Glowing tube

Wankel engine's exhaust gases are very hot. An environment gentle motorcyclist can however, install a catalyst in an old Hercules, to avoid this expensive item breaks into pieces at more than 1'100º C.

Measuring exhaust gas temperatures

It is better to know than believe, thus, exhaust gas temperatures must be measured. As measurement point, considering an already existing flange, the left part of exhaust manifold in the left part of a bending a bit behind the bifurcation lin2. Ralph Shelle, who additionally was the one having the idea of installing a Catalyst, provided a high temperature probe and a Handy Reading device.

The Bensinger's work: "Rotary piston internal combustion engines", indicates that Wankel engines have a higher exhaust gas temperatures under partial than under full load Thus, it was not enough climbing any hill and then read temperature, once our curiosity was awaken, it was needed configuring a comprehensive temperatures chart, as far as it was possible.

After a careful carburetor and ignition tuning, I proceeded to move the machine in every gear at 2000, 3000, up to 7000 rpm, constant speed, until temperature stabilized in a certain value. This way, up to 32 measuring points were obtained. The steady temperature is reached in a few seconds when engine is hot.

From rpm and speed, with the help of the driving resistance curve, the power and torque needs can be approximately deducted. After some mathematical interpolations, the image or chart in the next page results, but of course, some inaccuracies must be considered when dealing with a measurement of so complex features.

Description of characteristic chart

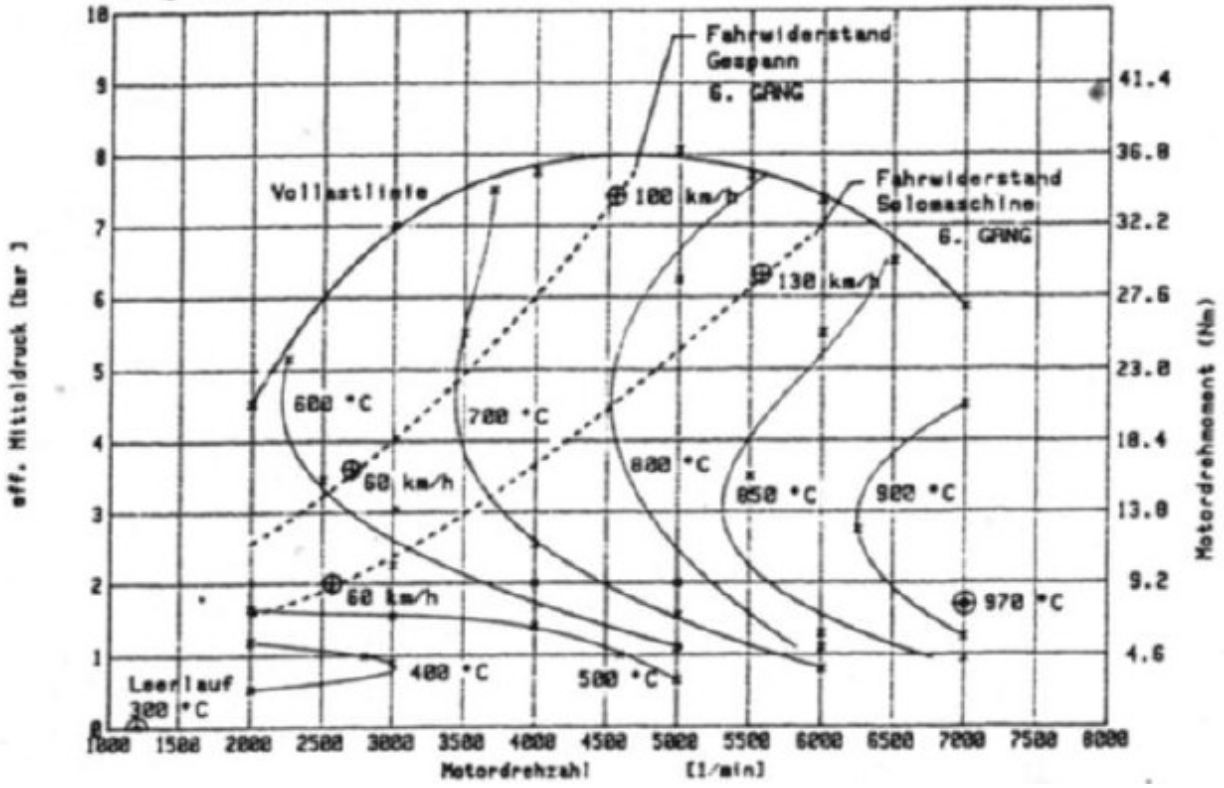
Noteworthy, as the interpretation of this chart is not easy for a person not being specialized in the field, a brief explanation of it follows:

- In axis 'x' engine rpm are plotted, in axis 'y' the Mean Effective Pressure. This last one is the mean pressure inside the working chamber. With a fixed chamber volume (295 cm^3) it's possible knowing also the torque supplied to the flywheel. It's plotted in the axis 'y'.
  -Diagram has an upper limit in the full load line, i.e. the maximum torque curve that the Sachs KC27 with Norton rotor at full open throttle can provide. For every throttle opening a different torque curve exists, that of course are under the full load curve, but are not parallel to it.

