WORLD SPEED RECORD ATTEMPT MACHINE

Part two

Hubs. The front steering hub design is of the centre-steering type, the only way to go when designing a streamliner. The unit accepts smaller bearings compared to others, reducing friction, cutting parasitic drag and allowing the wheel to spin more freely. Also, both front and rear wheels were made very light, using magnesium centres - this mainly concerns the front wheel. With a heavy wheel, when the friction coefficient between the salt and front tyre is not enough to turn the wheel any faster, the tyre begins to skate or slide over the salt, causing heat build-up in the tyre itself and results in almost immediate tyre failure. This has been a real problem with lots of streamliners, but hopefully we have alleviated this problem to a great extent with the magnesium hub.

Steering and wheel rake. Steering ratio was provided by Don Vesco. He found, through his experience, that a 3.5:1 steering ratio was a must. This slows down the steering and helps prevent over-corrections from happening. A hydraulic steering damper is also used to help in this area. The centre steering hub has a king pin which the hub pivots on. This is tilted to the rear 42 degrees, which provides excellent stability to the front wheel for straight ahead running.

Aerodynamics. No other topic affects a land speed record attempt more than aerodynamics. Aerodynamics determine the power required to achieve a given speed, the traction force required to punch a hole in the air at speed, and most importantly, the ability to travel straight down the course without losing control and crashing.

The power required to overcome aerodynamic drag increases with the cube of velocity. Doubling the speed requires the engine power to increase by a factor of eight. As the streamliner travels faster it requires ever-increasing horsepower to achieve decreasing improvements in speed.

Another aerodynamic limitation of top speed is the ability of the bike to produce the needed traction force to push against the increasing air drag. While the traction force is basically constant with respect to velocity, the aerodynamic drag force increases in proportion to the velocity squared. Doubling the speed increases the drag force by a factor of four. When the drag force exceeds the limited traction, the rear wheel will spin and the vehicle has reached its limit. This limitation cannot be easily overcome with down force as it is in many forms of car racing. In these forms of racing, notably circuit and road racing, the vehicles are willing to trade top speed for valuable cornering speed to lower lap times. In Bonneville-type racing, top speed is the name of the game. Increasing traction through the use of down force may only change the limit from one of traction to one of horsepower.

Aerodynamic forces have a tremendous effect on stability; the most apparent problem is lift. If the wheels are not on the ground with sufficient weight for traction, the bike can no longer be controlled or accelerated. Another stability problem is less obvious. A theoretical point called the `centre of pressure' must be behind the centre of mass. Centre of pressure is a point where side wind gust force vectors will act. Centre of mass is simply the three-dimensional balance point for the vehicle's mass. The greater the length, the more self-correcting the vehicle will be when hit by a cross wind or yaw with respect to the airstream. This is why straight flying arrows have feathers at the back and a heavy arrowhead in front.

The need for traction and stability is one of the tricks nature has played on salt flats racers. Stability is improved by placing more weight on the rear wheel. Unfortunately, the Bonneville racer needs both, and front wheel drive is not allowed on motor cycles, as well as having built-in limitations itself.

John Reed, a good friend of mine, has over the past few years compiled a lot of good information regarding the aerodynamics of motor cycles. The following is a letter he wrote a few years back, which helped a great deal in the design of `Black Lightning'.

"Regarding our discussion of HP required to go 425 mph, what follows is what I realistically believe you need from my research. The formula used and assumptions made are based on information I have collected over the past 12 years since becoming seriously interested in this subject. The core of this information came from research done by the Low Speed Aerodynamics Lab of the National Aeronautical Establishment (NAE) in Canada during 1974. The NAE is Canada's equivalent to NASA. The research was targeted specifically at motor cycles: road bikes, partially streamlined road racers and full streamliners. The testing was done by Kevin R. Cooper, who was Chief of Aerodynamics at the Can/Am Motorcycle Company during their record attempts at Bonneville. To date this is the most complete body of work on the subject I have found released to the general public. I have found almost nothing from the Japanese although no doubt they have mountains of info. Data from the NSU records of the middle 60s have also been used as a baseline for validifying my estimates as their data is the only information I have found containing hard figures on frontal area, HP and actual speed coupled to C_D (drag coefficient). The formula used: $P = .00000069 \times V^3 \times A \times C_D$ resulted in HP estimates of between 384 and 480 to go 425 mph, where V=velocity in mph, A=frontal area in sq ft, and. P= HP required. As I have no C_D data on your machine, as it can only be obtained with a wind tunnel or by coast down tests, I have made an educated guess of between 0.2 and 0.25 for your vehicle. Factored into this was a 25% HP requirement to overcome rolling resistance and drive train friction. I guess only time will tell how good a predictor my estimates are."

