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METROLOGICAL ASPECTS REGARDING THE ADMISSIBLE ERRORS OF DRUM FLOWMETERS

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After a brief presentation of the drum flowmeter,built for the measurement and real time integration of the alcoholic liquid flow transited on the production lines of ethylic alcohol distilleries, there is an explanation of the algorithm proposed by the author for the calculation of the admissible relative indication errors, a presentation of the main program functions, resulted after the implementation of the respective algorithm in source code written in Pascal programming terms, and there is a description of the user interface.

Keywords: Metrology, drum flowmeter,admissible relative ,indication errors.

1. Introduction

The equipments used to establish the production of ethylic alcohol are amongst the durm flowmeter category wich carries out the direct and discontinued measurement of the fluid flow.

2. Equipment description

The drum flowmeter, presented briefly in Fig. 1**,**consists, of a set of operational blocks, under a strict dependence, which include [1-3]:

- The transducers block, (BT),
- The central unit, (UC).

The transducers block incorporates:

- The volume transducer,
- The density transducer,
- The temperature transducer.

The volume transducer consists of a measuring drum (TM) with three equal volume compartments and a proximity inductive sensor (SR), which allows the metering of the successive discharges of the drum's compartments.

The liquid enters the central area of the drum and starts filling the compartment (C1) through the admission aperture (A1). During the filling, the centre of gravity of the accumulated liquid volume increases its eccentricity and a motor resulted moment occurs, which establishes the drum's counter clockwise rotation and the

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discharge of the compartment, respectively, through the exit slot (E1) concurrent with the filling of the compartment (C2) through the admission aperture (A2).

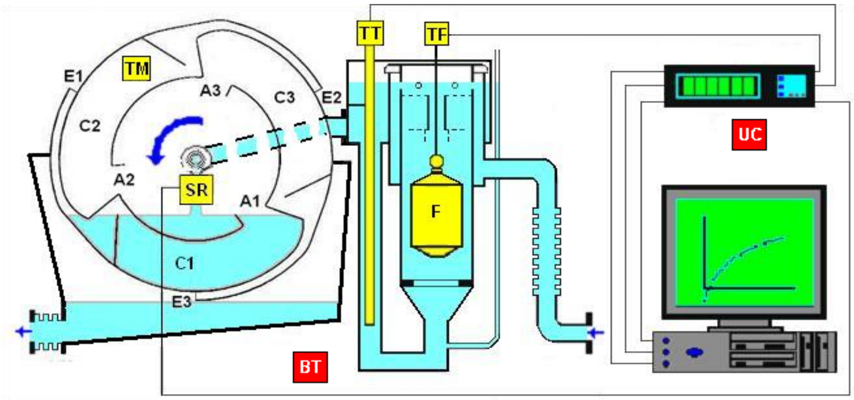


Fig. 1General layout of the drum flowmeter

After the complete discharge of the compartment (C1), corresponding to a partial 120^o rotation, the drum finds a new balanced position which will be retained, following the continuous filling process of the compartment (C2), a new motor moment will occur which will lead to the beginning of the compartment's discharge (C2) through the exit slot (E2), concurrent with the filling of the compartment (C3) through the admission aperture (A3). After the compartment's complete discharge (C2) and the partial 120^o rotation, the previously cycle described is resumed.

The density transducer has in its composition a force transducer (TF), from which a float (F) is suspended with a rigorously calibrated mass and volume. The float is immersed inside a soothing recipient in order to eliminate the turbulences produced by the flow of the alcoholic liquid. The weight of the immersed float modifies according to the density of the alcoholic liquid and, as a consequence, the force transducer offers at the output an electrical signal proportional to its density [4] and [5].

The temperature transducer, (TT), monitors the temperature of the alcoholic liquid.

The central unit of the flowmeter incorporates a microcontroller which runs a program with the following entry data **[6]**:

- ➢ Chart data according to and representing:
  - – Values from *table* 1, [4-6],which allow the transformation of apparent mass processes, *pma*, in real mass percentage, *pmr*;
  - – Values from *table 5*, [4-6], which offer the correspondence between the mass concentrations of the alcoholic liquid at t=15°C and$t$=20°C;

- Values from *table 6*, [4-6], which emphasize the correspondence between densities, mass concentrations and pure ethylic alcohool masses found in 100 l of liquid at t=20°C having the respective densities and mass concentrations;

- V_{fl}: the volume estimation of the float, determined under laboratory conditions;
- m_{afl}: the absolute mass estimation of the float, determined under laboratory conditions;
- V_{ctm}: the estimation of the alcohoolic liquid volume discharged by compartment of the measuring drum, determined under laboratory conditions;
- $G_{fl_{im}}$:unified signal in a proportional current, with the weight estimation of the float immersed in alcoholic liquid;
- t: the unified signal in a proportional current with the temperature estimation of liquid;
- T_{dctm}: the time period elapsed between two consecutive discharges of the measuring drum compartments.

