German ideas on improvements of wood gasifiers

Summary in Teknisk Tidskrift of a thesis by H Lutz
published in ATZ. Editor C V Nordenswan
English translation, 2000, Joacim Persson

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The German authorities' interest in producer gas has become significant during the war, and among other things, a research institute 'Gasschlepper-Entwicklung' has been established, led by dr-ing H Lutz. Herein is given a short summary on some of the views and findings published by him in ATZ. They solely concern wood gas, but the article may also be of interest for charcoal gas.

The best gasifiers of present standard types gives, with pine wood of 15 % moist content, a gas with a heat value of 1 275 kcal/m^3, which renders a heat value for the air-gas mixture of about 610 kcal/m^3. This is significantly less than the corresponding value for common fluid fuels and explains the lesser mean pressure for producer gas power. It is of course of interest to increase the heat value of the gas and thereby also the mean pressure in the motor.

1 Theoretical views on improving gas heat value.

Modern wood gasifiers work satisfactory on wood from practically all kinds available, once cut up in a proper manner and sufficiently dry. The latter is very important. At present, the best gasifiers have an upper limit on acceptable moist content at about 30%, but already at 20% a steep and increasing degradation of the gas' heat value and thus the motor power can be noted. An increase of the upper limit on fuel moist is from the practical viewpoint desired, because one can't always count on well dried fuel being available and no practical fast methods to determine the moist content exist.

Moist impact on gasification.

The water in the fuel has great influence on the process of gasification. It must be vaporised by heat from the combustion zone. The heat need U_1 per kg fuel for this vaporisation can approximately be expressed by the formula:

$$U_1 = 6,25 \cdot m \,\text{kcal}, \tag{1}$$

where m is fuel moisture in %.

The steam formed in the fuel tank passes the gasification zone, and it is a common misconception that the steam there is dissociated into hydrogen and oxygen. Some people even believe that extremely moist wood in this way would give gas with particularly high heat value, i.e. high motor power. The dissociation of steam however takes a certain reaction time to reach significant levels. Fig 1 — from Clement and Adams — gives a hint on this. As shown steam, in the presence of charcoal, needs to stay in the high temperature zone of 1 100° for 0.5 sec. to reach a level of merely 20 % dissociation. The contact time in a vehicle gasifier is however far less; 1 m^3 gas passes for example the combustion chamber in the Imbert gasifier on 0.2 sec.[1]

[1] *Really? 0,2 sec for a particle to travel through the gasifier, rather than a whole m^3 sounds more reasonable. — JP 2000*

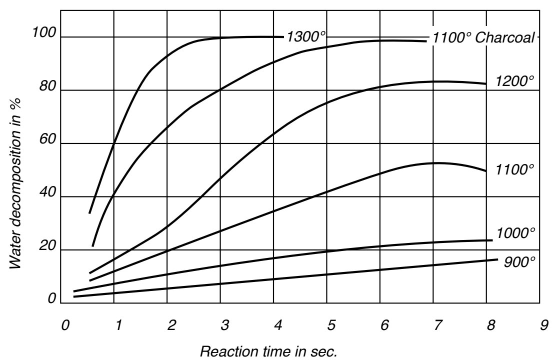

Figure 1: Dissociation of steam

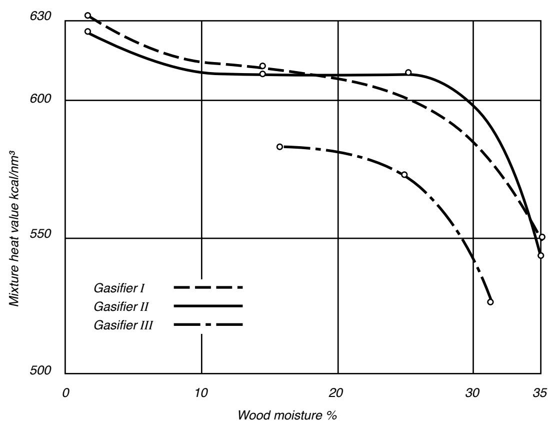

Figure 2: Mixture heat value as a function of fuel moisture for three different gasifiers.

The number goes for the *entire* gasification space; in the tight high temp. zone with its extreme gas velocity the reaction time is thus significantly less. The conditions for dissociating water molecules is therefore very unfavourable.

To investigate this the research institute has examined the most well-known German wood gasifiers' function at various fuel moistures. Fig. 2 displays the results from testing of three such models. The tendency of all the three curves are that fuel-air mixture heat value decreases with increasing fuel moisture. — The curve points show the mean values for 10 hour tests on full load with pine fuel; subtests gave similar results.

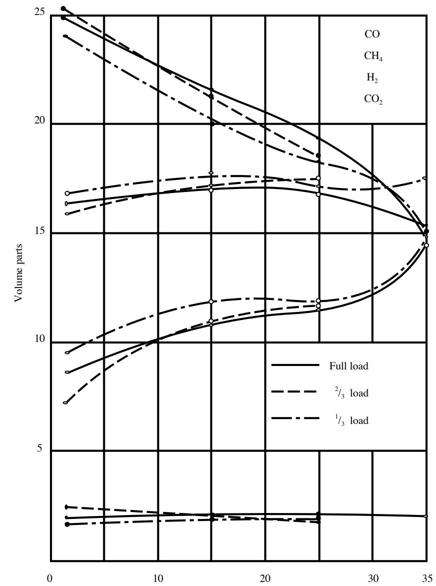

Figure 3: Gas composition at different fuel moisture levels.

