"Mircea cel Batran" Naval Academy Scientific Bulletin, Volume XVII – 2014 – Issue 2
Published by "Mircea cel Batran" Naval Academy Press, Constanta, Romania // The journal is indexed in:
PROQUEST SciTech Journals, PROQUEST Engineering Journals, PROQUEST Illustrata: Technology, PROQUEST Technology Journals, PROQUEST Military Collection PROQUEST Advanced Technologies & Aerospace

THE COMBUSTION PARAMETER OF THE MARINE HEAVY LIQUID FUELS, SIMPLE, AND WATER EMULSIFIED FUEL

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Abstract :*To determine the parameters necessary for making a comparation between the naval residual heavy fuels burning, simple and with water in emulsion, used in marine power systems, we conceived a computer program to establish the composition of combustion gases and combustion point on the diagram, in which the combustion processes can be interpreted and cams to the conclusions regarding to the fire control. The ARDIAG program determines the amount of CO and CO_2 from flue gases, the combustion point on the diagram, for liquid heavy fuel simple and with water in emulsion.*
Keywords*:naval heavy fuels, emulsion, gas burning, burning.*

1. INTRODUCTION

1.1. The determination of gravimetric participations of fuel for emulsified fuels

Depending on the water amountbeingfound in the marine water-fuel emulsion [W_f], itsgravimetricshares, the gravimetricshares, the fuel isdetermined by:

$$C = C_i \frac{1}{1+W_f}\ [\%];\quad H = H_i \frac{1}{1+W_f}\ [\%];$$

$$O = O_i \frac{1}{1+W_f}\ [\%];\quad S = S_i \frac{1}{1+W_f}\ [\%];$$

$$N = N_i \frac{1}{1+W_f}\ [\%];\quad W = W\frac{W_i+100W_f}{1+W_f}\ [\%];$$

$$A = A_i \frac{1}{1+W_f}\ [\%] \tag{1}$$

2. The control of emulsified fuel combustion by means of the combustion diagram of liquid fuels

To determine the combustion imperfection of a fuel itisnecessary to establish the excess-air coefficient [α] as well as the CO content in the burninggases. But the last value isdeterminedwithdifficulty and so, itisbetter to determine the CO_2 and O_2 contents and to establish α and CO analytically and graphicallyitisintroduced the simplifyinghypothesisaccording to which the combustion process imperfection appearsat the carbon combustion. The evidenceisbased on the following argument:the H_2atoms have an average molecular velocity higher than that of carbon atoms, the number of collisions with the oxygen atoms is bigger and so the probability of carbon incomplete burning seems to be more likely.Supposingthat "xC" burns in CO_2 and (1-x) C burns in CO, the consumedoxygenresultfrom the relation:

$$O_C = O_{min} - \frac{1}{2}\cdot\frac{22{,}4}{12}\cdot(1-x)\cdot C =$$

$$\frac{22{,}4}{12}\cdot C\cdot\left[\sigma-\frac{1}{2}\cdot(1-x)\right]\quad [m^2\ N/kg], \tag{2}$$

$$\sigma = 1+3\cdot\frac{H-\dfrac{O-S}{8}}{C}\,. \tag{3}$$

The dry products of combustion when α>1 are given by the relations:

$$V_{CO_2} = \frac{22{,}4}{12}\cdot xC\quad [m^3\,N/kg], \tag{4}$$

$$V_{CO} = \frac{22{,}4}{12}\cdot(1-x)\cdot C\quad [m^3\ N/kg], \tag{5}$$

$$V_{O_2} = \lambda - O_{min} - O_C =$$

$$\frac{22{,}41}{12}\cdot C\cdot\left[\sigma\cdot(\lambda-1)+\frac{1-x}{2}\right]\quad [m^3\ N/kg], \tag{6}$$

$$V_{N2} = \frac{0{,}79}{0{,}21}\cdot\frac{22{,}4}{12}\cdot\lambda\cdot C\cdot\sigma\quad [m^3\,N/kg]. \tag{7}$$