3. Program functions

The program performs the allocation of physical significance to the values of unified signals, the calculation, storage and real time display of the measurements:

- The estimation of the transited alcoholic liquid flow, reported at t=20°C;
- The estimation of the alcoholic liquid temperature;
- The estimations of the volume concentration and the density of the discharged alcoholic liquid, reported at t=20°C;
- The estimations reported at t=20°C of the transited alcoholic liquid volume and of the alcohol volume with a volume concentration of 95.6%.

The central unit can communicate using a serial connection with a process computer for the purpose of controlling the specific parameters of the technological process and can alert, both audio and visually in case one of the following situations occur:

- The overflow of the maximum allowed flow rate;
- Temperatures outside the work temperature interval, 10÷30ºC;
- Densities outside the work density interval, 0.78934÷0.98200 g/cm^3.

The algorithm underlying the program ran by the microcontroller from the central unit of the drum flowmeter is briefly presented below, [6].First, one has to estimate the density d of a volume V_{ctm} of alcoholic liquid at temperature t, discharged by one of the compartments of the measuring drum, as an arithmetic mean of a number m of density estimations $d_n$calculated at 2 s intervals, during the time frame T_{dctm}:

$$d=\frac{1}{m}\cdot\sum_{n=1}^{m} d_n \tag{1}$$

where m is the entire part of the $T_{dctm}/2$ ratio.

The estimations of the densities d_n are computed using the relation:

$$d_n=\frac{m_{afl}\cdot g\text{-}G_{fl_{im}n}}{V_{fl}\cdot g} \tag{2}$$

where g is the local gravitational acceleration.

The apparent mass concentration of the alcoholic liquid with the estimated density d expressed in mass apparent percentage, pma, is determined by means of interpolation with the relation:

$$pma=\frac{\left(d\text{-}d_{tab_6 i}\right)\cdot\left(pma_{tab_6 i+1}\text{-}pma_{tab_6 i}\right)}{0{,}0005}+pma_{tab_6 i} \tag{3}$$

$d_{tab_6 i}$, $d_{tab_6 i+1}$: densities from *column1,chart 6*, [4-6],between which the value d is situated;

$pma_{tab_6 i}$, $pma_{tab_6 i+1}$: mass percentage from *column 2, chart 6*, [4-6], correspondingto the density values$d_{tab_6 i}$and$d_{tab_6 i+1}$ [6].

Based on the pma values and on the estimation of the alcoholic liquid temperature t, one can calculate the real mass percentage values $pmr^*_{t,i}$, $pmr^*_{t,i+1}$with the following relations:

$$pmr^*_{t,i}=\left(t\text{-}t_{tab_1 k}\right)\cdot\left(pmr_{t_{tab_1 k+1},i}-pmr_{t_{tab_1 k},i}\right)+pmr_{t_{tab_1 k},i} \tag{4}$$

$$pmr^*_{t,i+1}=\left(t\text{-}t_{tab_1 k}\right)\cdot\left(pmr_{t_{tab_1 k+1},i+1}-pmr_{t_{tab_1 k},i+1}\right)+pmr_{t_{tab_1 k},i+1} \tag{5}$$

$pmr_{t_{tab_1 k},i}$, $pmr_{t_{tab_1 k},i+1}$, $pmr_{t_{tab_1 k+1},i}$, $pmr_{t_{tab_1 k+1},i+1}$: real mass percentage from *chart 1*, **[4-6],**which correspond *on columns* to the apparent mass percentage $pmA_{tab_1 i}$,$pmA_{tab_1 i+1}$,between which pma is situated and *on the rows* to the temperatures $t_{tab_1 k}$, $t_{tab_1 k+1}$, between which the value of t is situated.

Then, the real mass percentage pmr is calculated, corresponding to pma, using the relation:

$$pmr=\left(pma\text{-}pmA_{tab_1 i}\right)\cdot\left(pmr^*_{t,\,i+1}-pmr^*_{t,i}\right)+pmr^*_{t,i} \tag{6}$$

The estimation of the alcohoolic liquid density can now be determined at t=20°C, $d_{20°C}$, with the relation:

$$d_{20°C}=\frac{0.0005\cdot\left(pmr\text{-}pMr_{tab_6 i}\right)}{pMr_{tab_6 i+1}-pMr_{tab_6 i}}+D_{tab_6 i} \tag{7}$$

where $pMr_{tab_6 i}$, $pMr_{tab_6 i+1}$ are mass percentage from *column 2,chart 6*, [4-6], between which the value of pmr is situated;

D_{tab_6i}, D_{tab_6i+1}: densities from *column 1,chart 6*, [4-6], corresponding to the mass percentage pMr_{tab_6i}, pMr_{tab_6i+1}.

