METHODS FOR RESEARCH AND TESTING OF FUEL OIL MINIATURISED COMBUSTION (PART 2)

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Using the graphologic method and interpreting the combustion oscillogram (COS) supported by flame infrared thermo-gram (FIT) special economical results can be obtained. It is detailed the improving of symbiotic technologies, combustion of water-in-heavy fuel oil emulsion (CWHFOE) and combustion with additived air (CWA). By establish of new criteria for optimum operation variant, in fact are predicted the very advantageous solutions, and thus avoiding many expensive industrial experiments. Also theoretical bases of phenomena which determine the industrial advantageous results are analysed and scientifically explained for boiler furnace operation. Are presented the perspectives and results in other applications, as well the differences and similitude between the proposed methods.

4. SYBIOTIC TECHNOLOGIES CWA AND CWHFOE, IMPROVED USING COMBUSTION GRAPHOLOGY METHOD

4.1. COMBUSTION WITH ADDITIVED AIR

The experimental researches and the RCIC determination were carried out on a anterior presented combustion simulator, but having a small generator of activated (by additivation) electrolytic watery solution. This solution is passed through of a very low quantity of droplet necessary combustion air, generating aerosols in suspension. Also the RCIC of LFO results from the interpretation of the combustion oscillograms of same droplets, experimentally obtained. These characteristics for combusted droplets with additived and thus activated aerosols have specific different notations: self-ignition delay time $t_{ia}$; combustion time of the volatile matters $t_{va}$; cenosphere ignition delay time $\Delta t_a$, when it is distinctly marked on combustion oscillogram; combustion time of cenosphere $t_{ca}$; droplet existence time $t_{ea}$; droplet flame radiated energy $E_{va}$ transformed by photocell into

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electric energy determined of the surface $S_{va} = I_{va} = f_a(t)$ curve and $0t$ axe; energy radiated by the burning cenosphere $E_{ca}$ transformed by the photocell into electric energy and determined of the surface $S_{ca} = I_{ca} = F_a(t)$ curve and $0t$ axe; maximum radiation intensity $I_{va}^m$ obtained at the combustion of the volatile matters; maximum radiation intensity $I_{ca}^m$ obtained at the combustion of $Cn$.

Will be given necessary details about aerosols production systems and the mechanism of furnace beneficial ionization. Aerosols are disperse systems of solid or liquid particles suspended in gases, but having a relative in time stability. In the case a large energetic boiler it is comfortably to obtained aerosols using an additive electrolytic watery solution, which feed a small burner having atomization with low pressure preheated air. Thus the water of aerosols will be vaporized giving solid aerosols and the mixing between aerosols and water vapors will supply the general air-feeding canal of boiler burners. For relative small boilers, the operation principle of the aerosol generator equipments is based on the obtaining of aerosol particles in a tank partial filled with electrolytic watery solution that is passed through by a very low quantity of the burner combustion air. This air produces and transport fine particles, having average dimension $\sim 10\mu m$, towards the furnace of boiler, where first of all, the evaporated water dissociate in ions. The aerosol particles result from explosion of very fine watery pellicle surrounding the air bubbles formed in watery solution, pass through the liquid separation surface in the tank air volume. Due the combustion heat release, the fine solid particles of additive becoming aerosols decompose and give atoms of free oxygen. A part of the formed ions is transported by thermophores towards the cold inner walls of boiler, where react with existent carbon in soot deposits on the furnace heat transfer surfaces, becoming easy friable deposits. At the bottom, in air with activated aerosols will be developed two ionization components, having advantageous effects. Thus the released free oxygen having negative charge determine the acceleration of approaching between $O_2$ and hydrocarbons, resulting a faster combustion reaction with a flame shorter as closer, and the molecular aerosols with negative charge acting on the chains of hydrocarbons favoring their breaking off and reducing the necessary combustion energy.

