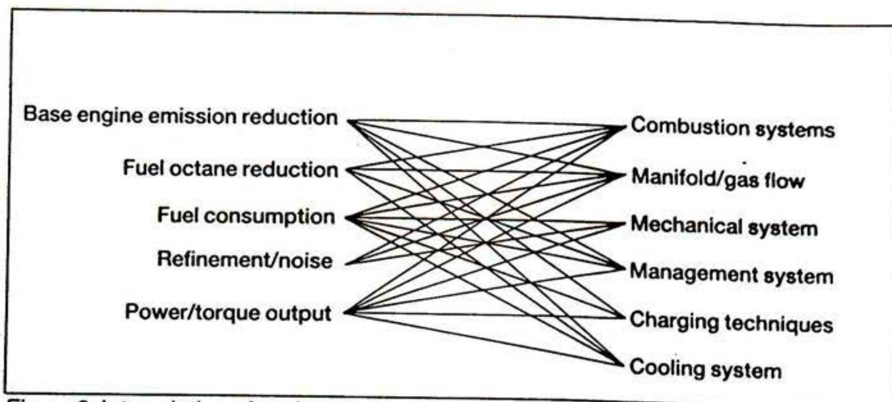


Figure 3. Interrelation of performance and design parameters.

below will exist, the application depending upon vehicle weight, engine capacity and emission constraints.

Lean burn technology (less than 1.4 litres): no catalyst; simple or programmed ignition; carburetter, singlepoint or multipoint fuelling; exhaust gas recirculation.

Lean burn technology (1.4 to 2.0 litres): oxidation or wild three-way catalyst; simple or programmed ignition; carburettor, singlepoint or multipoint fuelling possibly with feedback control; exhaust gas recirculation.

High dilution combustion (more than 2.0 litres): three-way catalyst; stoichiometric tune; feedback fuelling, single or multipoint injection; programmed ignition.

Figure 3 shows the complex interrelation of the performance parameter to the design parameter and emphasises the requirement of the system approach whenever any of the performance parameters is refined. It is this approach, particularly for the development and application of high dilution combustion chambers, that will become central to future engine development programmes, since without adequate understanding of the whole system performance objectives can be completely missed, for example when developing four valve combustion systems, incorrect exhaust system design causing dynamic head loss can completely destroy inlet system performance and mask any improvements that have been made over original systems.

Combustion systems: Emphasis can be expected to be placed on the development of high dilution combustion systems which can operate either as lean burn chambers for up to 2 litre capacities for European markets, or efficiently in a stoichiometric mode when three-way catalysts will be required to meet emission levels. Maintenance of optimum economy will remain essential. Figure 4 shows a comparison of current combustion systems against lean burn systems where the benefits of new generation chambers can clearly be identified if operated at stoichiometric or lean burn conditions.

Lean burn technology: It can be expected that combustion chamber development will focus on reducing NOx levels with high charge dilution by air while containing, and hopefully reducing, current hydrocarbon levels. Fast burn technology will be employed through optimising chamber shape for shortest burn patterns and chamber activity for fast turbulent flame propagation.

Traditionally, fast burn chambers have been of the compact or high-swirl design. Compact chambers are susceptible to hydrocarbon emission problems because of high squish areas. They also suffer from high NOx peaks, causing transient control problems, and generally have a high octane requirement.

High-swirl chambers are flow restrictive and need careful tuning of swirl to obtain the benefits of lean burn. Future chambers can therefore be expected to be of a more open design to provide the benefits of good geometry for flame development and reduced squish area for lower emissions. Hence squish generated flows will tend to give way to port generated flows.

Stoichiometric tune: Many of the chamber features employed in the lean burn approach are also pertinent to optimising stoichiometric tune.

Exhaust gas recirculation will be used for reducing NOx and improving engine efficiency. The techniques adopted for lean burn apply equally to EGR tolerance. With EGR, further attention will need to be paid to obtain adequate reaction ratios within the chamber to ensure that good initial flame developments are achieved.

Attention will also be paid to maintaining good flow capability consistent with adequate swirl generation to compensate for power losses associated with the use of catalysts.

For all combustion systems attention to octane requirement will be necessary with the engine management systems allowing operation nearer to the detonation borderline.

Manifold and gas flow: Manifold design can be expected to rely more heavily on the concept of inertial ramming, rather than the more familiar reflected pressure wave approach, which can lead to undesirable resonant systems.

Inertial ramming uses the initial inertia of the gas within the manifold system, plus the momentum generated once the gas flow is moving to ensure that useful work is done by the gas flow at critical phases during the induction and exhaust cycle.

Design constraints, such as packageability, minimal wetted area and so on, will often prevent the optimum manifold system being used, so that cam timing has to be selected to make full use of the available ram magnitude and phasing.