The estimation of the alcoholic liquid volume concentration at$t$=15°C,$cv_{15°C}$can be determined with the relation:

$$cv_{15°C}=\frac{\left(d_{20°C}-D_{tab_6i}\right)\cdot\left(cv_{15°Ctab_6i+1}-cv_{15°Ctab_6i}\right)}{0{,}0005}+cv_{15°Ctab_6i} \qquad (8)$$

where $cv_{15°Ctab_6i}$, $cv_{15°Ctab_6i+1}$ are volume concentration from *column 3,chart 6*, [4-6], corresponding to the densities D_{tab_6i}, D_{tab_6i+1}.

One can now calculate the estimation of the volume concentration pertaining to the alcohoolic liquid discharged at the reference temperature t=20°C,$cv_{20°C}$, with the relation:

$$cv_{20°C}=\frac{\left(cv_{15°C}-cV_{15°Ctab_5i}\right)\cdot\left(cV_{20°Ctab_5i+1}-cV_{20°Ctab_5i}\right)}{\left(cV_{15°Ctab_5i+1}-cV_{15°Ctab_5i}\right)}+cV_{20°Ctab_5i} \qquad (9)$$

where $cV_{15°Ctab_5i}$, $cV_{15°Ctab_5i+1}$ are values from *column 1*,*chart*5, [4-6], between which $cv_{15°C}$ is situated;

$cV_{20°Ctab_5i}$, $cV_{20°Ctab_5i+1}$ are volume concentrations from *column2*, *chart 5*, [4-6], corresponding to the volume concentrations $cV_{15°Ctab_5i}$, $cV_{15°Ctab_5i+1}$.

The estimation of pure ethylic alcohol, a,found in 100 l of alcohoolic liquid with the volume concentration $cv_{20°C}$and density$d_{20°C}$can be calculated with the relation:

$$a=\frac{(d_{20°C}-D_i)\cdot\left(a_{tab_6i+1}-a_{tab_6i}\right)}{0{,}0005}+a_{tab_6i} \qquad (10)$$

whith a_{tab_6i}, a_{tab_6i+1}: masses of pure ethylic alcohol from *column 4,chart 6*, [4-6], found in a volume of 100 l of mixture at t=20°C,corresponding to the densities D_{tab_6i}, D_{tab_6i+1}.

Then, one calculates the estimation of the alcohoolic liquid volume $V_{20°C}$, with the density $d_{20°C}$ and temperature t=20°C, the equivalent of the alcohoolic liquid volume V_{ctm} ,with the density $d$and temperature t, discharged by one of the measuring drum's compartments, with the relation:

$$V_{20°C}=V_{ctm}\cdot\frac{d}{d_{20°C}} \qquad (11)$$

and the estimation of the ethylic alcoholic volume with the volume concentration of 95.6% at$t$=20°C, $V95.6_{20°C}$, found in$V_{20°C}$, with the relation:

$$V95.6_{20°C}=0.01325\cdot a\cdot V_{20°C} \qquad (12)$$

The volume estimation of the transited alcoholic liquid, reported at t=20°C, is calculated with the relation:

$$Q=\frac{V_{20°C}}{T_{dctm}} \qquad (13)$$

By summing up the volumes, $V_{20°Cj}$, successively discharged by the compartment of the measuring drum, one can determine the entire volume estimation of the transited alcoholic liquid $V_{20°Ctotal}$, at t=20°C with the relation:

$$V_{20°Ctotal}=\sum_{j=1}^{N_{dev}} V_{20°Cj} \tag{14}$$

The number of discharges, N_{dev}, variable of the type *integer* unitarily indexed at the end of each discharge of the measuring drum's compartments, a fact emphasized by an impulse given by the proximity inductive sensor from the composition of the volume transducer.

