



Application Case

Noise reduction on a Superbike without com- promising performance

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NOISE REDUCTION ON A SUPERBIKE WITHOUT COMPROMISING PERFORMANCE

SCAN&PAINT FOR SOUND MAPPING A HIGH PERFORMANCE TWO-WHEELER

In this application the challenging task was to find a solution to reduce the noise produced by a superbike, a high performance two-wheeler, without altering its performance. Due to very strict noise regulations applying for events as for example motorraces, it is essential to reduce the motorcycles noise to be able to comply with these noise regulations, which are frequently exceeded.

It is challenging to reduce the noise of a high performance motorcycle and typical solutions used at the moment are reducing not only the noise but also the performance. There are two thresholds defined in the regulations. One is a maximum overall level at a defined distance from the racetrack that is produced as a total by all motorbikes on the racetrack. Secondly there is a maximum level at 1 meter that each individual motor cycle is allowed to produce. Typically this last requirement is dependent on

the first rule and specific for the event. At the moment both are frequently exceeded or only achieved by compromising performance. The noise could be reduced for example by using dB killers on the bike or reducing the throttle whilst racing at positions on the track where sound level meters are placed; both resulting in decreasing performance.

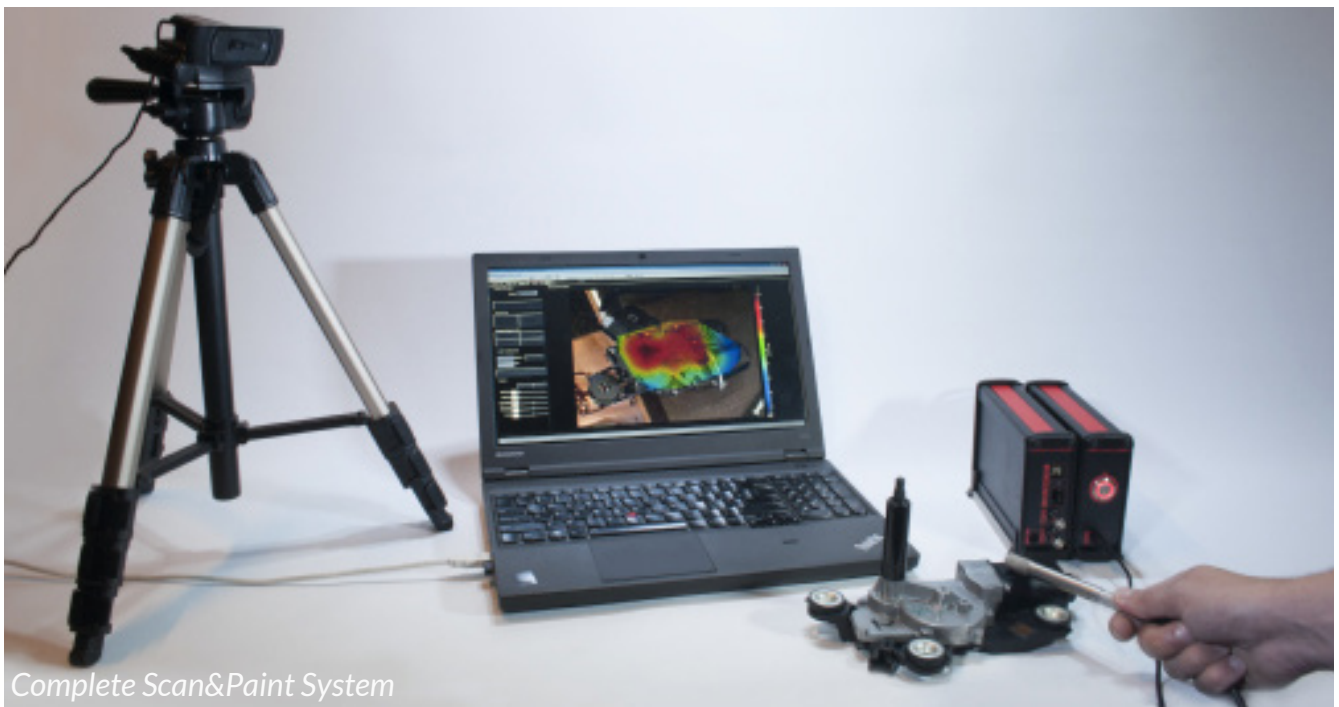
Scan&Paint was the measurement tool used in the development process of finding a solution that will reduce the noise and get the superbike within regulation limits keeping the same performance, such as horse power and torque, as before modifications. The superbike in this application was a Honda CBR 600 RR.