Figure 4 shows that the successful development of the manifold gas flow system will influence a number of important performance parameters. At full throttle inlet inertial ramming will increase volumetric efficiency which, combined with the benefits of reduced pumping losses and better scavenge efficiency from the exhaust suction, can give significant benefits in power/torque output.

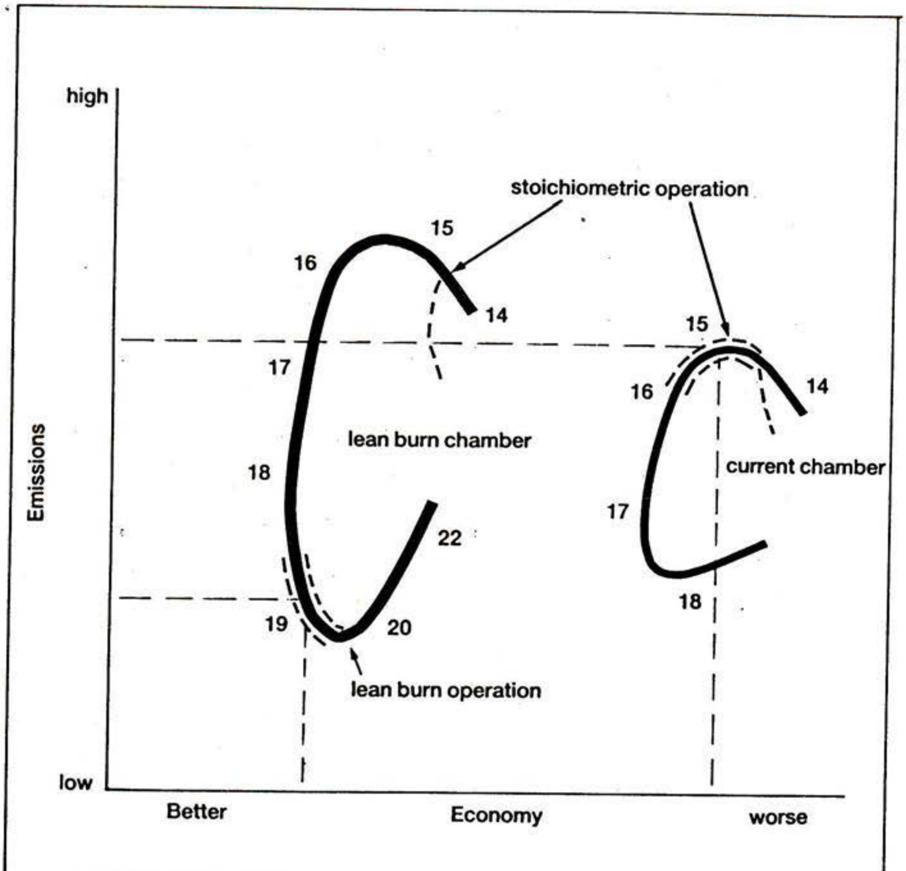


Figure 4. High dilution combustion.

The careful balancing of inlet and exhaust inertias to control scavenge, EGR at part load and idle can contribute to emission reduction, especially hydrocarbon emissions, while the increased inlet gas velocities can directly improve combustion efficiency through increased swirl and so on.

Mechanical systems: Particular attention will need to be paid to the losses in reciprocating and rotating components, for example, piston weight reductions, together with fewer rings and the use of friction pads, all contribute to reduced losses.

The mean torque to drive valve gear also constitutes significant loss and attention can be expected to be paid to improve design and predictive modelling of valve train systems. This is particularly relevant to the increased use of four-valve-per-cylinder engines. With careful design it is possible to keep the overall loss below that of a two-valve rocker-activated derivative of the same engine.

Acceptable mechanical durability will also be required in conjunction with the improved management systems to ensure that, for example, borderline knock can be tolerated by the piston design employed. This, together with the required lower parasitic losses, may necessitate the introduction of alternative materials within the engine.

Engine management: The current trends towards programmed ignition, fuelling and exhaust gas recirculation can be expected to continue where legislative requirements on vehicle performance and emissions dictate, being used in conjunction with catalysts as appropriate, dependent upon mode of operation of the engine selected, for example lean burn or stoichiometric. The use of sensors either to ensure the correct lean air ratio or adequate control on stoichiometry will become more common. Longer term, the complexity of the fuel modelling process within the manifold to allow for wall wetting will increase, particularly if lean burn engines are to operate nearer than three air fuel ratios from their lean limit.

Adaptive systems for ignition and fuelling based on self-diagnosis of the engine operating conditions obtained from cylinder pressure derived data will be developed, although the complexity versus operating benefit may delay introduction. Other areas where electronics will impact in future engine development programmes will include variable valve timing, particularly in four-valves, and sequential electronic fuel injection systems.