By summing up the ethylic alcoholic volumes, with a volume concentration of 95.6% at t=20°C, $V95.6_{20°Cj}$, found in each of the discharged volumes, one can determine the estimation of the total volume $V95.6_{20°Ctotal}$, with the relation:

$$V95.6_{20°Ctotal}=\sum_{j=1}^{N_{dev}} V95.6_{20°Cj} \tag{15}$$

4. The algorithm for the calculation of admissible relative indication errors

The algorithm contains the following initial data:

- The chart data, according to [4-6], pointed out in the introduction, paragraph 2;
- The true conventional values pertaining to the float volume, V_{CAfl}, to the absolute mass of the float, m_{CAafl}, to the volume of the measuring drum compartments, V_{CActm},, to the temperature of the alcohoolic liquid, t_{CA} and to their absolute admissible indication errors:
  - $\varepsilon_{V_{CAfl}}$: absolute admissible indication error of V_{CAfl}, calculated with the relation:

$$\varepsilon_{V_{CAfl}}=\frac{m_{CAfl_{aer}}-m_{CAfl_{apa}}+2\cdot\varepsilon_m}{\rho_{CAapa}-\rho_{CAaer}-\varepsilon_{\rho_{CAapa}}-\varepsilon_{\rho_{CAapa}}} \tag{16}$$

where:

$m_{CAfl_{aer}}$: the real conventional value of the float air mass, measured with an absolute admissible indication error ε_m;

$m_{CAfl_{apa}}$: the real conventional value of the float water mass, measured with an absolute admissible indication error ε_m;

ρ_{CAaer}: the real conventional value of the air density, measured with an absolute admissible indication error $\varepsilon_{\rho_{CAaer}}$;

ρ_{CAapa}: the real conventional value of water density, measured with an absolute admissible indication error $\varepsilon_{\rho_{CAapa}}$;

– $\varepsilon_{m_{CAafl}}$: the absolute admissible indication error m_{CAafl}, calculated with the relation:

$$\varepsilon_{m_{CAafl}}=\varepsilon_m+V_{CAfl}\cdot\varepsilon_{\rho_{CAaer}}+\varepsilon_{V_{CAfl}}\cdot\rho_{CAaer} \tag{17}$$

- $\varepsilon_{V_{CActm}}$: the absolute admissible indication error of V_{CActm};
- ε_t: the absolute admissible indication error of t_{CA}.

- Real conventional values of the float weight, $G_{CAfl_{im}i}$, immersed in alcoholic fluid with real conventional values of density d_{CAi}, which scavenges the interval of the work densities pertaining to the drum, and their absolute admissible indication errors $\varepsilon_{G_{CAfl_{im}i}}$, calculated with the relation:

$$\varepsilon_{G_{CAfl_{im}i}}=\varepsilon_{tf}\cdot G_{CAfl_{im}i} \tag{18}$$

where:

ε_{tf}: the admissible relative error of the force transducer.

- $\varepsilon_{d_{CA,i}}$: the absolute admissible indication errors of $d_{CA,i}$, calculated with the relation:

$$\varepsilon_{d_{CAi}}=max\left[\begin{matrix}\dfrac{\left(m_{CAafl}+\varepsilon_{m_{CAafl}}\right)\cdot g\text{-}G_{CAfl_{im}i}+\varepsilon_{G_{CAfl_{im}i}}}{\left(V_{CAfl}\text{-}\varepsilon_{V_{CAfl}}\right)\cdot g}\text{-}d_{CAi};\\ d_{CAi}\text{-}\ \dfrac{\left(m_{CAafl}-\varepsilon_{m_{CAafl}}\right)\cdot g\text{-}G_{CAfl_{im}i}-\varepsilon_{G_{CAfl_{im}i}}}{\left(V_{CAfl}+\varepsilon_{V_{CAfl}}\right)\cdot g}\end{matrix}\right] \tag{19}$$

where, for the number of N_{it} iterations, specified by the user, d_{CAi}, is calculated with the relation:

$$d_{CAi}=0.78934+\sum_{i=0}^{N_{it}} i\cdot\frac{0.19266}{N_{it}} \tag{20}$$

With the relations (3)÷(13), used by the program operated by the microcontroller pertaining to the central unit of the drum flowmeter, two sets of values are calculated, as a consequence of the scanning of work densities and temperatures, whose purpose is to simulate almost entirely the real measuring cases.

The first series consists of real conventional value sets e$V_{CA20°Ci_k}$, $V95.6_{CA20°Ci_k}$, Q_{CAi_k}, while the second series has in its composition their corresponding sets of maximised/ minimised values, $V_{20°Ci_k}$, $V95.6_{20°Ci_k}$, Q_{i_k}.

The calculation of real conventional values $V_{CA20°Ci_k}$, $V95.6_{CA20°Ci_k}$, Q_{CAi_k}, begins with the determination of real conventional values of the apparent mass concentrations pma_{CAi}, corresponding to the real conventional values of density d_{CAi} [7-8]. For the calculation, relation (3) is used.

