JCB DIESELMAX breaks the world record on the Bonneville Salt Flats for the first time *Courtesy of JCB*

Taking Diesel to the MAX

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EVERY SO OFTEN, a world land speed record is broken. On August 23rd 2006, a record that stood alone for more than 30 years was shattered on the world-famous Bonneville Salt Flats in Utah, USA. That week, the vehicle JCB DIESELMAX achieved an average speed of 350 mph (563 kph) in two successive runs to break the wheel-driven world land speed record for diesel-powered cars. The DIESELMAX also set speed records on two consecutive days, the first time any vehicle has made that mark since the 1960s. The British-designed car was engineered using guidance from JCB's consulting aerodynamicist, Ron Ayers, and CFD engineers at MIRA Ltd. in the UK. JCB designer Mike Turner used Alias software from Autodesk® to design the body shell and MIRA used FLUENT 6.2 to analyze the resulting shape without any wind tunnel testing.

The car was piloted by the RAF's Wing Commander Andy Green, who is no stranger to land speed records. He also set the first-ever (and current) supersonic world land speed record of 763 mph in 1997 in the jet-powered car ThrustSSC. The previous FIA (Federation Internationale de l'Automobile) diesel wheel-driven land speed record of 236 mph has been held by Virgil W. Snyder and the Thermo King Streamliner since 1973.

JCB DIESELMAX FLUENT model on the Bonneville Salt Flats with surface contours of static pressure and airflow pathlines colored by local flow velocity
Courtesy of MIRA Ltd and JCB

MIRA Ltd. is an engineering center of excellence, recognized as the UK's leading independent automotive design, development, and certification organization. MIRA's close working relationship with the DIESELMAX team in this project ensured that the challenging development timescales required to break the record were met, enabling the car to be thoroughly tested prior to the official Bonneville Speed Week.

JCB, who funded and drove the project, is the fifth largest manufacturer of construction equipment in the world. To reach speeds of over 300 mph (480 km/h), JCB developed the world's most powerful automotive diesel engine, with a specific power of 150 hp per liter. JCB's purpose in creating the world's fastest diesel automobile was to prove the versatility of the standard JCB444 engine, and to validate its inherent excellence in a totally different – and extremely demanding – engineering environment.

"Our intention all along with the speed record project was to use a standard engine block, cylinder head, and bedplate," explained JCB Group Engineering Director Dr. Tim Leverton. "I set that task at the very beginning. I wanted it to be the standard design block and have exactly the same fundamental architecture. It had to be recognizably the JCB444 engine. The land speed record engine develops almost 1500 Nm of torque at 2500 rpm, with a rev limit of 3800 rpm."

The JCB DIESELMAX car is over 9 m long with a wheelbase of 6 m, and is twice as powerful and twice as fast as a Formula 1 car despite the fact that it weighs four times as much. Using an enhanced version of its standard JCB444-LSR engine, the project aerodynamicists were looking for an optimal balance between aerodynamic drag, skin drag (which increases with surface area), and downforce. A wind tunnel was not used to test the car's design because the long, slender aspect ratio of the car made it difficult to find a suitable full-scale wind tunnel with a rolling road. Wind tunnel testing at scale would not have provided meaningful results because of compressibility effects. The net result of the design process was a beautiful and effective car with a perfect 50:50 downforce distribution and a drag coefficient of 0.154 – extraordinary even by land speed record standards.

In addition to a streamlined shape, a record-breaking vehicle needs an aerodynamically efficient underbody as well, because the air flowing under the car accounts for about one-half of the total aerodynamic drag. In fact, the designers believed that the interaction between the tires and salt on the flats could significantly affect the aerodynamic efficiency. For example, salt and debris stirred up by the car's passage could slow it down. To minimize this drag, several modifications were introduced in the vicinity of the wheels, enabling road spray to be deflected outwards so that the rear wheels and tires could run on as clean a surface as possible.

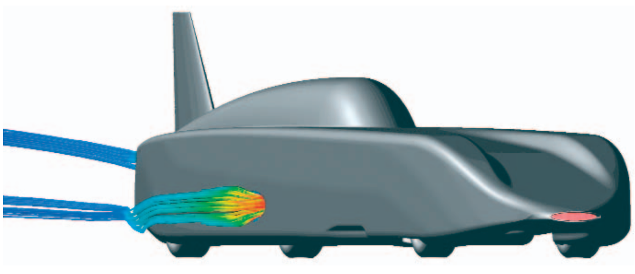
"Even at the speeds we envisaged, compressibility effects begin to become significant. Indeed, in the region near the wheel/ground contact points, the local airflow actually goes supersonic. We could not simulate such effects in a low-speed wind tunnel. To fit our long, slender vehicle into a tunnel with a rolling road would have meant restricting ourselves to a scale model of about one-sixth, and the errors would have been too great."

Ron Ayers
JCB's consulting aerodynamicist

MIRA used a parallel version of FLUENT ported to a powerful multiprocessor cluster to shape the vehicle's aerodynamic package. There were five phases of aerodynamic development, with a total of 24 CFD runs on the 20 million cell mesh they used to capture the car's geometrical shape. The study covered different ride heights, together with pitch and yaw angles, in order to optimize the attitude of the vehicle for the best stability. In a departure from motorsport applications, the JCB DIESELMAX was not designed to deliver huge levels of downforce. Instead, the nose height and diffuser angle were set to deliver trace levels of downforce to ensure a minimal increase in rolling resistance with speed. As the shape of the car evolved, other changes included lengthening the nose and tail, minimizing the frontal and base areas, covering the wheels more, and rounding the back of the wheel arches to reduce the wheel wakes. If the car is envisaged as an arrow or a dart, it is the tail fin that acts to maintain stability at maximum speed, so special attention was paid to its design as well.

JCB DIESELMAX was the brainchild of JCB Chairman Sir Anthony Bamford, born of his desire to showcase the extreme performance of the JCB444 diesel engine that normally powers the company's backhoe loaders and Loadall telescopic handlers. After watching the record-breaking runs, he said, "We have proven that we have the world's fastest diesel car and engine. The JCB DIESELMAX team has worked at times in adversity and faced numerous heartaches with fortitude. These record-breaking successes prove to the world the excellence of British engineering and teamwork." ■

The JCB DIESELMAX Team celebrates the new world record holding Andy Green aloft *Courtesy of JCB*



JCB DIESELMAX showing engine exhaust gas flow pathlines colored by local flow temperature
Courtesy of MIRA Ltd and JCB