Future fuelling strategy for engines will remain a combination of carburetter, single point injection and multipoint injection with fewer engines using carburetters as the wider use of catalysts and accurate air/fuel ratio control becomes necessary.

Pressure charging: The increased use of pressure charging techniques could become extensive. Currently only the high performance derivatives of vehicles use pressure charged power units. However, the potential to replace larger, naturally-aspirated engines with pressure charged units for either economy or emission reasons could become more common, being urged by the new emission regulations in Europe. Several potential routes are possible: the variable geometry turbocharger, the ceramic turbine rotor, and the mechanically driven supercharger.

The variable geometry turbocharger is thought to offer most improvement over present systems with the nozzles being closed to give maximum torque at low speed and for accelerating the turbocharger, and opened to limit high speed boost without the need for a wastegate. The ceramic turbine rotor is aimed at reducing rotor inertia to improve turbocharger and hence engine acceleration. The mechanically-driven supercharger is currently the best for low speed torque but wastes the exhaust usable energy and reduces fuel economy at high speeds. Ideally the supercharger requires clutching to minimise economy penalty at part loads —overall this system is probably not competitive if variable geometry turbochargers become available at moderate cost.

Cooling system: The importance of controlled cooling to achieve optimum fuel economy, emissions and octane requirements has been recognised with the current trend in engines of only cooling those parts of the engine which require it, such as valve seats, combustion chamber area and exhaust ports. This will continue to evolve with reduced cooling water volume within the engine to aid fast warm-up.

Further, splitting the head and block cooling flows to help achieve tighter control on temperature profiles within the engine will become increasingly popular. It is increasingly understood that present day engines tend to overcool the block, particularly in the lower part of the cylinders. With appropriate water cooling and split cooling systems, this problem can expect to be improved.

Suspension systems have been the subject of continuous development over many years and in a mechanical form are close to being optimised. A wide variety of innovations have been applied to achieve acceptable compromises between steer accuracy, isolation and traction. Most recent developments include elements of mechanical rear wheel steer, the intention of which is to improve stability under traction and increase yaw damping during transient manoeuvres. Damper systems have also changed very little over recent years and still comprise a number of orifice control characteristics linked by spring controlled blow-off.

Ride control: Systems are presently appearing which will electronically switch from one hydraulic characteristic to another, depending upon a series of inputs varying from a simple switch characteristic, such as boulevard to sports ride, or through analysing steer inputs versus speed and so on. The characteristics thus obtained are, however, still very heavily dependent upon the mechanical technology used within the damper. To fully optimise the damping characteristics it will be essential to fully microprocessor-control characteristics and store the damper parameters within the microprocessor memory.

When this is coupled with control of some or all of the suspension parameters, then control of ride height and roll characteristics and, if necessary, roll rate distribution can be obtained, the foremost example of this technology being the Lotus system.

It is doubtful, however, that full ride control will be adopted in other than the most exotic vehicles since it implies a constant power absorption and hence unacceptable economy losses, but electronically controlled damper characteristics will become increasingly popular.

Steering systems: Power-assisted steering systems, like dampers, are presently mechanically controlled with, on occasions, a speed dependent control of the power assistance to introduce heavier feel at speed. In principle there is no reason why this varying control should not be microprocessor controlled, or indeed, entirely electrically driven, thus reducing the need for expensive and complex hydraulics and possibly reducing weight and cost.

Rear wheel steer: The present European practice on some vehicles allows rear wheel steer to occur under the effects of traction, improving stability particularly in the throttle-on and -off situation. The Japanese have introduced controlled steer of the rear suspension which is essentially an extremely logical development, allowing as it does improved response when required plus stability at high speed, and can even be used to improve the turning circles during parking if so desired.

Such systems enjoy a great deal of flexibility over the simple mechanical system without introducing the tyre wear and energy losses that can be attendant upon mechanical design.

Suspension materials: Composites have found their way into suspension systems very slowly, being evident only on vehicles having high wheel rates such as sports cars and trucks, it being difficult to achieve a sufficiently low rate with adequate wheel travel.

Composites can, however, offer significant advantages when they are used in designs which accomplish more than one task — for instance, when combining lower wishbones with spring systems, in which case manufacturing costs, weight savings and simplicity outweigh the material cost increases associated with the use of such relatively exotic materials.

The need to secure greater economy between the late 1970s and early 1980s brought about the introduction of four-speed automatic gearboxes with converter lock-up and high overdrive ratios. It was expected that constantly variable transmissions would be available in the early 1980s and would provide even greater economy by optimising the engine transmission performance. More recently there has been renewed interest in optimising performance, hence the recent widespread adoption of four-wheel drive.