To gain a high specific motor power one should then use as dry fuel as possible. A test with a 4-cyl Ford BB motor at 1 800 rpms, fed with an Imbert gasifier, gave the following confirming results:

Wood moisture %	Motor power hp
2	26.5
10	24.6
15	23.4
20	22.2
25	21.0
30	19.7

Up to a moisture of 25 % the power loss is a linear function of the fuel moisture, beyond that the drop is steeper. (For the interval 0—30 % moist the test results can be described with the equation formula $N : N_0 = 1 - 0.009m$, where N_0 is the 'water free' power and m is the moisture in % — *Ed. note)*

Gas composition at various moistures is of particular interest, and is shown in fig. 3. While the CO-level displays steeply falling levels at increasing moisture, and the CO_2-levels displays a corresponding increasing tendency, the H_2-levels are almost and CH_4-levels completely constant. For almost fully dry wood (2 % water) the hydrogen level is only about 1 % lower than the highest measured level. 1 % hydrogen is generated from dissociating 21 g water, i.e. 2.1 % of the fuel weight or $\frac{1}{7}$ of the present 'moist water' at 15 % fuel moisture (at a load of 2.62 nm^3/kg). Dissociation of water in the fuel is thus insignificant, which confirms the reasoning above.[2]

So where does all the hydrogen from water free fuel come from? Some of the hydrogen may stem directly from the distillation and some from tar cracking in the combustion zone. Furthermore, large amounts of water is generated from gasification in the form of super-heated steam — according to our own tests, up to 30 % of the dry fuel weight. Even dry fuel thus supplies enough water to, as much as the reaction time allows, explain the formation of the measured levels of water dissociation gases. 22 % 'gasification water' is enough for forming about 10.4 % hydrogen, through dissociation.

From this it is obvious that fuel moisture is only an unnecessary ballast which by its heat need has a negative effect on gasification. Wood water must not only be vaporised with heat consumption according to (1), but must also be super-heated to a temperature of up to 1 200—1 300° when passing through the hearth. For the latter process, heat U_2 per kg fuel is required:

$$U_{2=0.0048\cdot m(t-100)} \qquad (2)$$

where m is wood moisture in % and t the temperature in °C to which super-heating is taken. Through addition of the equations (1) and (2) we get the heat need for fuel moisture as:

$$U_m = m(5.77 + 0.0048t)\,\text{kcal/kg fuel} \qquad (3)$$

[2]E Hubendick disagreed on this, see his reply in the article about gasifier efficiency. — JP 2000

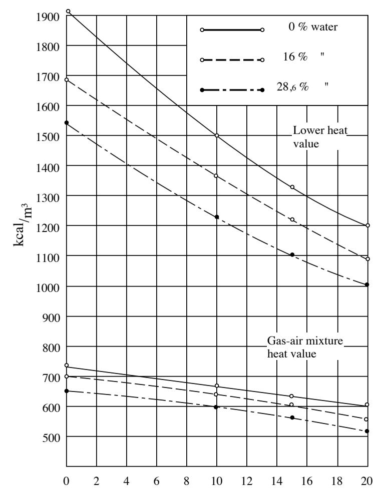

Figure 4: Calculated heat value as function of losses.

Increasing heat value and acceptance of fuel moisture, by decreasing heat losses.

In a wood gasifier we need, apart from the mentioned heat U_m, heat for distillation, super-heating of combustion products, cracking of tar and water, an reduction of CO_2. This heat is produced by oxidation of charcoal and tar char with air oxygen. The latter unfortunately implies a certain quantity of nitrogen, which 'dilutes' the producer gas. Obviously, by decreasing heat losses, the air needed for producing this heat and thus the amount of nitrogen per m^3 gas also decreases. Better heat economy also increases reaction temperatures and thereby improves CO- and H_2-production, with a consequential decrease of CO_2-levels.

Schläpfer and Tobler have calculated the heat value for gas as a function of losses by conduction and radiation (fig. 4), vs. heat loss through gas temperature (fig. 5). The authors also calculated the heat values for wood gas, produced without heat losses, see fig. 6. Their calculations emphasizes the importance of heat economy; the difference between "loss free" heat values and measured values is so apparent, that it should be possible to improve the latter by improved design.

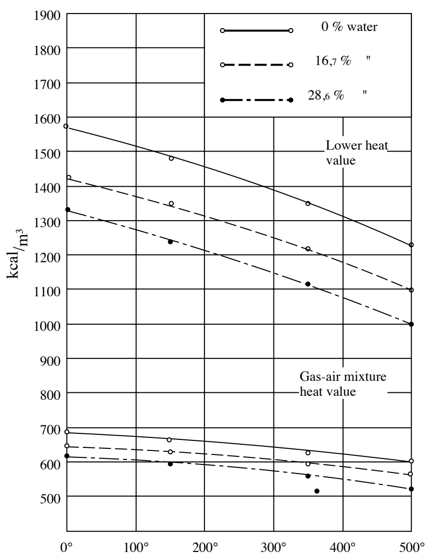

Figure 5: Calculated heat value as a function of gas temperature.