MEASUREMENT PRINCIPLE

Scan&Paint is a fast and easy solution designed to visualize stationary sound fields. Providing a solution to the ultimate acoustic problem of localizing noise sources in environments with presence of high background noise. It can localize noise sources on almost any surface in the full acoustic bandwidth. The system comprises of a single PU probe, signal conditioner, DAQ (Scout), Camera and a standard laptop. The PU probe included in the Scan&Paint system enables the direct measurement of sound pressure, particle velocity, sound intensity and acoustic impedance. Due to the unique characteristics of the particle velocity sensor, there is no need to create anechoic conditions during your measurements. The surface is scanned with one PU probe, while a camera, positioned toward the mea-

sured surface, records the scan. The recorded video and audio data are automatically synchronized by the software, thus minimizing the processing time. In the post-processing stage, from each frame of the recorded video, the position of the probe at that time is extracted. The auto-tracking function embedded in the software enables the automatic recognition of the location of the probe, using a freely customizable color marker. At each tracked probe position the particle velocity, sound intensity and sound pressure are calculated from the time block of data assigned to each probe position. A sound color map with unmatched spatial resolution is produced as a result. Extensive analysis options are available to provide deeper insight into the dominant sound sources that are mapped and detected with the systems.



Complete Scan&Paint System

MEASUREMENT RESULTS

Noise reduction on a superbike without compromising performance

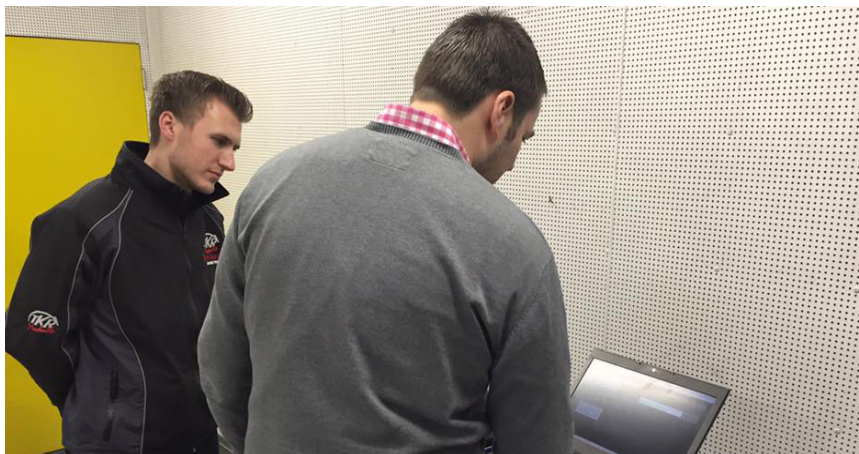
MEASUREMENT CAMPAIGN

The measurement campaign included both static and dynamic measurement series. The dynamic measurements, were purely done for compliance, to see the overall noise at the race-track. The soundlevel in dB(A) was measured in two stages, a baseline measurement at the beginning and one more at the end after the modifications.

The majority of measurements were static measurements carried out in a reverberant environment with the superbike running on a dyno test bench. Here the measurements were R&D focussed and the Scan&Paint was firstly used to rank the most dominant sound sources. Secondly it was used as benchmarking tool to see the effectiveness and differences between se-

veral modifications and components. On the original bike a baseline (static) measurement was performed measuring the overall soundlevel in dB(A) at one meter for a single bike. In preliminary test it was found that the highest noise levels appear in the conditions at 15.000 RPM with full throttle. The static baseline measurement in this condition on the original bike was

109.4 dB(A) SPL. In the Supersport World Championship, where this motorbikes are active, the maximum level that is allowed for each individual bike is 102 dB(A). The goal of this project was to at least, as minimum, to reduce 7.4 dB(A) to meet the regulation of 102 dB(A).



