Art and science

Jack Burns finds a lot of scope for improvement in exhaust system design

Some readers will be fortunate enough to be involved in the design and development of a race engine from a clean sheet of paper and will have available the best tools for the job. The majority have to compromise, restricted in design scope and in resources for development. Nevertheless, there is never any excuse for poor exhaust system performance in the opinion of Jack Burns, co-owner with Rick Popovits of Burns Stainless.

California-based Burns Stainless produces exhaust headers (manifolds, in European parlance) for many forms of professional racing including top NASCAR and NHRA classes and even Formula One. Burns says he finds that even in these enlightened times the design of headers can all too often be an afterthought, particularly for those developing stock block American racing engines without the benefit of the vast resources enjoyed by the top Cup teams.

"There tends to be a lot of time spent on the intake side and sometimes when we are asked to get involved on the exhaust side, we find that we have to do a damage limitation exercise!

"These people fail to appreciate that if they put the same amount of development effort into the exhaust system they would be further ahead on the overall engine package…

"This situation is partly down to tradition and is partly a function of the relative ease of modifying the head and intake system. By contrast the exhaust system is costly and time consuming to alter. Then you have to consider the interface between engine and chassis builder: typically it is the chassis builder who makes the exhaust system.

"On top of that it can be difficult to understand precisely what is occurring in the exhaust system, in view of which we find that there is a lot of misunderstanding among engine builders. We recently made a four-cylinder header for an engine builder who thought he understood: his existing header made 8 bhp more than any other he had tried so he considered it a superior design. Nevertheless we were able to find him another 8 bhp over that and at the same time broaden the engine's power band!

"Our strength is that our knowledge comes from a systems standpoint. We are often able to apply that to advantage, as in this instance."

So we can see that the difficulties involved in exhaust system design and development have contributed to a widespread lack of appreciation of the potential to be gained. Given the aforementioned lack of understanding of what is happening in the exhaust, can the use of simulation tools improve header design?

"Exhaust flow is more difficult to model than intake flow. This means that the software accessible to smaller engine builders who are confined to the more affordable packages tends to be less accurate on the exhaust than on the intake side. We have found that even with the more sophisticated software employed by the likes of Formula One teams the user needs a certain amount of expertise to be able to get real benefit from it.

"We work with bright college students developing headers for Formula SAE and some of them have access to sophisticated modelling software. But we still find that they often need the benefit of our experience to keep them on the right track. You need the expertise as well as the software."

As we have reported in the past (Race Engine Technology issue 14) Burns offers its own X-design software to assist the header design process. This is not a complete engine performance modelling solution but is intended to put the user developing a common type of racing engine into the header design ballpark.

"This software quantifies what we have learned over the years. The customer provides us with the required data from their application and we will run our model for a charge of $75, which we will refund against the cost of the system itself."

Burns warns, however, that there is no substitute for actual dyno testing.

"We make adjustable headers for dyno testing. These provide some


The Chevrolet drag boat engine

flexibility in terms of primary sizes and lengths and collector sizes, to aid the engine development process. There is no substitute for physical testing."

Not that testing on a regular dyno can always provide the definitive picture, Burns cautions. "Sometimes you lose horsepower on the dyno but go faster on the track. This is typically due to engine response issues that can only be evaluated on a transient dyno.

"If you take the example of a NASCAR Cup restrictor plate engine, an extra 0.5 bhp will make the car faster whereas a Sprint Car is influenced by transients. We have found that Sprint Car header design can help smooth the fuel delivery, which makes the car faster, even though it might not show more horsepower on the dyno."

Again, there is no substitute for experience. So the message is not to overlook the importance of exhaust system design and to employ the best design and development tools that can be accessed. Even if sophisticated tools are not available, that is no excuse for overlooking header science, particularly given the opportunity to take advantage of specialist knowledge, such as Burns Stainless offers its customers.

"Here at Burns Stainless we live an exhaust-centric world," Burns concludes as he surveys a world that tends all too often to be unhealthily intake-centric! ■

WET FLOW

"We designed and made improved headers for a 562 cubic inch Chevrolet jet drag boat engine that produces 950 bhp," reports Jack Burns. "This engine breathes through a tunnel-ram manifold fitted with a pair of four-barrel Holley carburettors. The engineering exercise required designing, constructing and tuning the exhaust to maximize the power curve in a narrow band: between 6600 and 6700 rpm.

"We utilized our DesignSYS software and built the header shown in the accompanying illustration. We utilized our adjustable BTEC collector system. The baseline headers were good-quality commercially available racing units.

"On a SuperFlow dyno, our system improved peak torque by 24 ft.lb. and increased maximum power by 14 bhp. But the target was to increase power in the 6600-6700 rpm range, which we increased by 21.5 bhp. Overall, the powerband broadened during the dyno test runs from 5500 thru 7500 rpms, with an average torque increase of 16 ft.lb. and average power increase of 20 bhp compared to the baseline."