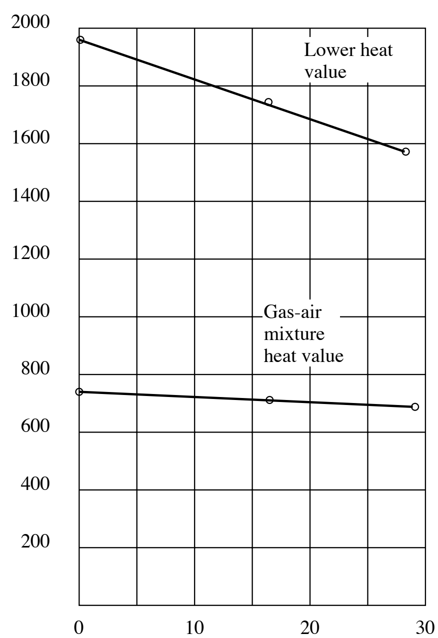

Figure 6: Calculated gas-air mixture heat value as a function of losses.

Gasifier efficiency and gasification heat.

By gasifier efficiency we mean the ratio between heat value of the produced gas, and heat value of the gasified fuel; a good gasifier should reach, say, 80%. The lost 20% is on account of conduction, radiation, and gas temperature. The high efficiency perhaps tempts us to conclude that the gain from decreased heat losses does not stand in proportion to the necessary technical measures. This is admissable regarding fuel economy but certainly not regarding the improvement of gas heat value and improved tolerance for very moist fuel.

The significance of increasing gas heat value by decreasing heat losses, is accentuated by that only $\frac{1}{3}$ of the *total fuel heat value* is transformed to free heat in the gasification process. From gasification of water-free wood of 4 500 kcal/kg, only 1 500 kcal/kg is thus active in the gasification zone, and for wood of 30 % moist, no more than 1 050 kcal/kg.

According to equation (3), for super-heating to 1 200°C of the moist water (30 %) in wood, about 350 kcal/kg fuel is necessary. That is *one third* of the active heat in the gasification zone, which must also suffice to the other gasification subprocesses and on top of that, losses by conduction an radiation.

2 Practical steps for realising the theoretical findings.

It is remarkable that manufacturers have hardly made any attempts to put the theoretical knowledge into practise. The research institute have therefore lined out an extensive test programme, which directions and results is referred below.

Decreasing losses due to conduction and radiation.

Conduction losses via metal parts (gas pipes and mounting details) are insignificant and it should be possible to eliminate any practical importance of it by proper insulation.

Radiation losses goes through the gasifier walls, either from the gasification and fuel spaces straight

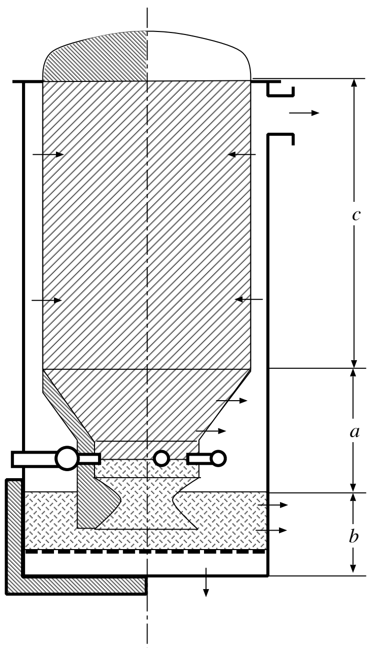

Figure 7: Insulation of double-mantled gasifier.

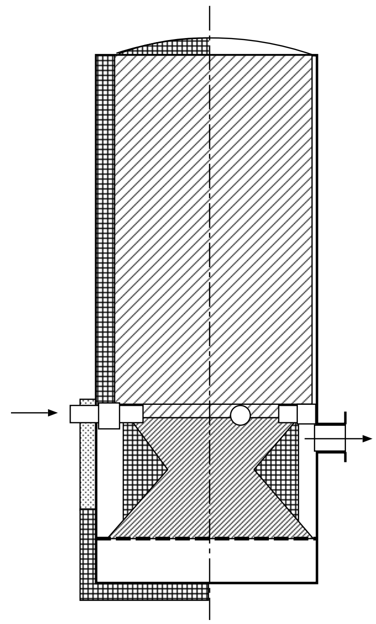

Figure 8: Insulation of gasifier with no outer mantle.

over to the mantle, if a temperature fall exists in this direction. On fig. 7, right side, the arrows shows heat flow schematically in an Imbert, from the hearth with 1 200° to the surrounding gas mantle with 600° temperature in section *a*, and losses through gasifier walls in section *b*. To decrease losses one should insulate the gasifier according to the left half of fig. 7. Regarding the hearth this is easiest done with a ceramic fitting and for the outer walls with a sleeve of rock wool, kieselguhr or similar contained in a protective cover. The lid should also be be insulated in this manner. Insulation must not be too thin, but be calculated such that it becomes fully effective, or the result will be unsatisfying.