The gradual scanning of the work temperatures interval, 10÷30ºC, offers to the alcoholic fluid temperature a number of real conventional values t_{CAk}, calculated with the relation:

$$t_{CAk}=10+k=t_{tab_1k} \tag{21}$$

where $k$is an *integer* type variable whose value is unitarily indexed from 0 to 20.

Thus, each of the $N_{it}+1$ values pma_{CAi}will be associated to 21 real conventional values $d_{CA20°C,i_k}$ calculated with the relations (4)÷(7).

Based on the $d_{CA20°C,i_k}$ values,$(N_{it}+1)\cdot 21$sets of real conventional values can be calculated $V_{CA20°Ci_k}$, $V95.6_{CA20°Ci_k}$, Q_{CAi_k}, with the relations (8)÷(13).

With some particularities, which will be emphasized shortly, the determination of the estimation values $V_{20°Ci_k}$, $V95.6_{20°Ci_k}$, Q_{i_k}, follows the same calculation pattern.One begins with the maximisation/minimisation values of the d_i estimations, of the real conventional values of the density d_{CAi}.

If:

$$\varepsilon_{d_{CAi}}=\frac{\left(m_{CAafl}+\varepsilon_{m_{CAafl}}\right)\cdot g\text{-}G_{CAfl_{im}i}+\varepsilon_{G_{CAfl_{im}i}}}{\left(V_{CAfl}-\varepsilon_{V_{CAfl}}\right)\cdot g}-d_{CAi}$$

the following values are assigned to the d_i estimations:

$$d_i=d_{CAi}+\varepsilon_{d_{CAi}} \tag{22}$$

And if

$$\varepsilon_{d_{CAi}}=d_{CAi}\text{-}\ \frac{\left(m_{CAafl}-\varepsilon_{m_{CAafl}}\right)\cdot g\text{-}G_{CAfl_{im}i}-\varepsilon_{G_{CAfl_{im}i}}}{\left(V_{CAfl}+\varepsilon_{V_{CAfl}}\right)\cdot g}$$

The following values are assigned to the d_i estimations:

$$d_i=d_{CAi}-\varepsilon_{d_{CAi}} \tag{23}$$

With the relation (3) the values of the pma_i estimations, corresponding to the density d_i , are then calculated.

During the scanning of work temperatures interval, the real conventional valuesof the alcohoolic liquid temperature, t_{CAk}, will be attributed the values of thet_k estimations, for which the maximum deviations of the pmr_i estimations are obtained, from the real conventional values pmr_{CAi}.

The maximum values $pmr_{i,max}$of the estimations$pmr_i$are calculated according to the relation (6):

$$pmr_{i,max}=\left(pma_i-pmA_{tab1,i}\right)\cdot\left(pmr^*_{t_{CAk}+\varepsilon_t,i+1}-pmr^*_{t_{CAk}+\varepsilon_t,i}\right)+pmr^*_{t_{CAk}+\varepsilon_t,i}$$

$$pmr_{i,min}=\left(pma_i-pmA_{tab1,i}\right)\cdot\left(pmr^*_{t_{CAk}\text{-}\varepsilon_t,i+1}-pmr^*_{t_{CAk}\text{-}\varepsilon_t,i}\right)+pmr^*_{t_{CAk}\text{-}\varepsilon_t,i}$$

The values of real mass percentages, $pmr^*_{t_{CAk}+\varepsilon_t,i}$,$pmr^*_{t_{CAk}+\varepsilon_t,i+1}$, $pmr^*_{t_{CAk}-\varepsilon_t,i}$and $pmr^*_{t_{CAk}-\varepsilon_t,i+1}$are calculated according to the relations (4) and (5):

$$pmr^*_{t_{CAk}+\varepsilon_t,i}=\varepsilon_t\cdot\left(pmr_{t_{tabk+1},i}-pmr_{t_{tabk},i}\right)+pmr_{t_{tabk},i}$$

$$pmr^*_{t_{CAk}+\varepsilon_t,i+1}=\varepsilon_t\cdot\left(pmr_{t_{tabk+1},i+1}-pmr_{t_{tabk},i+1}\right)+pmr_{t_{tabk},i+1}$$

$$pmr^*_{t_{CAk}-\varepsilon_t,i}=\left[\left(t_{CAk}-\varepsilon_t\right)-t_{tabk-1}\right]\cdot\left(pmr_{t_{tabk},i}-pmr_{t_{tabk-1},i}\right)+pmr_{t_{tabk-1},i}$$

