Note 37
Determination of Thermal and Volumetric Efficiencies

Thermal Efficiency

Given the Specific Fuel Consumption (SFC) of an engine, the Thermal Efficiency (ThE) can be found from:-

$$ThE = \left(\frac{\text{Power}}{\text{Mechanical Equivalent of Heat Value of Fuel Flow Rate}} \right)$$

Where J = Mechanical equivalent of Heat;
C = Heat Value (Lower Calorific Value + Latent Heat of Evaporation) of Fuel per unit mass;

and $SFC = \left(\frac{\text{Fuel Mass Flow Rate}}{\text{Power}} \right)$;

then $ThE = \left(\frac{1}{J} \times \frac{1}{C} \times \frac{1}{SFC} \right)$

In Imperial units*:-

$$J = 778.26 \text{ ft. Lb. Wt./BTU} = \left(\frac{1}{2544} \; \frac{\text{BHP.Hour}}{\text{BTU}} \right)$$

C is in BTU/lb
SFC is in lb/BHP.Hour

$$\text{So } ThE = \left(2544 \times \frac{1}{C} \times \frac{1}{SFC} \right)$$

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*Retained because much of the fuel data was published originally in Imperial units egs. (52, 242, 294, 594).

Alternatively:-

$$ThE = \left(\frac{\text{Power}}{\text{Ideal Power for the same airflow}} \right)$$

So, as shown in the Power equation of Note 10 and with the same symbols:-

$$ThE = \left(\frac{\text{Ideal MEP x MDR x V x N x EV x ASE x EC x EM}}{\text{Ideal MEP x MDR x V x N x EV}} \right)$$

So $ThE = [\,ASE \times EC \times EM\,]$

and $ThE = \left(2544 \times \frac{1}{C} \times \frac{1}{SFC} \right)$ as shown above

So $[ASE \times EC \times EM] = \left(2544 \times \frac{1}{C} \times \frac{1}{SFC} \right)$

Volumetric Efficiency

Therefore, substituting the latter relation for [ASE x EC x EM] in the Power equation 3 in Note 10 and using the same units, i.e.:-

Power in BHP; V in cc; N in RPM;
and with C in BTU/lb; SFC in lb/BHP.Hour as before:-

$$\text{Volumetric Efficiency, EV} = 9.257 \times \left(\frac{C \times BHP \times SFC}{MDR \times V \times N}\right)$$

Example

Eg.6 1914 Mercedes M93654. DASO 468 p.59.

This is the first example in this review for which full Power and SFC data are available, on a facsimile of the original Daimler test chart **(see P.3).**

$$V = 4{,}483\text{cc}$$

$$PP = \left(\frac{105PS}{1.01387}\right) = 103.6\text{BHP} \quad @ \quad 3{,}100\text{RPM}$$

$$\text{Corresponding SFC} = 265\text{g/PS.Std} = \left(\frac{265}{1{,}000} \times 2.2046 \times 1.01387\right)$$