The ionization effect propagates in the whole combustion chamber and taking into account the temperature increase in the same time, are obtained favorable conditions for complete combustion and decrease of environmental pollution. Especially when the $LFO$ has an important mineral mass content, it is possible as the formed deposits to adhere at the boiler heat transfer cold tubes, forming a solid crust very difficult to clean. In these cases it is necessary additional to complete the watery electrolytic solution with an additive for decreasing the melting-point temperature. The advantageous effects especially are function of: characteristics and percentage content of additive in electrolytic watery solution; rate between air with aerosols and total air for combustion; type of burned $LFO$ and the length of
boiler operation time with activated aerosols. According to these considerations, results what difficult and expense is to obtain the optimal solution only direct by industrial experiments on a power boiler [3].

According to the experimental results, using combustion with additive aerosols it is possible to obtain the following main advantages: saving of fuel oil consumption which increase the boiler thermal efficiency; intensification of combustion processes; reduction of pollutant emissions NO2, CO, SO3; decrease of the pollutant fine solid particles released in the form of soot and/or flying cenospheres; self-cleaning of heat transfer surfaces, the deposits of solid particles becoming easy friable, decreasing the maintenance costs. A good additive for the combustion process intensification must accomplish the following main conditions: chain reactions in furnace due the air oxygen quick to decompose his molecules in atoms; production by decomposition of a large quantity of free atomic even at relative low temperatures in furnaces; to give a great friability for the fine solid particle deposits formed on heat transfer surfaces or permit the mixing with an other adequate additive; to have a good solubility in water and therefore to give easy the liquid aerosols; preservation of the advantageous characteristics at ambient temperature for the resulted electrolytic watery solution; does not be toxic and it does not give pollutant products of decomposition; does not be corrosive itself and his decomposition products; does not be explosive at the operation normal conditions and to be cheap and available.

All these conditions are not possible to be simultaneously accomplished at a single additive. For this reason, the optimal additive is a mixing among different substances as bichromates and chromates of potassium or sodium, derivates of nitric acid etc., these mixtures being patented. Below are given the decomposition chemical reactions for some main potential additives:

\[
2K_2CrO_4 \leftrightarrow Cr_2O_3 + 2K_2O + 3O, \quad (3)
\]

\[
K_2Cr_2O_7 \leftrightarrow Cr_2O_3 + K_2O + 3O, \quad (4)
\]

\[
Na_2Cr_2O_7 \leftrightarrow Cr_2O_3 + Na_2O + 3O, \quad (5)
\]

\[
KNO_3 \leftrightarrow KNO_2 + O. \quad (6)
\]

These four reactions put in evidence the important quantities of released free atomic oxygen.

The maximum value points for radiation intensity (point \(M\) in Fig.2) of LFO droplet burning, with and without combustion air additivation, establish the times for DFMV where \(FIRT\) method give useful details on \(T_a\) values and repartition of these temperatures in the \(IRT\). Using the same presented combustion testing method, for the case of combustion with additived aerosols we obtain the main \(RCIC\), with a special attention for \(S_{\alpha}^c\) and \(S_{\alpha}^a\).
With \( \theta = t_{ca} - \Delta t_a \) (when exist \( \Delta t_a \)), we have:

\[
S_{ca} = \int_0^0 I_{ca} \, dt = \int_0^0 F_a(t) \, dt,
\]

and

\[
S_{va} = \int_{t_{va}}^{t_{va}} I_{va} \, dt = \int_{t_{va}}^{t_{va}} \int_a (t) \, dt.
\]  

The function \( I_a \) and \( \Phi_a \) give integrated values for a spectral band interval \( \lambda_1 \rightarrow \lambda_2 \) of the photocell absorption. Only if the sensibility of the photocell \( \xi_a = dI_a / d\Phi_a^{-1} \) is considered constant, results:

\[
S_{ca} = \xi_a \int_0^0 \Phi_{ca} \, dt,
\]

and

\[
S_{va} = \xi_a E_{va} = \xi_a \int_{t_{va}}^{t_{va}} \Phi_{va} \, dt,
\]

having

\[
\Phi = \int_{\lambda_1}^{\lambda_2} \Phi_\lambda(\lambda) \, d\lambda.
\]