RANKING OF DOMINANT SOUND SOURCES

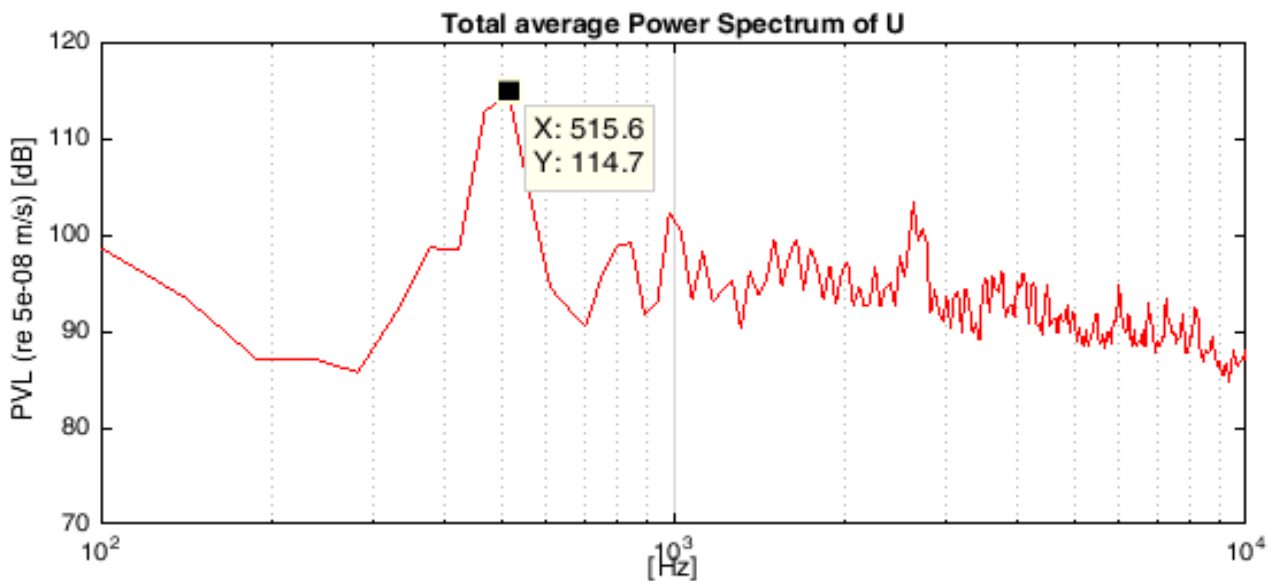
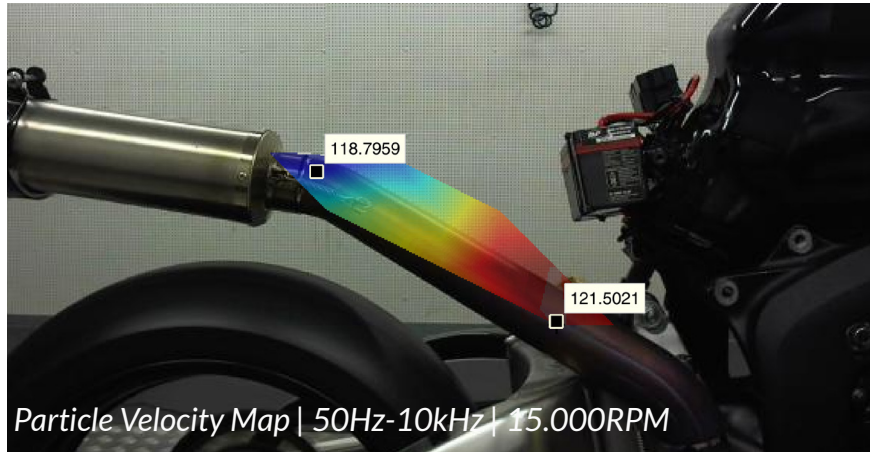
After knowing the baseline value for the superbike and setting the goal on what reduction has to be achieved, the next step was to rank the areas and frequencies where most sound is emitted. The whole superbike was measured using Scan&Paint providing sound visualisations of areas, local spectras and ranking of dominant areas. There were two main areas found listed here below in order of importance and highest local level.

1. Exhaust System
2. Intake System



Exhaust System

As expected one of the dominant sources detected on the superbike is the exhaust system. During the static measurement a harmonic peak of 114.7 dB PVL was found at 515Hz in the overall averaged spectrum for the exhaust system. In the measured plane, very near the exhaust surface, even overall values over 120 dB PVL are measured.



Particle Velocity at 15.000RPM for the total exhaust system

In this application case we'll focus on the modifications on the exhaust system. A variety of different exhaust systems available in the market, from brand such as Arrow and Termignoni with and without dB killers, were tested in terms of sound (dB(A)) versus power (kW) performance. As expected the configurations with dB killer reduced the noise but also reduces the power. The best configuration, that had a negligible influence on the performance, was the Arrow Endurance exhaust.

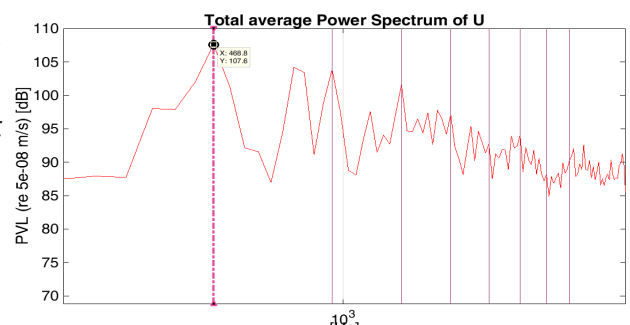
Changing to this type of exhaust already reduced the overall noise on average with 5dB(A).

To comply however with the regulations further reduction is required, as per goal set at least 7.4 dB(A) has to be reduced.