$$= 0.592 \text{ lb/BHP.Hour}$$

Fuel:- 50% Petrol + 50% Benzole (from quoted Specific Gravity),

Therefore $C = \frac{1}{2}.[(19{,}000 + 135) + (17{,}300 + 169)]$ BTU/lb

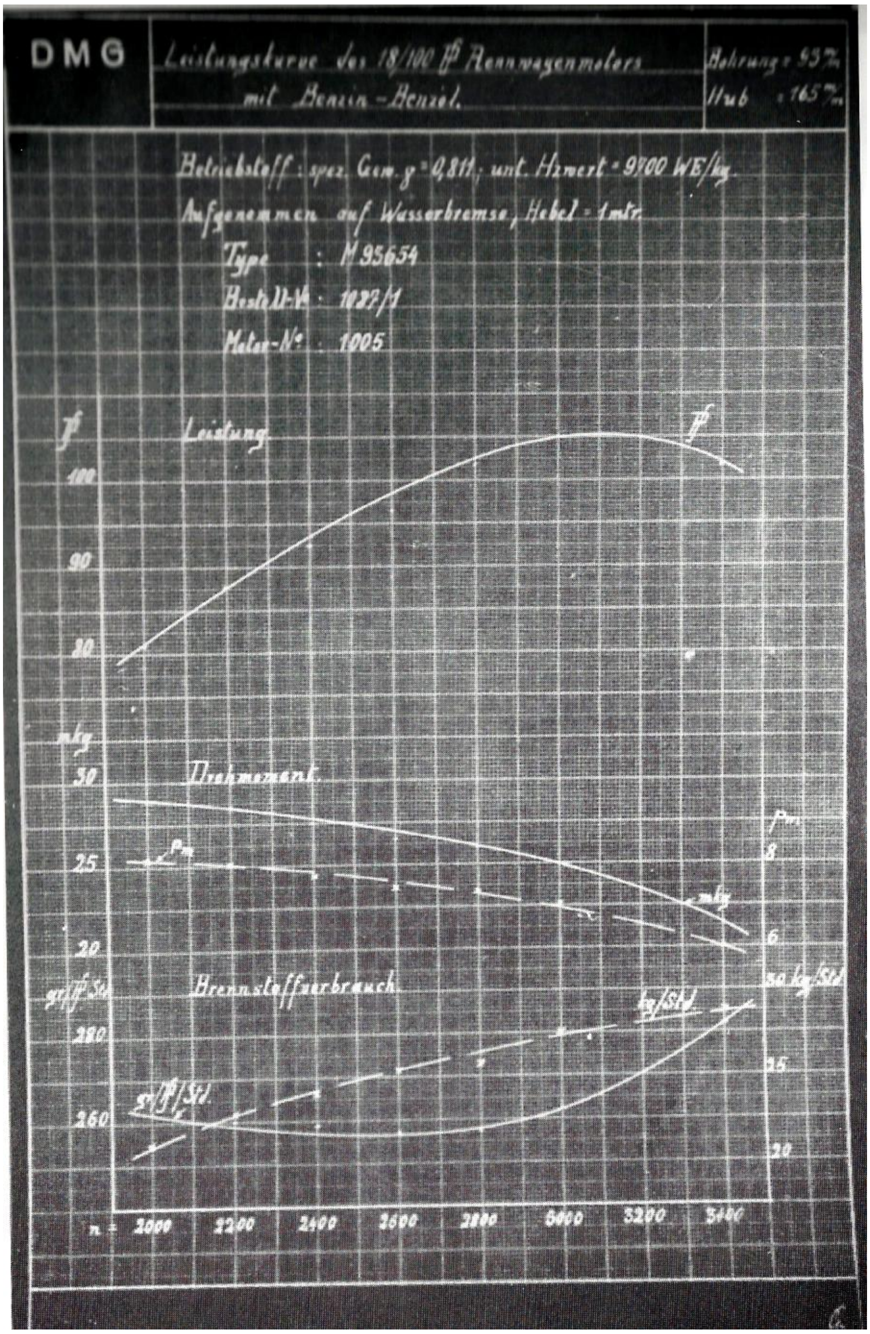
$= 18{,}302$ BTU/lb.

So $$BThE = \left(2544 \times \frac{1}{18{,}302} \times \frac{1}{0.592}\right)$$ (BThE = Brake Thermal Efficiency)

$$BThE = 0.235$$

And $$EV = 9.257 \times \left[\frac{18{,}302 \times 103.6 \times 0.592}{1 \times 4{,}483 \times 3{,}100}\right]$$

$$EV = 0.748.$$


DMG
Leistungskurve des 18/100 PS Rennwagenmotors
mit Benzin-Benzol.
Bohrung = 93 m/m
Hub = 165 m/m
Betriebstoff: spez. Gew. γ = 0,811; unt. Hzwert = 9700 WE/kg.
Aufgenommen auf Wasserbremse, Hebel = 1 mtr.
Type : M 95654
Bestell-Nº : 1027/1
Motor-Nº : 1005
PS
Leistung.
100
90
80
mkg
30
Drehmoment.
25
Pm
20
mkg
8
6
Brennstoffverbrauch.
gr/PS Std
280
260
gr/PS/Std.
kg/Std.
30 kg/Std
25
20
n = 2000 2200 2400 2600 2800 3000 3200 3400