- The curved lines represent the constant exhaust gas temperature lines.This way, for example, at 3'700 rpm and around. 35 Nm torque 700º C exist, but also with 3'500 rpm and 18 Nm torque or with 5'700 rpm and 4.6 Nm torque.

Gas temperatures in the exhaust elbow

Sachs KC 27 Motor Wankel
Rotor Norton F1
Bing constant pressure carburetor (HD 155)



(Fahrwiderstand Gespann: running resistance with sidecar; Fahrwiderstand Solomaschine: resistance without sidecar; Volllastlinie: full load curve; Gang: gear; Eff. Mitteldruck: Effective Mean Pressure in bar; Motordrehmoment: torque in Nm; Motordrehzahl: engine revolutions in rpm; Leerlauf: no load or idle running)

- In the aim of having a reference or orientation point to move inside the chart, the resistance curves with solo machine and with a side-car are plotted. It show the torque that the engine must supply, to maintain a constant speed in a no wind condition, on a flat terrain, and with the 6th gear engaged.
  Fort he motorcycle only, to sustain a constant 130 km/h speed, around 29 Nm are needed, and for 60 km/h, around 9 Nm torque is needed
  Under acceleration and climbing a slope, a zone above these curves is entered, and in going down, you pass to a zone below.
  The running resistance curves in lower gears are in part clearly below the 6th gear curve.
- At 1’200 rpm, a 300º C temperature is shown with the engine idling. However, this actually depends on the engine working temperature and may be between 200º C and 400 ºC.

Results

What conclusions can be drawn from this chart?

- The paradox stated in the Bensinger's book is confirmed: at high rpm, exhaust gas temperatures are actually higher under part load that under full load.
  With the motorcylce alone, running at, for example, 130 km/h, around 825º C. are reached. If then you climb a hill or have head wind at full load, temperature drops to 800º C. If instead, you reduce throttle going downhill, sustainig the same speed, temperature may raise up to above 850º C
- Motorcycles with a too short transmission ratio, where in the top gear, gas must be released in order not to enter the red zone, but also in machines prepared for off-road operation, that must in consequence run frequently at partial throttle opening and high rpm for long distances, are thus subjected to high thermal loads.
- Maximum measured temperature was 970º C at 7'000 rpm and with a mere 1,8 bar mean pressure. Margin left to the top catalyst converter temperature, at 1'100º C, looks still wide enough. However, it must be taken into consideration, that with a leaner fuel-air mixture, exhaust gas temperatures can be even higher.
- Considering the strong dependence respect to the engine's rpm, it would be interesting looking at what the exhaust gas temperatures would be in the Norton motorcycle at 10'000 rpm.
- The motorcycle with sidecar in 6th gear at 105 km/h and 4'700 rpm goes around 770º C, in 5th at 110 km/h and 5'900 rpm, 820º C. By slowing down 5 km/h in upper gear, engine's thermal load can be effectively reduced, due to the extra-long transmission ratio. Even more, the running resistance curve will then move to the best efficiency or performance zone. The old idea that you'll drive in a more careful and economical way by shifting soon to higher gears and letting the engine pull also applies here. The small Sachs Wankel engine does this without problems.
- In the zone under the 600º C curve with the depression capsule broken, the well known jerks and irregular functioning appear. Temperature is certainly low, but in this case huge amounts of unburned fuel are lost through the exhaust, that do accumulate in the catalyst and can even ignite.This is probably the biggest danger of having an early catalyst's death.

If a catalyst can be maintained or not in the long term in an Hercules is something that only experience will prove. Efficiency is shown in another page. In 2-Stroke engines, it was realized that a catalyst gives satisfactory results only with an added device supplying air injection to the exhaust.

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(The exhaust gas temperature has an inverse correlation with the Effective Compression Ratio [CR] and Mean Effective Pressure [MEP], the lower the CR is, the higher the exhaust gas temperature would be. -Translation Editor's Note-)