The volume of dry productsis:

$$V_{gu} = \frac{22{,}4}{0{,}21}\cdot\frac{C}{0{,}21}\cdot\left[\sigma\cdot(\lambda-0{,}21)-0{,}21\cdot\frac{3-x}{2}\right]\quad [m^3\,N/kg]. \tag{8}$$

By the formula of V_{gn} the shares of eachelement in the dry gas mixture canbedetermined. Due to the equality:

$$(CO_2)_f + (CO)_f + (O_2)_f + (N_2)_f = 1, \tag{9}$$

The expression of $(N_2)_f$canbeneglected and under the hypothesisthat CO_2 and O_2 are determined by analyzing the dry gases, a set of threeequationswiththreeunknowns, x, α, CO. By analyzing the relations of N_2:

$$\frac{(N_2)_f}{(CO_2)_f+(CO)_f} = \frac{0{,}79\cdot\lambda\cdot\sigma}{0{,}21}\,, \tag{10}$$

- the value of excess-air ispointed out:

$$\alpha = \frac{0{,}21\cdot(N_2)_f}{0{,}79\cdot\sigma\cdot\left[(CO_2)_f+(CO)_f\right]}\,. \tag{11}$$

- x isobtainedfrom the ratio:

$$x = \frac{(CO_2)_f}{(CO_2)_f+(CO)_f} = \frac{0{,}21\cdot x}{0{,}21}\,. \tag{12}$$

andsubstitutinginto the relations (12) weobtain:

$$(CO_2)_f + (CO)_f = \frac{0{,}21}{\sigma\cdot(\lambda-0{,}21)+0{,}21\cdot\dfrac{3-x}{2}} \tag{13}$$

The volumes of α and x, takingintoaccount the relation (13), are obtain by:

$$(CO_2)_f\cdot(0{,}21+0{,}79\cdot\sigma)+(CO)_f\cdot\left[0{,}21+0{,}79\cdot\left(\sigma-\frac{1}{2}\right)\right]+(O_2)_f = 0{,}21 \tag{14}$$

The equation (14) is the equation of a plane, named the combustion plane. From the intersection of this plane with the perfect combustion plane $(CO)_f$=0, itresults the line of perfect combustion with the followingequations:

$$(CO_2)_f \cdot (0{,}21 + 0{,}79 \cdot \sigma) + (O_2)_f = 0{,}21 \,. \tag{15}$$

The perfect combustion line intersects the axes $(CO_2)_f$and $(CO)_f$ in points A and B having the coordinates:

A de $\{ (CO_2)_f = 0;\ (CO_2)_{fmax} = \dfrac{0{,}21}{0{,}21 + 0{,}795} \}$;

and

B de $\{ (O_2)_f = 0;\ (O_2)_{fmax} = 0{,}21 \}$.

A point placed on AB line means a perfect combustion with an excess-air coefficient λ=1 and for thisreason the CO_2 coefficient in smokeis minimal. If the combustion isimperfect, $(CO_2)_f \neq 0$from the equation (12) , the maximum CO content from the burninggasesisobtained in the origin of coordinate axes and its value isgiven by:

$$(CO)_{fmax} = \frac{0{,}21}{0{,}21 + 0{,}79 \cdot \left(\sigma - \dfrac{1}{2}\right)} \tag{16}$$

To plot the lines of $(CO)_f$ =ct., a line OD of arbitrary inclinations isdrawn, sothat the segment OD canbedivided in as muchequal parts as the value of $(CO)_{fmax}$ shows and, the linesparallelwith the perfect combustion line are drawnthrough the division points soestablished. To determine the nature of curves α=ct. thefollowing relations isanalyzed:

$$\frac{(CO_2)_f + 2}{(O_2)_f - 1} = \frac{A + B \cdot \lambda}{C + D \cdot \lambda} \,, \tag{17}$$