Some gasifiers are designed as in fig. 8, right side,with proper hearth insulation in ceramic materials. Losses go through the outer walls, which thus should be insulated as in the left part of fig. 8. As recapturing of gas heat appears to demand a heat exchanger (more about that below), it is, due to the better heat transfer in that device, appropriate to keep the gas temperature as high as possible up to the exchanger and thus insulate the lower part all the way up to the fuel container; this will also decrease heat flow from the hearth to the surrounding mantle.[3]

A fuel container without double mantle and without condenser should absolutely be insulated, or else a significant heat loss will occur because of the air circulation around it, degrading drying and charification processes in the fuel container. Heat losses through the walls will naturally be greater in cold weather, high vehicle speed, and in rain (due to vaporisation of rain drops falling on the gasifier parts). Bad function of the gasifier may in many cases be caused by some of these conditions.

Decreasing losses via gas heat content.

The generated gas' heat content can be recaptured either by putting it back to the fuel container, i.e. the fuel, or to the air sucked in to the hearth. The former

[3]Meaning is somewhat obscure. The Swedish text says 'ringrummet', i.e. 'ring space'. I assume they mean the space surrounding the hearth. — JP 2000

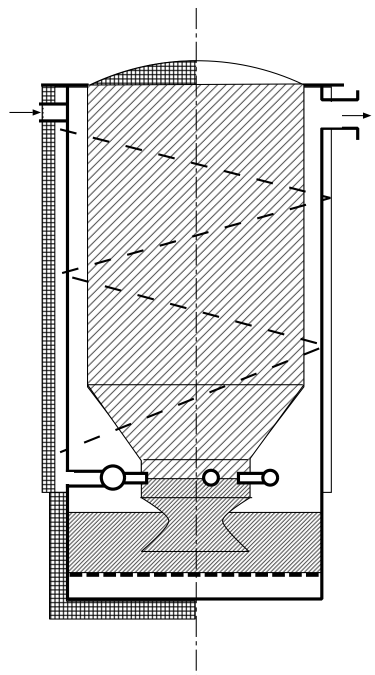

Figure 9: Insulation of triple-mantled gasifier.

can be done by for example using a double mantle as in the Imbert gasifier; the high heat value of the gas for this design is partly due to the heat economy through insulation of the fuel container and heat recapturing, partly also due to pre-heating of primary air at the air pipes mounted inside the mantle. As at least half the heat is lost to the surrounding air through the tin wall for a double mantle design, a triple mantling design has been used, fig 9, in whose outer area air is led against the stream of the gas. For such a modification to be successful, the outer wall should be insulated as shown in the left part of the figure, and air — for example via a tin metal spiral inside — be led such that it effectively flows around the entire gas mantle.

One may also recapture gas heat by transferring heat to primary air in a special heat exchanger. Experience shows that a heat transfer surface of 0.015—0.02 m^2/nm^3 of full load is sufficient[4]. The heat ex-

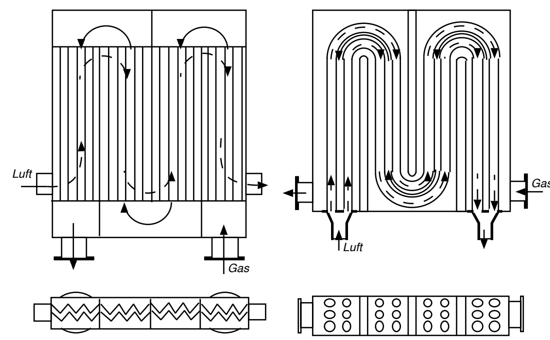

Figure 10: Heat exchanger with wafers (left) and pipes (right).

changer can be built with wafers or pipes, (fig. 10) or in the form of a 100 mm thick box, in which air is brought against the stream of the gas. Fig. 11 displays such a heat exchanger, attached to a rectangular fuel container and combined with a cyclone, placed between the gasifier and the heat exchanger. The cyclone is necessary to prevent the heat exchanger from acting as a gas cleaner and thereby be clogged up or contaminated with dust, degrading its operation. Cyclone as well as heat exchanger should be insulated.

Devices for air pre-heating are by the way incorporated in many gasifier designs, but usually have the flaw of taking heat from combustion instead of from the gas flowing out; some also have too small surfaces for gaining sufficient heat transfer.

The research institute has examined the function of a heat exchanger of above box type, combined with a gasifier of 60 nm^3/h maximum capacity with a Ford BB 3.24 litre motor with $n_{max} = 1\,800$. The tests were carried out with fully open throttle at various rpm's, and the results are shown in fig. 12.

At full load, the gas inlet temperature in the heat exchanger was 540°, and air was heated to 340°, whereby the gas was cooled to 294°, i.e. about as much as in an Imbert double-mantle gasifier. The removed heat from this temperature fall (about 50% of the heat content) was brought back to the gasifier

[4] Is that $m^2/[nm^3/h]$? Anyway, heat conductivity in a heat exchanger also depends upon gas velocities, apart from surface size. JP — 2000

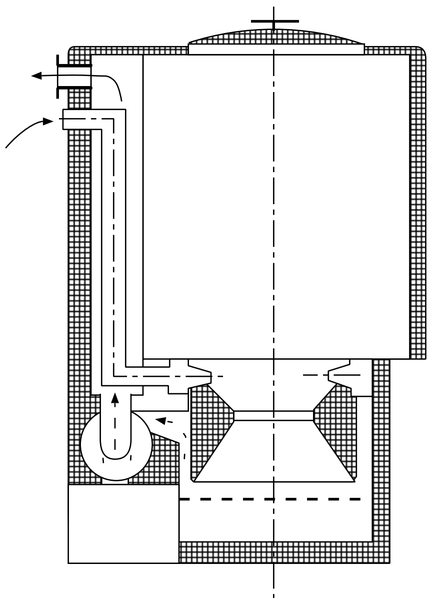

Figure 11: Heat exchanger combined with cyclone and single mantled gasifier.