$$pmr^*_{t_{CAk}-\varepsilon_t,i+1}=\left[\left(t_{CAk}-\varepsilon_t\right)-t_{tabk-1}\right]\cdot\left(pmr_{t_{tabk},i+1}-pmr_{t_{tabk-1},i+1}\right)+pmr_{t_{tabk-1},i+1}$$

where:

$$t_{tabk}<t_{CAk}+\varepsilon_t<t_{tabk+1}$$

$$t_{tab1,k-1}<t_{CAk}-\varepsilon_t<t_{tab1,k}$$

If

$$pmr_{i,max}-pmr_{CA,i}\geq pmr_{CA,i}-pmr_{i,min}$$

The estimationst_k,will receive the values calculated with the relation:

$$t_k=t_{CAk}+\varepsilon_t \tag{24}$$

And if:

$$pmr_{i,max}-pmr_{CAi}<pmr_{CAi}-pmr_{i,min}$$

the estimations t_k,will receive the values calculated with the relation:

$$t_k=t_{CAk}-\varepsilon_t \tag{25}$$

Relation (7) is used to calculate the values of the alcoholic liquid density at $t=20^oC$,$d_{20^\circ Ci_k}$.

Thea_{i_k}values are determined by means of consecutively applying the relations (8)÷(10).

If:

$$\frac{d_{CAi_k}}{d_{CA20^\circ Ci_k}}\leq\frac{d_{i_k}}{d_{20^\circ Ci_k}}$$

The V_{ctm} estimation receives the value:

$$V_{ctm}=V_{CActm}+\varepsilon_{V_{CActm}} \tag{26}$$

and, as a result, the values of the volume estimations $V_{20^\circ C,i,k}$, are calculated according to the relation (11):

$$V_{20^\circ Ci_k}=\left(V_{CActm}+\varepsilon_{V_{CActm}}\right)\cdot\frac{d_{i_k}}{d_{20^\circ Ci_k}}$$

Similarly, if:

$$\frac{d_{CAi_k}}{d_{CA20^\circ Ci_k}}>\frac{d_{i_k}}{d_{20^\circ Ci_k}}$$

the estimation V_{ctm} receives the value:

$$V_{ctm}=V_{CActm}-\varepsilon_{V_{CActm}} \tag{27}$$

and, as a result, the values of the volume estimations $V_{20^\circ C,i,k}$,are calculated according to the relation (11):

$$V_{20^\circ Ci_k}=\left(V_{CActm}-\varepsilon_{V_{CActm}}\right)\cdot\frac{d_{i_k}}{d_{20^\circ Ci_k}}$$

The values of the $V95.6_{20^\circ Ci_k}$and Q estimations are determined with the relations (12) and(13).

The absolute partial error,$\varepsilon_{V_{20^\circ Ci_k}}$, $\varepsilon_{V95.6_{20^\circ Ci_k}}$, $\varepsilon_{Q_{i_k}}$, associated to the estimations $V_{20^\circ Ci_k}$,$V95.6_{20^\circ Ci_k}$,Q_{ii_k},are calculated with the relations:

$$\varepsilon_{V_{20^\circ Ci_k}}=\left|V_{20^\circ Ci_k}-V_{CA20^\circ Ci_k}\right| \tag{28}$$

$$\varepsilon_{V95.6_{20^\circ Ci_k}}=\left|V95.6_{20^\circ Ci_k}-V95.6_{CA20^\circ Ci_k}\right| \tag{29}$$

$$\varepsilon_{Q_{i,k}}=\left|Q_{i_k}-Q_{CAi_k}\right| \tag{30}$$

Their maximum values in the module,$\left|\varepsilon_{V_{20^\circ C}max}\right|$, $\left|\varepsilon_{V95.6_{20^\circ C}max}\right|$, $\left|\varepsilon_{Qmax}\right|$, allow according of [7-10], the calculation of the admissible relative indication errorsof the alcohoolic liquid flow rate, δ_Q,of the total volume transited by the alcoholic liquid at t=20°C,$\delta_{V_{20^\circ Ctotal}}$and of the ethylic alcohol volume at t=20°C with its volume concentration of 95.6 %, $\delta_{V95.6_{20^\circ Ctotal}}$, with the relations:

$$\delta_Q=\pm\frac{Q+\left|\varepsilon_{Qmax}\right|}{Q}\cdot 100 \tag{31}$$

$$\delta_{V_{20^\circ Ctotal}}=\pm\frac{V_{20^\circ Ctotal}+N_{dev}\cdot\left|\varepsilon_{V_{20^\circ C}max}\right|}{V_{20^\circ Ctotal}}\cdot 100 \tag{32}$$

$$\delta_{V95.6_{20^\circ Ctotal}}=\pm\frac{V95.6_{20^\circ Ctotal}+N_{dev}\cdot\left|\varepsilon_{V95.6_{20^\circ C}max}\right|}{V95.6_{20^\circ Ctotal}}\cdot 100 \tag{33}$$

When, in the specific case of the application when the flowmeter is used, the random component of the measuring error is insignificant with respect to the systematic one, the values of the measuring uncertainties of the mentioned physical dimensions can be declared, with a high trust level, as having the values calculated of the admissible relative indication errors of the drum flowmeter [9-10].