Where \( \Phi_\lambda(\lambda) \) is the radiant power for \( \lambda \) wavelength, having \( \lambda_1 = 0.35 \, \mu m \) and \( \lambda_2 = 1.3 \, \mu m \) according the used simulator photocell. For the combustion without additive aerosols the main RCIC are considered: \( t_o, t_v, t_c, I_{va}^m, I_{ca}^m, S_v, \) and \( S_c \). The functions \( S_c \) and \( S_v \), with the same meaning as \( S_{ca} \) and \( S_{va} \), result from similar relations as where presented. Effecting numerous experiments, resulted that for an industrial more efficient additive it is necessary to be simultaneously accomplish the conditions:

\[
t_{ia} < t_v; \quad t_{va} \geq t_v; \quad t_{ca} \geq t_c; \quad I_{va}^m > I_{ca}^m; \quad I_{ma}^m > I_{ca}^m; \quad S_{va} > S_v; \quad S_{ca} > S_c.
\]

When appear more solution, the best solution correspond to the maximum values for \( I_{va}^m, I_{ca}^m, S_{va}, S_{ca} \) and \( T_a \) temperatures in IRT for DFMV (determined by \( T_{dop}, T_{tor}, T_{ma} \)), together with minimum values for \( t_{ca}, t_{va} \) times. These are new scientifically criteria to select the variants using additives, for a boiler the optimal solution to establish. Thus the experiment effectuated on simulators can improve the combustion with activated aerosols and much to reduce the industrial experiments.
On the base of optimization of the quality and quantity of additive for aerosols, were effected industrial applications on different types of boilers using appropriate technologies as PIR and ACOM. The PIR technology conceived in Romania was applied [5] to relative small boilers with thermal power 5-12MW and to a large boiler as the energetic boiler of 530 MW electric power together with at a power boiler of 420 t/h steam with 137 bar pressure and 540°C temperature. This boiler with natural circulation, was equipped with 18 residual heavy fuel oil burners having mechanical pressure jet atomizers, the sulfur content in fuel being 0.6–0.8 %. Were used numerous aerosols generators what obtained the additive aerosols particles on an electrolytic watery solution which is passed through by a very low quantity of the total combustion air for burners. This air containing aerosol particles, in canal of total combustion air for burners is introduced, realizing with total air a homogenous mixing. For two boiler operation time periods of 27 days without combustion activation by additived aerosols and 52 days using combustion with aerosols, research experiments were effected. In the first period of time the boiler steam output gradually decreased between $B_t = 380$ t/h and $B_p = 300$ t/h, the pressure losses $\Delta p$ of the flue gases on the second boiler section, increased between 1750 Pa and 2570 Pa due the formed deposits of soot, flying coke and ash. For the second period of 52 days $>>$ 27 days, by decreasing of boiler steam output between $B_t = 380$ t/h and $B_p = 320$ t/h, the increasing of $\Delta p$ was practically the same as in the first period. CWAA also gave other important advantages [5], as: increase of the thermal efficiency in average with about 1.5%, especially due the reduction of solid fine particle deposits on the heat transfer surfaces, which become easy friable, and an important decrease of pollution due emission of solid particles. Thus at boiler steam output of $\sim 350$ t/h, the concentration of solid particles in the exhaust combustion gases was decreased with about 52%, and the decrease of unburned carbon in soot + flying coke was of 33.9% coming up to 8.9%; sensible decrease of maintenance costs and pressure losses on the combustion gas way through the boiler; decrease of NOx concentration in exhaust combustion gases, and decrease of the depression in the second section of boiler. But for steam boilers over 100 t/h and water boilers over 50 Gcal/h is more efficient to obtain aerosols using additive electrolytic watery solution which feed a small output burner having atomization with low pressure preheated air.