inwhich A, B, C, Drepresents the constants terms.
From the last relation itresultsthatwhateverits value is, all curves of α=ct. are concurrent lines in coordinate point $(CO_2)_f$ =2 and $(O_2)_f$=1. The concurrent points beingvery far away, the linesα=ct. appearparallels in the diagram. To plot the lines, two points are establishedso:
- in the equations $(CO)_f$, x=0 and α is a desired value determining the point of intersection with the axes of abscissae (x-axis).
- in the equations (10), x=1 and α at the above value determining the point of intersection with the perfect combustion line.Alike, the other lines of α=ct. are drawn. The line α=∞ passes trough the point B and physically it corresponds to a combustion with a very high excess-air. Knowing the value of the excess coefficient α = *optim*, and the analysis of combustion gases by means of the diagram, we can make the interpretation of combustion and draw conclusions regarding the fire control. A figurative (graphical) point of combustion has to be inside or on the outline (contour line) of the combustion triangle. Any point out of triangle represents an impossible composition of smoke from the physical point of view and it is a sign that the analysis of gases is incorrect (wrong).

3.THE ARDIAG PROGRAM

To determine the parameters of interestnecessary for a comparisonbetween the marine residual fuels, simple or emulsified, I conceived a program including all the stages mentions above and plotting the combustion diagram for a givengravimetric participation of fuel.The ARDIAG program determines the amount of CO and CO_2 in the combustion gases and the imperfect combustion point on the combustion diagram of liquid fuels for the initial input data. It isconceived and runsaccording to as logicaldiagram, in fig.2.The program candetermine the combustion characteristicsboth for water emulsified fuels and unemulsifiedones, the resultsbeingat option.

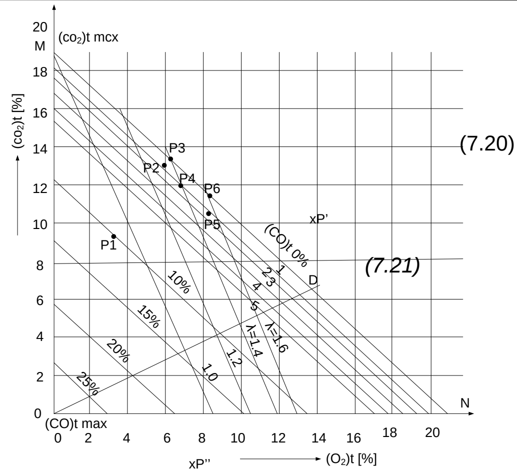

Fig.1. Combustion diagramdetermined for MRD 25 marine heavy. fuel.

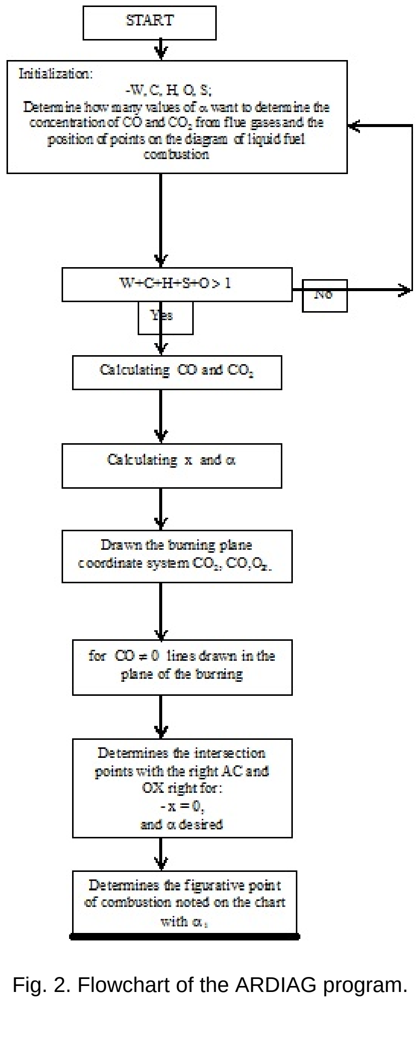

Fig. 2. Flowchart of the ARDIAG program.

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