5. The user interface and the main functions of the program elaborated based on the calculation algorithm used for the determination of the drum flowmeter admissible relative indication errors

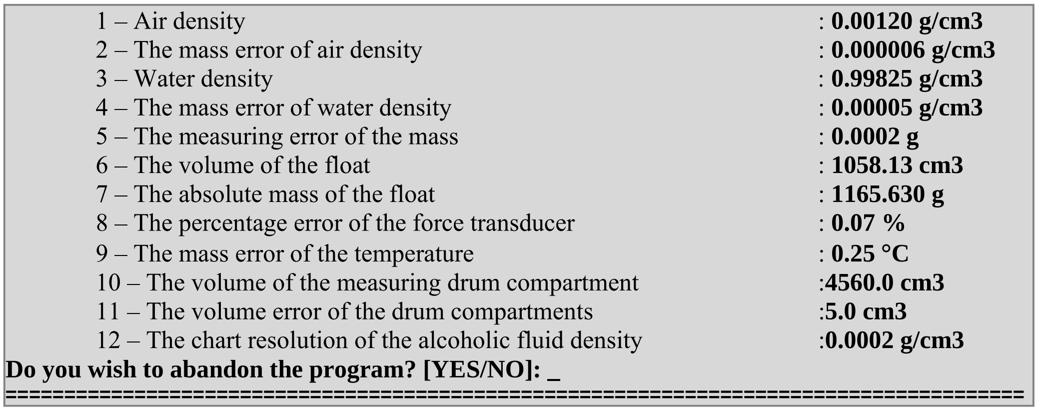
The program, resulted after the implementation of the algorithm used for the calculation of the drum flowmeter admissible relative indication errors in a source code written in Pascal programming terms, offers to the user, a friendly interface, which allows him, through some windows projected in text mode (Fig. 2) and in graphic mode (Fig. 3), the following:

- the launch or abandonment of the program;
- the modification of the entry data belonging to the algorithm calculating the drum flometer admissible relative indication errors;
- the establishment of the limits belonging to the density interval which will be analysed;
- the specification of the value number belonging to the density for which they are alphanumerically calculated and displayed (Fig.4):
  - the number of the iteration i, and the corresponding values of the density d_{CAi};
  - the temperature t_k, for which the values $\varepsilon_{V_{20°C}max}$ and $\varepsilon_{V95,6_{20°C}max}$ are obtained;
  - the densities:$d_{CA20°Ci_k}$and$d_{20°Ci_k}$;
  - the relative partial errors: *ev20* and *evpur20*, calculated with the relations:

$$ev20 = \frac{|V_{20°Ci_k} - V_{CA20°Ci_k}|}{V_{CA20°Ci_k}} \cdot 100 \tag{34}$$

$$evpur20 = \frac{|V95.6_{20°Ci_k} - V95.6_{CA20°Ci_k}|}{V95.6_{CA20°Ci_k}} \cdot 100 \tag{35}$$

- choosing the form under which the results are going to be presented: alphanumeric and/or graphic (the variation of the error *evpur20* is represented according to the values of the volume concentration $cv_{20°C}$);
- the possibility of printing the results or not.



```
             1 – Air density                                                  : 0.00120 g/cm3
             2 – The mass error of air density                                : 0.000006 g/cm3
             3 – Water density                                                : 0.99825 g/cm3
             4 – The mass error of water density                              : 0.00005 g/cm3
             5 – The measuring error of the mass                              : 0.0002 g
             6 – The volume of the float                                      : 1058.13 cm3
             7 – The absolute mass of the float                               : 1165.630 g
             8 – The percentage error of the force transducer                 : 0.07 %
             9 – The mass error of the temperature                            : 0.25 °C
             10 – The volume of the measuring drum compartment                :4560.0 cm3
             11 – The volume error of the drum compartments                   :5.0 cm3
             12 – The chart resolution of the alcoholic fluid density         :0.0002 g/cm3
Do you wish to abandon the program? [YES/NO]: _
==========================================================================================
```