4.2. COMBUSTION OF WATER-IN-HEAVY FUEL OIL EMULSION

At. combustion technology WHFOE, it has been replaced the old procedure of only mixing between water and HFO by high quality emulsion production, but the water content in emulsion being decreased. For this reason, according to the specialty literature, numerous beneficial advantages may be obtained by CWHFOE, with water content $W$ limited to approximately 10%. Main advantages
referring to the power boilers, are: a drastic abatement of environmental pollution, especially by high diminution the amount of soot and fly oil coke particles generated by industrial combustion; the boiler thermal efficiently increase, as a consequence of the combustion excess air diminution in addition to the deposit reduction of soot and coke particles on heating surfaces (which also decrease the maintenance costs); the reduction of sulfuric corrosion by decreasing the combustion excess air and water content of emulsions, together with the emulsion water additivation possibility; the decrease of the preheating fuel oil temperature due the reduction of emulsion viscosity; the utilization of water which will be emulsified in mixture with additives of the combustion intensification or additives for the adherent deposit and corrosion inhibition; the possibility to use as emulsion water of the waste, usually discharged in drainage channels or in effluents which increase environmental pollution; the possibility of economical using the CWHFOE in either new or old boiler. Ampleness of the majority of beneficial effects are also essentially function of the operating and technical characteristics for the used power boiler, especially as follows: quality of used fuel together with emulsions quality, combustion air excess for different operation loads, type of boiler burners and heating surfaces, as well the boiler wear.

The most applied system for preparing the emulsions uses special centrifugal pumps, working at high rotating speeds. Thus the HFO in previous mixed with water is inspired into the radial channels of pump rotor, where due the centrifugal forces, the water particles are removed into the very small space between rotor and pump carcass, so being cut in very fine particles. The system, operating with emulsion recirculation possibility, uses preheated HFO with the water inserted in precise amounts. The meaning of the appearance of advantageous effects when is used CWHFOE is related to the so-called secondary atomization. If the water fine particle size is of order about 2-5µm during the primary atomization process obtained with mechanical pressure jet atomizer, these small water particles will be incorporated into the HFO droplets, the later having majority a magnitude order of 20–100µm. When the emulsion droplet enter into the incandescent combustions chamber they are heated up and sudden vaporisation of water particles occurs, leading to a further atomization of the droplets into smaller ones. The result is the secondary atomization, produced by micro-explosions, which appear as a consequence of the important vapour pressure increase inner the fine water particles from the emulsion droplet. As a result, very many constituents are released from the combustible mass of the droplet. These components need a lower time to burn. The important decrease of the combustion time is mainly the result of the increase of the combustible mass surface which is in contact with the atmospheric oxygen. For maximum reduction of soot and fly oil coke from exhausted combustion gases, using a small percent of water in HFO it is necessary the water to be uniform dispersed into very small particles. Some authors consider that the fine water particles uniformly distributed in the oil, with a diameter larger
than 6µm, have no advantageous effect on the combustion. They waste the chemical energy developed during the combustion process for vaporisation only. About some opinions, the limit percentage of water in emulsion of up to 6% frequently appears as economically justified because the completely burned oil coke particles that were released, may provide an energy to counterbalance the energy wasted of the water particles vaporisation. Obtaining the double atomization, primary and secondary, constitutes the physical explanation to the beneficial development of the emulsion combustion. But, there is a chemical explanation referring to the beneficial combustion development. The water and the carbon react violently at high temperatures, thus resulting the water gas fuel, that obstructs the formation of soot and oil coke particles. Will be distinguished by theoretical calculation, the effect on the gross thermal efficiency of a steam boiler, by adding the water mixed in HFO for a first variant, and water emulsified in HFO for the second variant. The boiler total consumption $C_t$ of HFO (having mixed $W$) is the sum of three components [4]: $C_m$ boiler consumption of the anhydrous heavy fuel oil (AHFO) necessary to obtain the useful heat $H_u$, water consumption in the used HFO, and $C_v$ consumption of AHFO which is utilized for water vaporisation, or:

$$C_t = H_u (\eta_m Q_m)^{-1} + 0.01 C_t W + 0.01 C_t W \Delta H (Q_m)^{-1},$$  \hspace{1cm} (13)

where: $Q_m$ – lower heating value for AHFO; $\eta_m$ – gross thermal efficiency for $C_m$ fuel consumption; $\Delta H$ – heat consumed for heating and vaporisation of 1 kg water, after which follows superheating of water vapours till the boiler exhausted temperature.

