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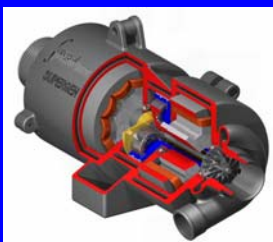
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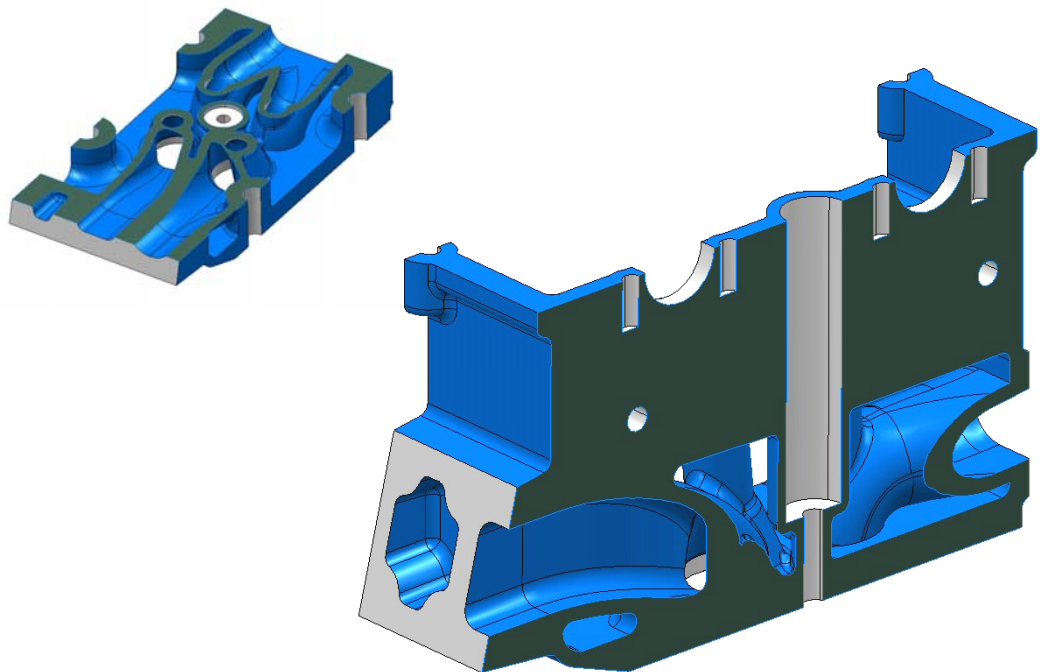
... reducing misfire detection calibration workload ...



Intelligent Design Template for Diesel Cylinder Heads

In response to high levels of industry activity, IP has created an intelligent design template for 4V diesel cylinder heads. The tool is based on similar architecture to our gasoline template but with revisions to cover asymmetric inlet porting, cross-flow cooling and fuel injector and glow plug packaging.

Design rules for valve spacing have also been revised and modifications made to enhance model stability at low or zero included valve angle.



This new tool, used in conjunction with the AIED tools for the other major engine components, enabled IP to complete a major engine concept study for a client earlier this year.

Incorporation of advanced boosting and emissions control systems within increasingly tight vehicle package constraints creates tough challenges for the development of tomorrow's diesel engines. The complexity of a simultaneous engine geometry and vehicle package study can easily lead to sub-optimal or un-workable solutions which are not immediately apparent. IP's AIED tools enable the engineer to evaluate many options and make critical decisions quickly, with confidence, supported by comprehensive analytical and 3D package information.



... Intelligent Engineering enables companies located in "high cost" economies to compete in the global market ...

IP Comment: Intelligent Engineering or Low Cost Sourcing?

It is clear that in line with the previous 40 years, the future will see us spending a lower proportion of our income on products that more closely match our needs and aspirations. In manufacturing this has already driven substantial movement of capacity to economies with a lower cost base. Engineering too will have to meet this challenge – but how?