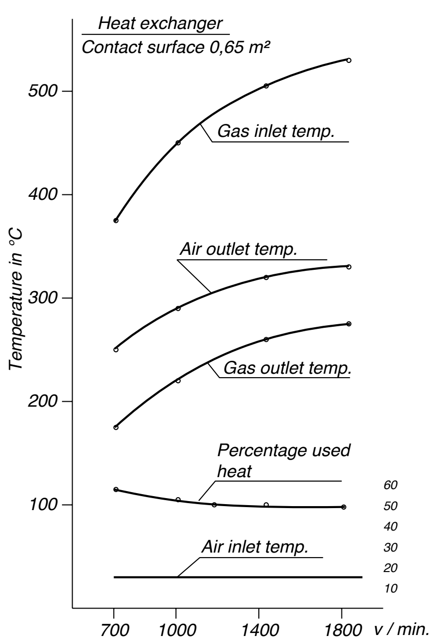

Figure 12: Results from heat exchanger tests.

with the combustion air, apart from the small losses through insulation. For an Imbert double mantle on the other hand, at least half this heat is lost to open air, although certainly at least the fuel container is well insulated outwards by the double mantle, so here we have a gain of heat. The experiments have shown that a gasifier without double mantle but with heat exchanger, recapturing 50 % gas heat, gives gas with about the same heat value as for an Imbert under the same operation circumstances.

It is important that the heat exchanger even at low gas production (half load or less) give good air preheating. As fig. 12 shows, the air outlet temperature at 700 rpm's was as high as 254°C. Of course, gas heat recapturing is in particular noticed in transition from full load to idling. Then the heat generation in the hearth drops because of the decrease in air intake flow, but the heat stored in the gasifier is transported away with the gas and the temperature begins soon to fall — degrading the gasification process. If there is a heat exchanger in the system, some of the heat still remaining from the previous full load condition is captured and brought back into the combustion zone with the primary air. The temperature in the hearth thereby do not fall as quickly, and the gasifier can better cope with periods of idling within reasonable limits, particularly with moist fuel.

Tests were carried out with a Hansa-gasifier (in principle same as in fig. 8, right side) at full load (50 nm^3/h) with and without heat exchanger, at various fuel moist levels, where the gas was sucked out with a pump; pine wood of low quality was used as fuel. Fig. 13 shows the results with (solid line) an without (dashed line) heat exchanger. At 15 % moist a heat value improvement of 80.5 kcal, from 1 187.5 to 1 268 $kcal/m^3$ was detected with the heat exchanger in use. At greater moist levels the effect is less, apparently because the heat consumption due to the water has a greater impact than heat recapturing through the exchanger. *Note however, that a significant displacement of the limit for acceptable moist level occurs,* since with heat exchanger and for example 30 % moist, the same mean heat value is achieved as for 22 % without heat exchanger, and at 35 % with heat exchanger the same mean heat value as for 28 % without heat exchanger. The heat ex-

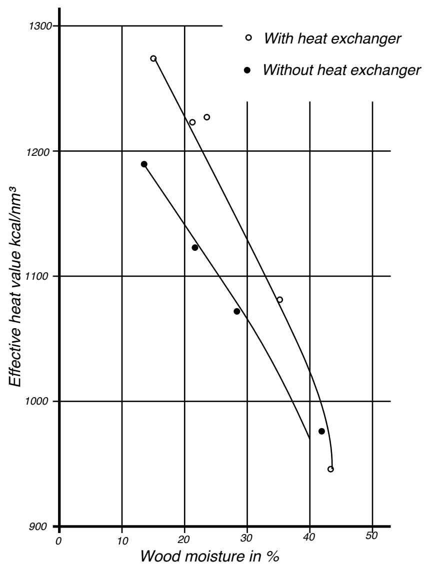

Figure 13: Comparison of Hansa-gasifier with and without heat exchanger.

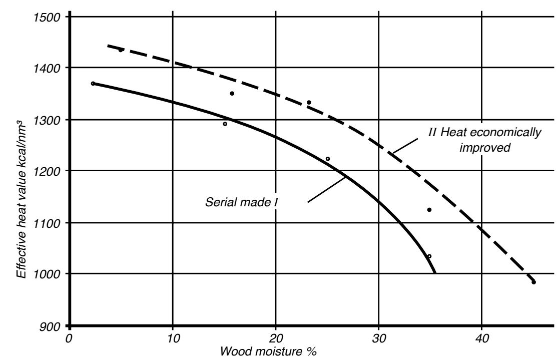

Figure 14: Comparing heat value vs. fuel moisture for Imbert with and without improvements.

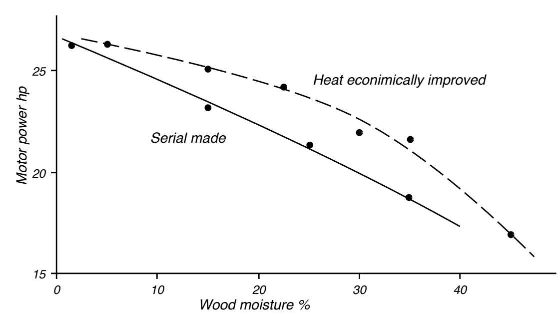

Figure 15: As for fig. 14, motor power and fuel moisture.

changer thus makes the gasifier less sensitive for fuel moisture.