After some transformations results:

$$\varphi = C_t /C_m = 100 \{(100 - W)(1 - \beta)\}^{-1},$$  \hspace{1cm} (14)

$$\psi = C_v /C_m = \beta (1 - \beta)^{-1},$$  \hspace{1cm} (15)

where

$$\beta = W \Delta H \{Q_m (1 - W)\}^{-1}. $$  \hspace{1cm} (16)

From (14), (15) and (16) result that increasing $W$, will increase the characteristics $\beta$, $\varphi$ and $\psi$ i.e. also increase the consumptions $C_v$ and $C_r$, which is a disadvantage. Thus for $W=10\%$ and a usual HFO, results $C_v /C_m \approx 0.69\%$ and $C_i /C_w \approx 1.12$. In real case using HFO, the boiler gross thermal efficiency has the decreasing value:

$$\eta_t = H_u (C_i /Q_i)^{-1},$$  \hspace{1cm} (17)

where: $Q_i$ – lower heating value for HFO. Using the above relations, after some transformations:
\[ \eta_t = \eta_m C_m Q_m (C_i Q_i)^{-1} = (1 - \beta) \eta_m, \quad (18) \]

and

\[ \Delta \eta_t = \eta_m - \eta_t = \eta_m \beta. \quad (19) \]

*CWHFOE* can take place at a combustion air excess smaller as *HFO* combustion and also smaller deposits of soot and oil coke on the boiler heating surfaces. Thus a large increase of boiler gross thermal efficiency at value \( \eta_e \) is obtained, and the difference \( \Delta \eta_e = \eta_e - \eta_t \) may be determined by means of industrial measurements. The difference \( \Delta \eta_e > 0 \), although takes place a supplementary fuel consumption for evaporation of the \( W \leq 10\% \).

The combustion testing method of *WHFOE* similar as anterior experiments, initially consist in the ignition and burning into the simulator incandescent miniature furnace, under standard conditions, of a calibrated *WHFOE* droplet. The determined *RCIC* are for *CWHFOE*: \( t_{ce}, t_{ce}, I_{ce}^m, I_{ce}^c, E_{ce}, E_{ce} \) and \( E_{ce} \). The emulsion quality is obtained expensively and difficult, by determining the dimension and number of the water particles according their size and dispersion type in the *HFO*, with an electronic microscope, or more expensive by analyzing the effects of the industrial combustion of emulsions. When we analyze by the precognized method the combustion of emulsion droplets, two possible distinct cases may appear: the first case, when \( t_{ce}, E_{ce} \) and \( I_{ce}^m \) are sensitively decreasing due the faster combustion of the \( C_n \) in comparison with the *HFO* combustion, the effect of secondary atomization being partially present; the second case when the secondary atomization is total, the whole droplet exploding due the cumulative micro-explosions, during or after the volatile matters combustion. Thus:

\[ t_{ce} = 0, E_{ce} = 0 \text{ and } I_{ce}^m = 0. \quad (20) \]