The procurement or resource management of certain engineering activities as commodities now presents one viable opportunity for reducing costs. Where data communications are well organised, labour content is high and tasks can be precisely specified, work can be effectively transferred to a number of economies where the required skills are available and labour costs are lower.

IP believes that the way forward for engineers in higher labour cost economies must be to radically improve the engineering process itself and the *value* it delivers to the OEM. That is to say to use engineering excellence and its effective integration with other functions to drive efficiency and responsiveness throughout the organisation. We call this "intelligent engineering".

But this is not something engineers can do in isolation. Only by engaging with functions such as marketing, manufacturing and purchasing will we be able to develop the ideas and processes that will produce tomorrow's winning products.

Engineering as a commodity

- Costs can be reduced by buying from cheapest viable source
- Intelligence, education and motivation make emergent economies viable for many engineering tasks
- Data and knowledge are increasingly portable

Difficulties

- Reduced hourly costs offset by increased set-up and communications overhead
- The commodity procured is generally an engineer hour; focus is removed from the value of this and R&D to improve this
- Short and medium term show emergent economies are most viable sources but the costs in these markets are set to rise substantially

Intelligent engineering

- By streamlining engineering and properly integrating it with marketing, purchasing, manufacturing and other business functions a fitter, more responsive organisation can be created
- The three pillars of intelligent engineering are:
 - Capture, refine and deploy best practice
 - Combine the intelligence of humans and computers effectively
 - Implement via design
- Cost and time for engineering tasks will be reduced by the same mechanism that assures quality

Difficulties

- Purchasing or resource management task is far more complex than buying hours
- Investment in tools and data management systems required
- Significant changes required to organisational culture

The emergence of low-cost "commodity engineering" is clearly reducing the cost of many of today's established engineering processes. Interestingly, this phenomenon is also providing a major stimulus for improvement to engineering communities where labour costs are higher and the benefits arising from this may well be greater. By using advanced techniques to capture, deploy and evolve our best practice we believe we can offer improvements in product specification, time to market and cost that are not achievable by other means. The challenge for us and for our customers is to harness this potential effectively.





... VCP doesn't always deliver the expected drive feel benefit for turbocharged engines ...

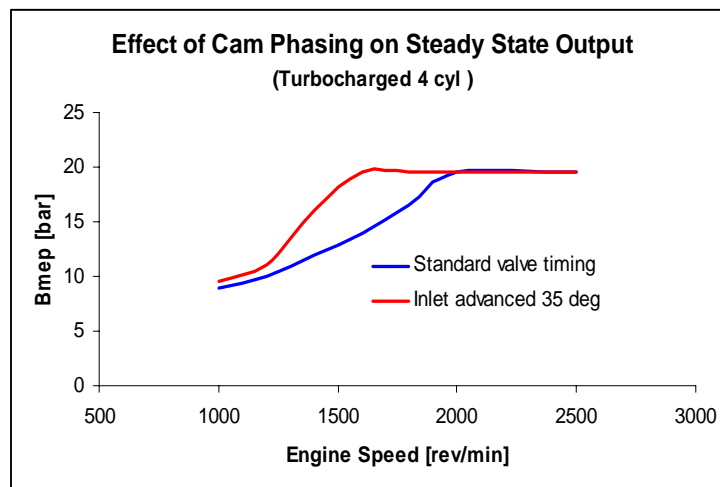
Why Doesn't it Feel as Good as it Looks?

Luke Barker – Technical Director – discusses some interesting physics associated with the launch feel of turbocharged gasoline engines.

I remember seeing for the first time (1992) the potential of using VCP on a turbocharged gasoline engine. The development team had spent much effort optimising the engine to reduce by a few revs/min the speed at which peak BMEP could be achieved and with the aid of a pulse divided manifold we were down at 1950 rev/min (quite respectable then for a 100 bhp / litre engine).