In this case resonance frequencies had to be reduced that were found at the exhaust. Two main resonances were found, one at 468Hz (14.000RPM) and another at 515Hz (15.000RPM).



Particle Velocity at 14.000RPM for total exhaust system with a harmonic resonance freq. at 468Hz



In this case a resonator will be designed for the exhaust to achieve the goal set. Besides the frequency another parameter is critical to design a resonator. The speed of sound has to be taken into account, which varies depending on the temperature. For this reason the temperature was measured at the exhaust during operation. The temperature measured during static testing at the exhaust is between 500-600 degrees Celsius. With all required parameters acquired the theoretical optimal length for

$$\lambda = \frac{c}{f} = \frac{576}{468.8} = 1.228 \text{ m} =$$

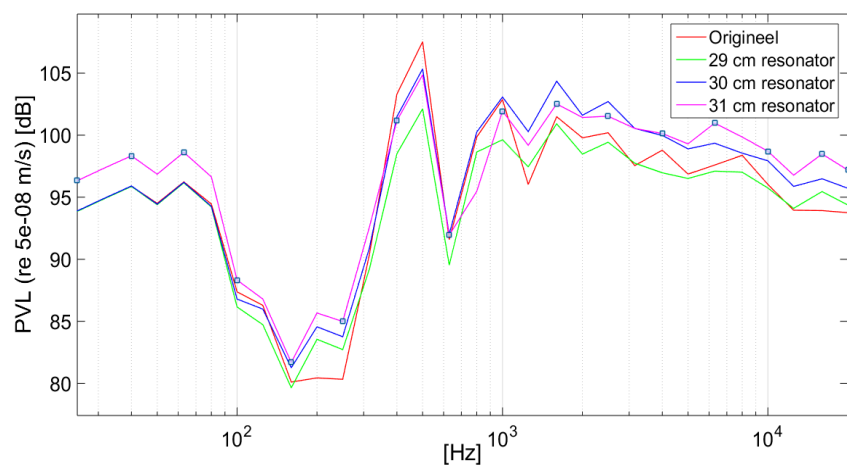
$$\text{Length Branch} = \frac{\lambda}{4} = \frac{1.228}{4} = 0.307 \text{ m}$$

the branch resonator was calculated. As per calculation above you can read that the theoretical optimal branch resonator would have a length of 30.7cm. Based on this value a variable prototype branch resonator was designed. With this prototype the length

could be easily adjusted between what could vary between 29-31cm. With this branch resonator installed initial measurements showed that this modification has no impact on the performance.



After extensive measurements at different lengths of the branch resonator it showed that the optimal length would be 29cm. This configuration reduced the level compared to the baseline measurement (with Arrow Endurance exhaust) overall with 4dB and even 6dB at the dominant frequency around 500Hz. In the graph on the right the results for the baseline and different sizes are plotted.



Branch resonator 29cm

The outcome of the measurements on the prototype branch resonator were showing really good, promising results. To get one step closer in the process to a final product, a second prototype was designed for the optimal size of 29 cm. Static tests proven again the same noise reduction and no decrease in terms of performance. A final proof was a dynamic test on a circuit with this branch resonator installed on an actual superbike.

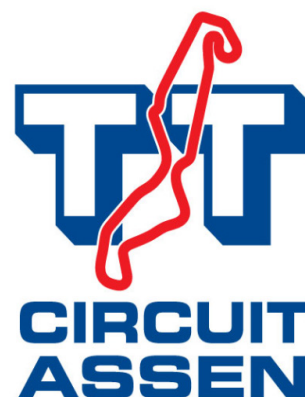


Dynamic testing with a Superbike during a race weekend at TT CIRCUIT ASSEN

During a race weekend on the TT circuit in Assen a final dynamic measurement took place. The starting point, as the outcome of the baseline measurement at the beginning of the project, with the original superbike was a level of 109.4 dB(A). The maximum level prescribed by the regulations for this weekend was 102 dB(A). During the measurements with the modified superbike including an Arrow Endurance exhaust with a branch resonator the measured level was only 97.8 dB(A). The noise level of

the superbike was now reduced by 11.6 dB(A) overall and therefore no longer exceeding regulations but within 4.2 dB(A) margin of the max level. So a big success!

As the ultimate test the actual superbike would be participating the official race with this branch resonator installed. To complete the success-story and proving noise reduction without compromising on performance is possible, the race was won by Danny van der Sluis, on his TKRP Honda 600 RR Superbike. Everybody, including the two wheeler, was silenced with this excellent result.



	Baseline measurement on original Superbike	Modified Superbike with branch resonator
Total averaged SPL in dB(A)	109.4 dB(A)	97.8 dB(A)

REDUCE THE PRESSURE IN YOUR WORK GO FOR PARTICLE VELOCITY



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