Engine cooling. A problem with most streamliners, due to the enclosed engines, is adequate cooling, even though the total running time for each run is only about three minutes. One of the things you must do is to reduce the ambient temperature inside the engine compartment. I helped solve this problem in two ways: first the exhaust pipes, which generate a lot of heat, were ceramic coated both inside and out, then they were wrapped with heat insulating material. Then two air scoops were placed in the skin of the 'liner' to move outside air over both the front and rear engines. The air exits the 'liner' at the cut-out for the rear wheel. I think this will help stop salt build up on the rear tyre. Additional cooling would probably also be needed, so the Tony Maughan cylinders were machined around the upper portion to accept water jackets.

Max at work on his streamliner earlier this year

The system has no radiator as such, but uses two water tanks and employs a 12 volt electric water pump to circulate the water through the water jackets to the cylinders. The five gallon volume of water should be adequate to keep the thermal factor under control, if not ice will be added to the water tanks as required. It is possible to take too much heat away from the engine's combustion chambers, resulting in a loss of horsepower.

Cylinder heads. Stock Vincent cylinder heads breathe very well with very little work. However, the few of us who have supercharged and put nitro fuel to them have found they are weak in several areas. It was decided to beef them up in the high stress areas and fatten them up around the intake and exhaust ports, much like the big port heads made by the factory. D.V. Godden came to my rescue and cast four heads to my specifications. He also made them from better material than used with his standard reproduction heads. A two-bolt flange was added to the exhaust port and a round spigot added to the intake; these were both welded on, after which the heads were heat treated, then machined. A second plug boss was `let in' opposite the original, as dual-plug ignition had been planned from the beginning, as well as provision for an additional pair of head bolts - sited left and right through the fins, where they engage the thicker sectioned cylinder castings nicely. This last modification materially assists rigidity and integrity at the jointing surfaces, which are so highly stressed in blown fuel motors. Stock diameter valves of special material are used. Gold Star valve springs, collars and keepers have been adapted to keep the valve train working at the rpm the engines will be turned. The intakes were opened up a little over 1.1/2 inch and the exhausts to two inches.

Valve train and gears. All the cam gears, half-time gear and idler gear (which is a Tony Maughan steel unit) have been lightened, and narrowed aluminium push-rods with hardened ball-ends are used; rockers, cam lifters and valve adjusting screws were lightened considerably. The cams were specially made for the 'liner by Andrews Cam Manufacture. The cam lobe grind is similar to his Mk III; however, the lobe centres were changed due to the fact that the engines are supercharged. The cams and lifters have been coated with a space-age material which helps prevent scuffing and reduce power-robbing friction.

Pistons. The pistons were made by Airias, again to my specifications. The rings were lowered to provide wide ring lands for strength, a must for any blown fuel engine. The top ring is of the step, or rather dykes, type. The pistons have been coated with a lubricant on the skirts and a ceramic heat shield coating on the crown as well as the combustion chamber and exhaust port. This helps keep the heat in the combustion chamber where it belongs. Bear in mind that, as the fuel is burning, expansion and heat are created to force the piston down. If the heat is lost too much in the combustion process to the mass around the combustion chamber, ie, heads, pistons and cylinders, there will be less expansion of burning fuel, therefore less pressure on the piston and less horsepower. No matter how efficient you try to make the combustion process, heat or expansion will be lost. This is not totally unacceptable, due to the fact that if no heat were lost to the atmosphere, the engine parts would soon become an unrecognisable molten mass of aluminium and steel.