We then swung the inlet cam by 35 degrees and as if by magic achieved peak torque at 1600 rev/min! A quick inspection of the test sheet showed that we had increased the volumetric efficiency by around 20% and improved the knock resistance significantly.

A vehicle was hastily adapted to run the test set up but the results were very disappointing. The low speed tip-in and launch behaviour were actually *worse*, after a brief investigation the reason became apparent.



The volumetric efficiency and knock limit gains at the heart of the test bed improvement were caused not only by early inlet valve closing, but also by scavenging during valve overlap. This works well provided the inlet pressure is greater than the exhaust; but during launch tip-in this was not the case – hence the effects worked in reverse!

Now with CO₂ emissions in focus, boosted, downsized engines are once again of great interest and the transient feel under low speed tip-in and launch conditions is critical. Poor performance under these conditions usually requires shorter gearing or else the driver will select a lower gear based on the responsiveness of the Powertrain. This can negate much of the benefit of downsizing. Fortunately in 2005 our ability to understand and optimise this type of system is greatly enhanced!

At the centre of our approach is a MATLAB / Simulink vehicle model. This captures the physics associated with hardware and control system and allows us to really get to grips with transient performance issues such as vehicle launching.

New modules cover electric motors and generators, exhaust valve, port and pipe temperatures and intercooling.

As well as our customer work, the model is being used for internal R&D including:

- The potential for VNT and full load EGR in gasoline applications
- Quantification of benefits of compressor map enhancement
- Alternatives to sequential turbocharging for high output diesels
- Control strategy for SuperGen, our electro-mechanical variable ratio supercharging system

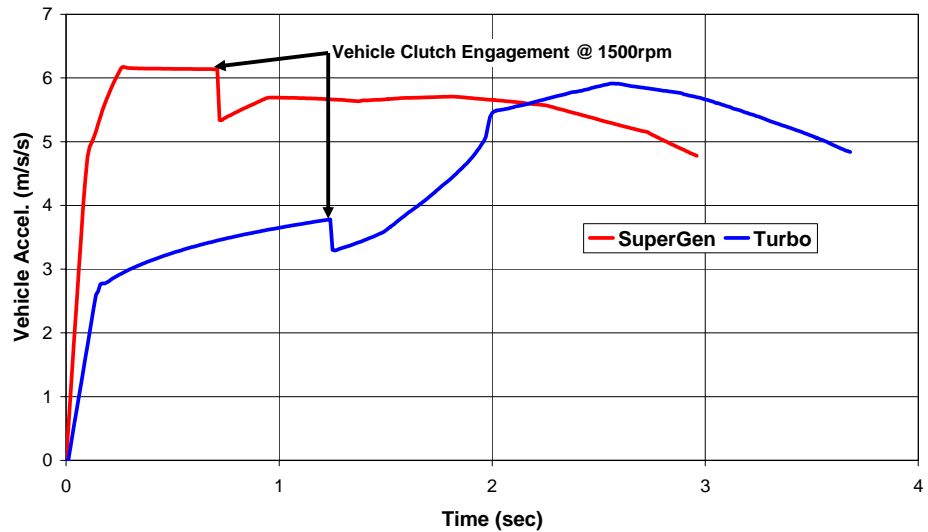




... modelling can provide valuable insights into transient performance effects ...

... applying IP's vehicle CO₂ model to traffic management ...

1st Gear Vehicle Launch Acceleration



This approach is more stable and quicker to set-up and run than traditional 1D simulation methods, allowing a thorough exploration of options or large parametric studies to be completed rapidly. The same model can also be run over complex cycles to predict CO₂ emissions. Model set-up time is minimal and simulation run time is typically less than 30 seconds per test.

How Much CO₂ Does a Speed Hump Cost?

We are all quite rightly focussed on the hardware and control aspects of CO₂ reduction but are we currently neglecting a very significant factor – the infrastructure?

As part of our CO₂ reduction activities IP developed a very high level tool for well to wheels estimation of a number of radical concepts.