This second case is determining the optimal quality of emulsion, and when it is burned, may lead to the achievement of maximal beneficial effects. The classification into the first or the second category depends on: principally of the emulsion quality, which, first of all by the emulsifying installation type used and its working conditions; the natural disposition of *HFO* to permit obtaining of a very well emulsified water; the thermal conditions inside the furnace where the droplets combustion occurs, these conditions are favorably to intensifying the combustion at higher relative temperatures, but also may be favored when are used low amounts of water in emulsion. These three characteristics \( t_{ce}, E_{ce} \) and \( I_{ce}^m \), establish the main new criteria for obtaining the necessary quality of an emulsion. By experiments, can establish for an industrial emulsifying installation, which is the most satisfactory rate of operation.
In an electric power station with units of 200 MW capacity, every unit having two power boiler of 330 t/h were realized a complex unit for WHFOE production and emulsion depositing, together with apparatus for industrial combustion experiments [5]. There were used special centrifugal pumps having emulsion recirculation possibility according to a Romanian patent and the main characteristics of emulsions were: lower heating value \(36870 \pm 840 \text{ kJ/kg}\); density \(960–985 \text{ kg/m}^3\); preheating temperature 120–150 °C; coks Conradson 11.5–12 %; water content 7.5–10.8 %; sulfur content 2.2–3.2 %; mean of average sizes \(\phi\) for water fine particles \(m_a = 3–4.4 \mu\text{m}\); proportion of water particles with average size \(\phi<4.8 \mu\text{m} \rho_a = 90–98.65\%\). The used power boilers of 330 t/h burning EWHFO are once-throught boilers, having intermediate superheating steam at 540 °C temperature and 13.7 MPa pressure. The EWHFO burner with nominal consumption of 3400 kg/h have a spill pressure-jet atomizer having whirling chamber and emulsion supply under an excessive pressure of 3.5 MPa. Testings were developed [5] at boiler thermal load between 60% and 94%, using EWHFO with water content \(W = 7.7–10.8\%\). During the effected tests, was established that even a viscosity of 6 °E for EWHFO determined an efficient industrial combustion. The boiler gross efficiency had values of 92.6–9.35% with a relative constant value till \(W \approx 9.5\%\) and after this value it decreases. As a result of industrial thermal test was established that for at long time boiler exploitation, combustion of EWHFO with \(W = 8.5\pm1\%\) gave a: certainly and economical operation with the increase of boiler gross thermal efficiency of minimum 1.5; deposit diminution of soot and oil coke particles in the convective heating surfaces and high pollution decrease of the environment due unburned solid particles, carried off from the combustion zone by flue gases.

5. CONCLUSIONS

Between the proposed methods for RT of FO miniaturized combustion on the shape of a single droplet combustion, there are important differences but also a certain similitude, as follows:

– use the same operation principle in laboratory experiment, based on conversion of burning droplet heat radiation in electrical signals, voltage (\(I\)) or electric power (\(\Phi\)), but in different bands of wavelength of burning droplet radiation and with different type of detectors;

– the main obtained experimental results are given in graphic representation, as a \(\text{COS}\) for combustion graphology method, as \(\text{IRT}\) for combustion thermography method, and \(\text{COS}\) with \(\text{IRT}\) add, for use in combination of the mentioned methods;

– for the use of these methods were conceived two types of specialized combustion simulators, but also having same common devices.
– in fact, the reply concerning differences and similitude is founded on the knowledge of FO droplet combustion graphology and thermography. This new branch of combustion science conceived in Romania can be developed separately in new institutions or by extension of QIRT traditional activity, thus creating an adequate large background of work. Indeed, the biennial prestigious International Conferences on Quantitative Infrared Thermography QIRT were initially realized by the world specialists, especially for infrared thermography problems development.

Are used FO negligible quantities as droplets which burn for laboratory experiments in miniature furnace of simulator, by comparison with the great fuel oil consumption for industrial experiments. By interpretation of the RCIC experimentally obtained, predicting industrial results as for example are CWHFOE and CWAA presented in detail, it is possible to avoid numerous industrial expensive experiments. Thus the saved FO can be regarded as a non-destroyed sample. For this reason, the proposed FO droplet combustion testing, in addition become an equivalent non-destructive testing (NDT) for respective industrial application. Due this important activity, can be considered to increase very great the field of different workings for NDT, presented and developed with regularity in the traditional World Congresses and International Conferences of NDT.