Break in. What I am about say on this subject is the way I do it, and I don't recommend this method to anybody. Racing engines should be designed so that there is no need for break in; in other words the engine should be set up loose. Virtually all the clearances must be increased on both reciprocating and rotating parts. It is mostly left up to the builder as to the amount of clearance; I probably lean towards the really loose side - it seems to work for me. The only thing in a properly clearanced engine for racing is the seating of the rings. This should take place during the initial start-up in a minute or less, and the problems I have encountered are two-fold: one being the modern rings employed today are very hard-faced and the other the modern synthetic oils are very good. When assembling I oiled everything well, cylinders, pistons and rings. After the start-up and a short run for the engine, a compression check was made. It was obvious the rings were not seating! Also, it appeared that hard spots were being created in the cast iron liner bores. Not a good thing for ring seating. The next thing I tried was a bit drastic, but it worked for me. The cylinders were re-honed with a very fine cross hatch and were installed perfectly dry from oil. The pistons were lubricated only slightly on the skirts, with no oil on the rings. The engines were started and run up to 2,000 rpm for one minute. A compression test revealed that an increase of 15 lbs pressure was achieved. The rings had seated with zero scores on the cylinders - who would have thought it?

Rods. The rods were designed and built by Carrillo. The only thing I did was make them all the same weight and polish them.

Crankpins. These were made by Tony Maughan and are a quarter of an inch larger than standard. Manx-type nuts are used.

Flywheels. Stock flywheels are used; however, they were polished and machined to accept the larger crankpins. The mainshafts are 1.1/8 inch in diameter at the flywheel bore and, like the pins, are welded. Due to the fact that the pistons, and the rods, are heavier, it was necessary to add `heavy' metal to the flywheel halves to achieve proper balance. The engines coupled together don't vibrate at all; incredible, but true.

Oiling system. The oil used is 40W Castrol R racing oil. To move the oil through the now very expensive engines and back to the separate oil tanks, Tony Maughan two-speed oil pumps are used. The only thing done to the otherwise standard oiling system was that a seal was made for the oil feed quill to the crankshaft. Two additional holes were drilled in the cylinder liners and an oval-shaped O-ring is used around the, now three, holes; the oil feed jet to the camshaft spindles is also larger. A standard oil filter is used and it is inspected after each run for metal particles, warning me of impending disaster. When nitro fuel is being used, the oil and filters are both actually changed after each run, due to the fact that the large volume of nitro fuel required (for proper air/fuel mix) washes the cylinder walls and the nitro fuel winds up contaminating the oil and the oil filter - you can smell the nitro and the oil appears milky. If the nitro-contaminated oil is not changed you are asking for expensive trouble, ie, loss of lubricating qualities of the oil and a real possibility of a crankcase explosion. Really bad when you are trying to set a record with no back-up engines! - so it is relatively cheap insurance when you consider the consequences.

Crankcases. The crankcases used, neither of which was in the best of shape, had the usual worn-out used and abused look to them, so I turned on the argon bottle and fired up the Heliarc welder and after about two days of welding they started looking pretty good - a little warped here and there, but still reasonable. The inside webbing was completely filled for added strength around the main bearing bores. The boss for the gear-change cam pin was strengthened and necessary metal was added where needed to couple the engines together and provide a means to run the chain (which goes from the engine to the jack shaft) in oil. The next step was the machining of the cases. All the surfaces were mated and brought back to standard specifications. The cases were align bored and a shouldered steel sleeve (inboard) was pressed into the drive side (left case). A small ring nut on the outboard side holds the sleeve secure in its bore. The theory behind all of this was to have the outer main bearing races pressed into similar metal which, when heated up, will grow at about the same rate, therefore maintaining their press fit and staying in place. This method also provides a much stronger unit with less crankshaft deflection at high rpm with heavy percentages of nitro fuel.

To be continued.