The suggested improvement in fig. 9, left side, for Imbert has also been tested in practice. For the test, a 3.24 litre Ford BB motor was used, running at 1 800 rpms, and both heat value as well as power measurements were carried out. The results are displayed in figures 14—16.

The first of these show us that the increase in heat value reaches 80—90 kcal/m^3, and that the limit for moisture acceptance was moved a fair bit up. *The 1 000 kcal heat value limit is for the standard gasifier 36 % while for the improved design is at 44 % moisture.*

The power increase shown in fig. 15 is welcome; at 15—35 % moisture it reaches about 2 hp, i.e. 8.5—11 % of the corresponding power. The gas diagram, fig. 16, show about the same methane levels (not above 2 %) for both types across the whole moisture interval. The higher heat value of the improved design is mostly due to an increase in CO and H_2 levels; regarding the latter, the reason is probably higher reaction temperature. The low CO_2 levels at

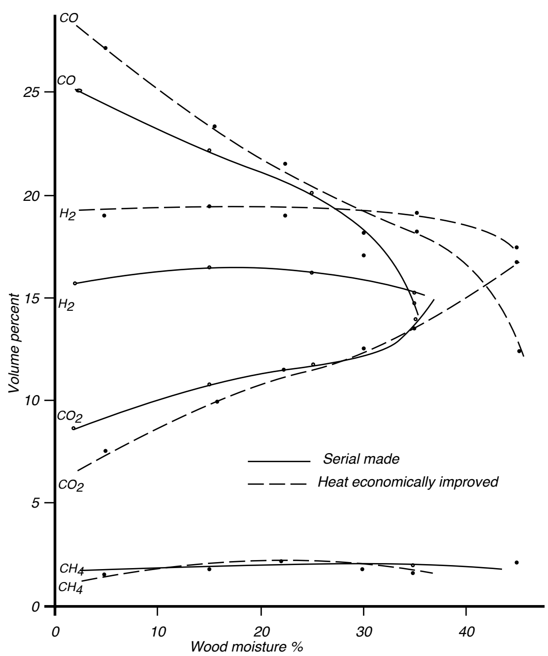

Figure 16: Gas composition for Imbert with and without improvements.

20 % moisture are also remarkable.

In these experiments it was determined that it is possible to significantly improve even a well reputed gasifier by improving heat economy (by recapturing gas heat) and using insulation. The method cannot, however, be applied directly to an existing gasifier, without first ensuring that no over-temperatures occur at sensitive places. The improvement ought to be particularly significant for operation in cold weather — to be specially noted by Swedish technicians.

It should be pointed out in this context, that the laboratory results always are a little better than under practical conditions, which usually involves larger heat losses. A laboratory result of 1 119 kcal/nm^3 at 25 % moisture and 20° temperature in the room, corresponded for example to 1 074 kcal/nm^3, with the gasifier standing outdoors in +8°C.

Improving gas heat value by removing steam from the fuel container.

When realising that the fuel container is burdened with an excess of water, fully or partially separating the water vaporised in the fuel container before it reaches the combustion zone has been attempted. The simplest method consists of the familiar condenser mantle, where steam is condensed by cooling the outer walls with the air flow around the gasifier. The effect is however poor; in the winter, in rain, and with extremely wet wood the separated amount of water can reach 10—12 % of the fuel weight, in the summer and with dry wood it can decrease to almost none.

Another tried method is to fit a pipe from the upper part of the fuel container to the car's exhaust pipe, using an ejector nozzle. When the motor runs, a significant amount of gas, consisting mostly of water, vapor is sucked out from the fuel container, but unfortunately also combustionable or crackable substances (e.g. tar) goes out with it, why the fuel consumption increases and the hydrogen content in the gas decreases. The motor's inlet and exhaust can under certain circumstances also interfere with each other.

Instead, dr-ing. Lutz has suggested and tested the device shown in fig. 17, with forced circulation of the

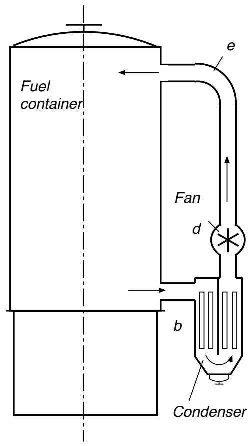

Figure 17: Primary condenser

distillation gases through a condenser. The low pressure fan d is motor powered and could during the test supply a circulation of maximum 100 m^3/h through the system b–d–e from and to the container. The gasifier was the previously used Hansa, with a gas flow of 50 nm^3/h at full load.

To mimic practical conditions, cooling wasn't taken below 50—60°C from 65—75°C of the gas sucked out from the container[5]; the gas was thus only cooled about 15°. In fig. 18, results from a test using 35 % moist pine wood is shown. Gas circulation per hour is chosen as abscissa. Ordinates is for the upper diagram effective heat value of gas; for the middle diagram, separated water in % of wood content, and for the lower diagram the separated amounts of water and tar, in kg/h and in percentage of fuel weight. (The fact that water was separated, although the fan was standing still, was due to self-powered flow of steam to the condenser, and condensation in the gasifier's condense mantle.)