This tool has now been configured so that it can estimate the impact of new road schemes or traffic management modifications on overall CO₂ emissions. We are now talking to the UK authorities to investigate the potential for integration with planning software so that CO₂ implications can be assessed accurately as part of cost / benefit analysis processes.

Inputs required are readily obtainable from survey results such as traffic density, average speeds and distribution of vehicle types. The model then captures the effects of features such as gradients, traffic lights, junctions and roundabouts to build a comprehensive understanding of how the infrastructure impacts CO₂.

One case study shows that adding 20mph speed humps every 100m to a stretch of 30mph limit suburban road increases CO₂ emissions by a factor of over 2.





... a new desk-top simulation based approach to misfire monitor window timing optimisation ...

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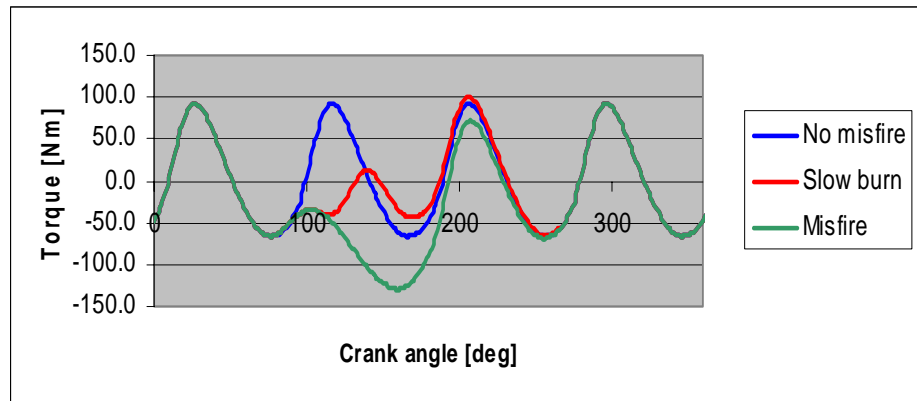
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Desk-top Misfire Detection

Robust detection of misfire over a wide range of engine speeds and loads is essential to meet the latest stringent On-Board Diagnostics (OBD) regulations. This is particularly important during engine warm-up where retarded combustion and leaner AFR can be part of the catalyst light-off strategy.

As part of IP's strategy of reducing reliance on time consuming and costly testing, we have developed a new desk-top approach combining engine combustion and EMS software simulation. This has been used successfully in a production calibration project, resulting in software changes that have improved misfire detection performance.



Graph showing crank torque profile over one revolution

Detection is usually done by measuring small changes in angular motion in pre-defined "windows". Using our powertrain simulation, we found it possible to model the engine's uneven combustion using IMEP statistics. By also modelling the strategy, it was possible to determine the robustness of the misfire detection process.

This approach allows optimisation of the sampling windows and other parameters to be performed on the desk-top. It also enables combustion stability targets to be set with confidence and reduces the amount of testing required to achieve a robust misfire monitor calibration.

IP joins The MathWorks' *Connections* Program

Integral Powertrain has partnered with The MathWorks Inc., joining MATLAB Connections Partner Program.

The MATLAB Connections program is available to third-party organizations that develop complementary, commercially available services based on the MATLAB technical computing environment. Partners offer solutions that are seamlessly integrated with The MathWorks products and ensure ongoing compatibility in conjunction with new MATLAB releases.

Integral Powertrain Director, John McLean explains; "The rapid expansion of desk-top simulation and data processing techniques is delivering substantial benefits in terms of cost and timing on customer projects. The MathWorks products provide an ideal platform particularly where hardware and control systems meet, as in powertrain transient performance, CO₂ emissions and EMS applications."

IP clients can benefit from this in two ways:

1. IP delivers engineering projects at lower cost and in less time
2. IP can develop customised processes supported by MATLAB tools for its clients to improve their engineering methods for EMS applications

For additional information, visit www.mathworks.com