FO droplet FIRT represents an important part of combustion thermography, which can be developed in the future especially referring to the Cn combustion and radiation. The FIRT proposed method of FO droplet combustion, open a new field of activity which improves the knowledges of FO volatile matters combustion processes. But is established a droplet combustion physical model for fruitful RT experiments and referring to GO are given already new criteria for their quality determination. In this development stage of miniaturized FO combustion for RT, the combustion thermography method appear as an useful complement for the combustion graphology method permitting to realize a complex GTM method with different important applications. Thus, is resulted the economic optimization of HFO and IFO symbiotic combustion technologies, for reducing environmental pollution and obtaining fuel savings. Apart of already presented advantages by using the proposed RC combustion graphology method, it is possible to be carried out other economical applications, as follows: the determination of RCIC for different FO at producers (especially crude oil distilleries) for accurate control and optimum directing of technological processes, the result being high quality petroleum products, and improved industrial combustion; the determination of fuel oil RCIC at buyers, enabling them to set out the necessary adjustments and mixing procedures at industrial burners and Diesel engines, for an optimum operation; the determination of RCIC for different FO at distributors (pumping plants in harbours, units for correct cleaning treatment of heavy or intermediate fuel oils which supply
petroleum products); the elaboration with minimum expenses, of the quality and quantity of additives that must be added to different FO, in order to improve their ignition, respectively combustion characteristics; the setting down by means of much limited research, of the industrial efficient use possibilities of same non conventional fuels, as vegetable oils, fuel oils produced by means of coal and different type of liquid ecological fuels; the establish with minimum expenses the efficient combustion equipment of liquid combustible wastes, as residual methanol for example; the caring out of deep investigation in fuel oil combustion structure, the initially possible results being the establishment of same new phenomenological details which can contribute to the optimization of combustion chambers, and elaboration of unconventional methods for improvement of different combustion pollution decrease and fuel savings technologies.

**MAIN ABBREVIATION AND NOMENCLATURE**

$\text{CHFOE} - \text{combustion of water-in-heavy fuel oil emulsion; WHFOE - water-in-heavy fuel oil emulsion; DCPM - droplet combustion physical model; DFMV - droplet flame maximum volume; RCIC - radiation combustion ignition characteristics; FIRT - flame infrared thermography; CWAA - combustion with additived air; NDT - non-destructive testing; IRC - infrared camera; FIT - flame infrared thermogram; ITH - infrared thermography; HFO - heavy fuel oil; IRT - infrared thermogram; CGM - combustion graphology method; CG - combustion graphology; RT - research-testing; Cn - cenosphere; }$ $t - \text{time variation, [ms]; } I - \text{radiation intensity of the burning droplet converted by photocell into voltage, [mV]}$ or into electric power noted with $\Phi$, [mW]; $t_i - \text{self-ignition delay time, [ms]; } t_v - \text{combustion time of volatile matters, [ms]; } d_0 - \text{initial mean diameter of droplet, [mm]; } \lambda - \text{wavelength, [} \mu \text{m}; E_r, E_c - \text{energies radiated by the flame and Cn of burning droplet, transformed by photocell into electric energy, [mJ]; } T_h - \text{initial temperature inner the miniature furnace of simulator, [K]; } T_e, T_0 - \text{environmental air and fuel oil temperatures, [K or } ^\circ \text{C]; } T_a, T_r - \text{apparent and real temperatures, [} ^\circ \text{C]; } T_{xx}, T_t - \text{average of apparent temperatures, on xx' axe, and total flame, [} ^\circ \text{C]; BTL - boiler thermal load; PIR, ACOM - technologies for combustion with additived air by aerosols; AHFO - anhydrous heavy fuel oil (HFO minus water content); W - water content in HFO, mixed or emulsified [%]; C_w - \text{water consumption [kg/h]; } C_t - \text{boiler total consumption of HFO (mixed with water) [kg/h]; } C_m - \text{boiler consumption of AHFO [kg/h]; } C_v - \text{consumption of AHFO utilized for water vaporization [kg/h]; } H_u - \text{boiler useful heat at the consumption } C_m [\text{kJ/kg}; \Delta H - \text{heat consumption for heating – vaporization of 1 kg water, and superheating of resulted vapors till the boiler exhausted temperature [kJ/kg]; } Q_m, Q_t - \text{lower heating value of the AHFO and HFO [kJ/kg]; } \eta_t, \eta_m, \eta_e - \text{gross thermal efficiency for the consumption } C_t, C_m$
and of WHFOE; a – index concerning CWAA; e – index concerning CWHFOE; 
m – exponent concerning the maximum value for burning droplet radiation intensity I;

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REMEMBRANCE. The published paper (Part 1 and Part 2 in addition) celebrates the passing of
50 years from the publication in german of the scientific-technical paper “Eine neue
Berechnungsmethode der Verbrennung mit Gasumwälzung für ihre Anwendung bei Industrieöfen” by
Victor Victor Ghia, in the same revue, which had the denomination Revue d'électrotechnique et