Gearbox: The relatively makeshift introduction of four-speed automatic gearboxes by grafting on the fourth speed introducing a converter lock-up was beset in its early development by unsatisfactory shift characteristics.

Hydraulic development has greatly improved the performance but the introduction of electronic control has allowed the optimisation of the gearbox and power unit by allowing control of the engine torque during shift, and providing the driver with the choice of a number of shift patterns to suit his driving requirements.

Constantly variable transmissions were expected to be available in the early 1980s but have not yet appeared. To a degree this later-than-ideal introduction of the gearbox may introduce a problem since the rather unexciting operation of a CVT may be less acceptable to drivers no longer aware of the need for economy.

Four wheel drive: The necessity for four wheel drive first arose when front wheel drive cars were developed to sufficient power outputs to experience traction difficulties. Front wheel drive layout lends itself readily to modification to four wheel drive, hence systems were quickly developed.

Rear wheel drive cars run into this difficulty at higher power-to-weight ratios and hence, since there is greater difficulty in arranging drive shafts on in-line engines, they have been slower in reaching the market place. The torque splits available with this configuration can be more acceptable in terms of handling characteristics.

The most attractive feature of a four wheel drive car is its performance on low mu, since very few cars are of such power-to-weight ratio that four wheel drive is necessary on normal surfaces. It is mostly for this reason that four wheel drive has become so popular.

The widespread adoption of ABS carries with it, however, some interesting developments in terms of the optimisation of performance through a single axle by way of traction control in which the difference between four wheel drive and single axle drive is considerably less marked, and under some circumstances can even provide better traction than a conventional four wheel drive system.

Such systems, requiring some form of drive-by-wire throttle control, offer a very cost-effective means of improving low mu traction and are very likely to replace four wheel drive as the low mu option, being cheaper and more reliable without the 80 to 100kg weight penalty attendant upon the adoption of 4WD.

In all areas of motor car development the pressures imposed by requirements for greater quality and reliability, and improved performance in all respects, and cost-effectiveness, are driving the industry towards tighter and tighter controls, not only in the design of the vehicle but in the manufacturing processes that produce it.

The most important effect this is having upon the design of the vehicle is the rapid introduction of electronic controls in almost every area of the vehicle. It appears to be inevitable that this trend will continue and that there will be movement away from the mechanical and hydromechanical systems which are presently the norm, towards much more flexible and ultimately more cost-effective and reliable electronically controlled systems.

The adoption of new materials will not now be driven by the need for improved economy, but will be driven by the desire to improve the cost-effectiveness of manufacturing processes and component durability. Overall the automobile industry appears to be set for introducing at least the level of change in the next five years as has been seen in the preceding five years, and may be considerably more. □

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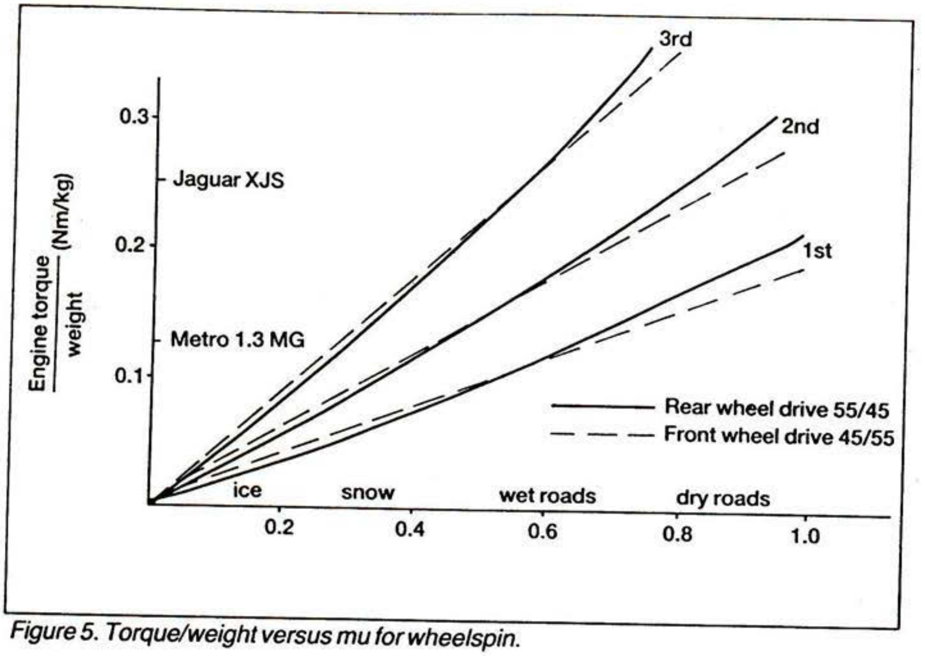

Figure 5. Torque/weight versus mu for wheelspin.

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