The gain with this method consists only of saving the heat that would have been necessary for superheating the separated water in the form of steam.

The gain shows in an increase in gas heat value. At a circulation flow of about 60 m^3/h this increase ceases and at increased circulation turns into a loss. This because circulation involves a loss of heat in the

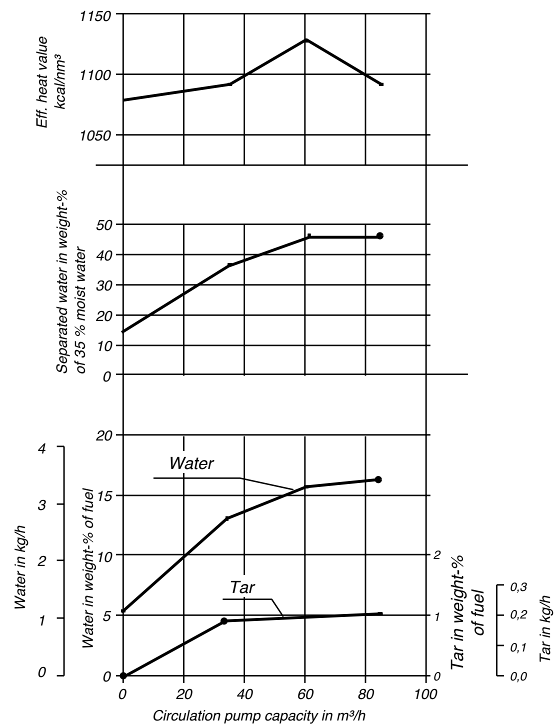

Figure 18: Test of primary condenser attached to a Hansa gasifier.

[5]... and the dewpoint was? — JP

container; this loss increases with temperature, while the gain due to water separation hardly increases for circulation above 60 m^3/h. There about we have an optimum for heat value; in the test it reached 1 130 $kcal/nm^3$. This is a very high number for the present moist level, and even supersedes the corresponding value for a standard Imbert with 90 kcal (see fig. 14).

However, this method would not be of great practical importance, because it does not decrease the need for heat for vaporisation per se, which always is quantitively greater than super-heating heat. There are better ways to improve the gas though, for example:

Supplying heat to the gasification process from an external heat source.

When running a motor on producer gas, one heat source that is always available is exhaust heat, which otherwise would be blown to the skies to no avail at all. Its heat content compared to the gasification heat is tremendous.

Pine wood with a moist content of 27 % has a heat value of about 3 120 kcal/kg (dry wood 4 500). At 80 % efficiency in the gasifier the gas then contains circa 2 500 kcal/kg. If we assume that 20 % of this is lost from the motor in the form of exhaust heat[6], and that 60 % of this may, with proper measures, be added to the gasification process, the added heat would reach 300 kcal/kg wood of 27 % moisture. This addition is practically the same as the heat need, according to equation (3), for vaporising and super-heating moist water to about 1 200°. By recapturing exhaust heat in this manner, wood of 27 % moisture would, to the gasifier, appear as completely dry wood without external heat source. The increase in heat would be tremendous, and the limit for fuel moist content could be moved a fair bit up.

To put this idea in practice one could supply the device in fig. 17 with an exhaust fed heat exchanger. If this device can extract 50 % exhaust heat, the heat addition would be about 4.5 times as large as the heat saving from water separation in the condenser. It is tempting then, to skip the latter and build the device as in fig. 19[7], where the mix of distillation gas and steam is made to circulate only to serve as carrier of exhaust heat. (Thereby one would step off from the goal to *maximise* gas heat value, which indeed was the original incentive to the suggested improvements. On the other hand there is at least a theoretical way to achieve this even without a condenser, namely by prolonging the steam's time in the high temperature zone long enough for a significant steam dissociation to occur. If this is doable in practise, is a different question. — *Ed. note.)*

For the practical tests, the research institute kept

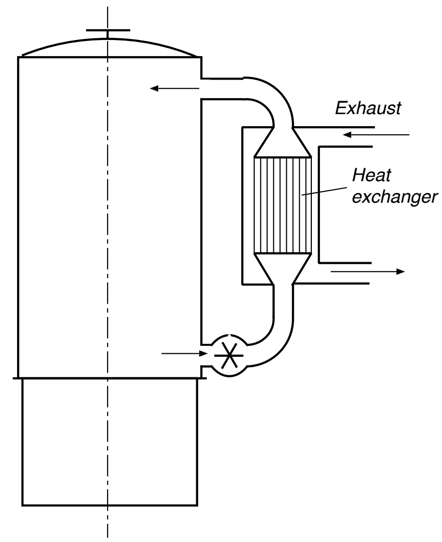

Figure 19: Pre-heating fuel using exhaust heat, via a heat exchanger.

[6]The real number is much higher. However, perhaps Lutz wrote off some heat that inevitably will be lost closer to the exhaust mainfold? — JP 2000

[7]I wonder how gasifier dynamics would be effected by this, when using very moist fuel? Large amounts of steam will be formed, particulary when the gasifier is newly filled. Although there is quite a lot of *heat* available in the exhaust gases, the *temperature* isn't high enough to power the water-gas reaction *without* oxidation heat, i.e. we would still need a net inflow of air to keep the hearth temperature up. But with a large amount of steam flowing from the fuel container, the portion of air may become too small, practically none at idling loads. I would suggest keeping the condenser along with the heater, on a vehicle gasifier or any other gasifier operating under a varying load. — JP 2000

the condenser. For measuring technical reasons, the circulation gases was not heated by exhaust heat, but rather in a heater with a gas flame. At the first test, only as much heat as corresponds about 15 % of the available exhaust heat was supplied. The result was however an increase in heat value for as much as 1 314 to 1 351 kcal/m^3. (Pine wood of 15 % moisture.) Then the heat supply was increased to 50 % of the available exhaust heat. The lower limit of the heat value increased, but only from 1 351 to 1 386 kcal/m^3, a seemingly small increase compared to the added heat. The reasons are as follows.

When the returning circulation gas is supplied a significant amount of heat, the temperature in the container rises steeply, and an intensive drying and pre-distillation takes place in the upper part of the fuel container as well. Wall temperature increases, and with that, losses to the surrounding air also increases significantly. The same goes for the lower parts of the gasifier, because the gas heat emanating from the hearth is also larger than before, when some of the combustion heat was used up in the fuel container. Heat losses through radiation from this Hansa-gasifier's lower part reaches roughly $0.04 \cdot t^2$ kcal/h, where t is the wall temperature. (Above 400° wall temperature the losses increases faster than the above expression shows.) If one has for example a fuel consumption of 20 kg/h with 15 % moisture, one gets 12 000 kcal/h exhaust heat. With 50 % extraction 6 000 kcal/h is supplied to the gasifier fuel container. This amount of heat corresponds to radiation losses from the lower parts at a wall temperature of 385°C. Proper insulation of the gasifier is thus even more called for, when external heat is provided to it.

Before the next test, the whole gasifier was insulated (container and bottom part) with a 25 mm thick layer of glass wool. This resulted directly in an increase of the lower heat value from 1 386 to *1 420* kcal/m^3, further increase ought to be possible by improved insulation.

Summary of test results.

The results can be compiled into the following table:

Design	Gas heat value kcal/m^3	Improvement %
Without heat exchanger	1 187,5	0
With heat exchanger	1 268	6,8
With heat exchanger and water separation.	1 314	10,65
With heat exchanger and water separation + 15 % exhaust heat	1 351	13,8
With heat exchanger and water separation + 50 % exhaust heat	1 386	16,7
With heat exchanger and water separation + 50 % exhaust heat + insulation	1 420	19,6

This table goes for pine wood with 15 % moist content. As a comparison, with the same type of fuel the regular Imbert gasifier gives gas with the heat value 1 275 kcal/m^3. The tests has thus shown that there are great possibilities to improve the present gasifiers; single maximum values on up to 1 650 kcal/m^3 gives hope for further gains. *Using fuel with 40—50 % moisture is already within reach.* — Tests beyond this is already under way at the research institute. — One can also, from the tests already carried out, draw the conclusion that heat economy in the gasifier has a more significant impact on the function, than various design details like hearth form and air supply has.

Fig. 20 shows a skeleton sketch of a tractor gasifier including all the improvement named herein. Next to one side of the fuel container is a heat exchanger for pre-heating air, and on the opposite side the exhaust fed heat exchanger for heating circulation gas and its circulation fan. The whole gasifier is most carefully insulated. Such a gasifier will, as far as we can tell

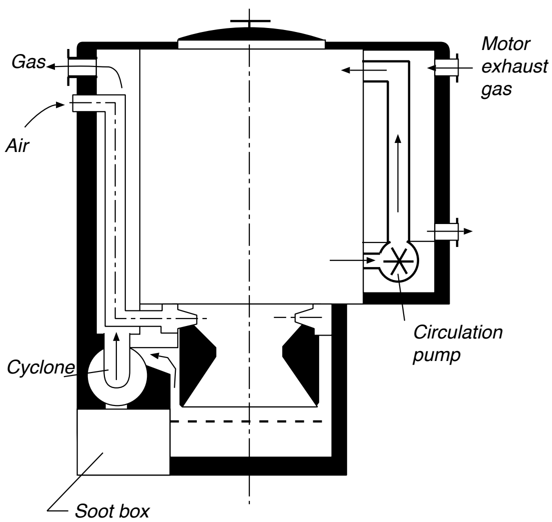

Figure 20: Recapturing both gas heat and exhaust heat.

from the referred investigations, render a gas with a significantly better heat value than the present gasifiers, and make gasification of fuel with a moisture of 40—50 % possible.

So far dr-ing. Lutz, whose thoughts and investigations are of great value for the development of gasification technology. Our gasifier industry has during this 'pioneer period' mostly been occupied with producing enough of safe gasifiers at all, whereby the issue of efficiency has been put aside. Now, however, the industry could be said to have reached a 'stable condition,' and it is now its next task to improve the brands as much as possible. That there in this respect is plenty to be done, no-one would disagree upon, and the thoughts from Lutz may therefore be of value.

For the designer, the improvement of design as usual involves turning the problem of finding best possible balance of profit — increased efficiency — and cost — increased manufacturing costs and gasifier weight. The thing is complicated by, that various aspects must be considered for gasifiers for different purposes. The task is difficult — but enticing.

G. V. Nordenswan.