Fig.2 The modification of the entry data in text mode display

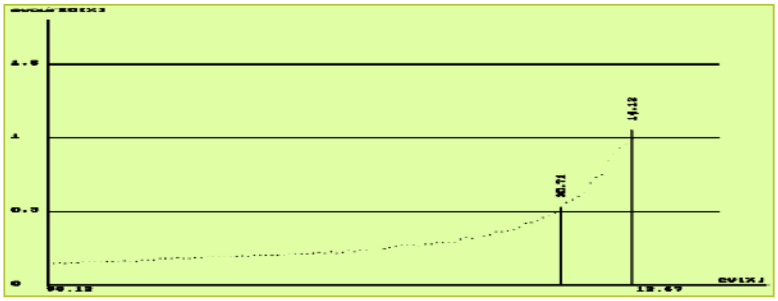
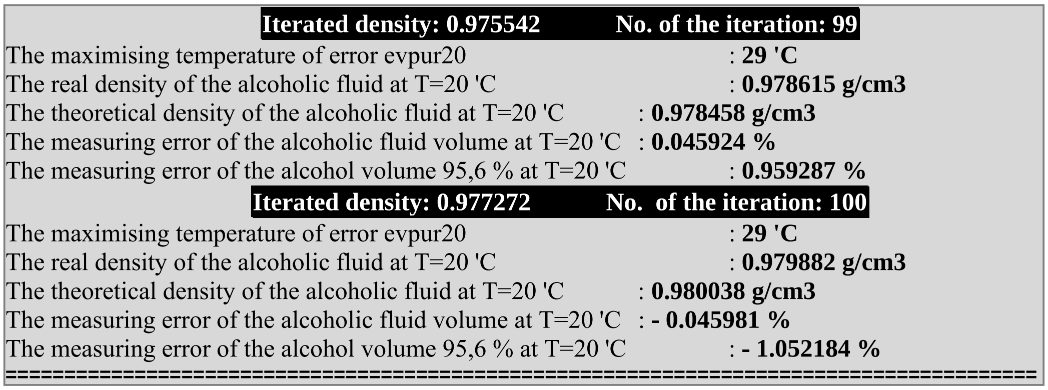


Fig.3Variation of the error according volume concentration in graphic mode display



```
                         Iterated density: 0.975542          No. of the iteration: 99
The maximising temperature of error evpur20                                : 29 'C
The real density of the alcoholic fluid at T=20 'C                         : 0.978615 g/cm3
The theoretical density of the alcoholic fluid at T=20 'C          : 0.978458 g/cm3
The measuring error of the alcoholic fluid volume at T=20 'C   : 0.045924 %
The measuring error of the alcohol volume 95,6 % at T=20 'C                : 0.959287 %
                        Iterated density: 0.977272          No.  of the iteration: 100
The maximising temperature of error evpur20                                : 29 'C
The real density of the alcoholic fluid at T=20 'C                         : 0.979882 g/cm3
The theoretical density of the alcoholic fluid at T=20 'C          : 0.980038 g/cm3
The measuring error of the alcoholic fluid volume at T=20 'C   : - 0.045981 %
The measuring error of the alcohol volume 95,6 % at T=20 'C                : - 1.052184 %
==========================================================================================
```

Fig. 4Calculation resultsin text mode display

Additionally, the program allows an evolution analysis of the error value , as a result of detailing some graphic areas at the level of the previously established density chart resolution[1-3].

6. Conclusions

The ease of modifying entry data offered by the program based on the calculation algorithm elaborated by the author, allows the user to balance the influence of the admissible errors associated to the processed physical measurements over the admissible indication errors of the drum flowmeter and over its measuring uncertainties.

To this end, after the program's launch, the user cancels all the admissible errors associated to the processed measurements except the one whose balance must be assessed [11-13].

The subsequent execution of the program's subroutines allows the calculation of the values belonging to the absolute indication errors corresponding to the estimations of the alcohoolic liquid volume flow rate, to the total volume of alcoholic liquid and to the ethylic alcohol volume with a volume concentration of 95,6% , which materialises the balance of the respective admissible error over the measurement uncertainties specific to the drum flowmeter.

The designer's task is thus facilitated during the establishment of the technical performances level which the transducers belonging to the drum flowmeter have to fulfil so that its admissible relative indication errors can situate within the limits specific to the application in which it is used.

As a result, a means of measurement characterised by an optimal report between the quality of the performed measurements and the manufacturing expenses will be created, which, from an economic point of view, satisfies both the producer and its beneficiary.

REFERENCES

[1] OIML R 86:1989, Drum meters for alcohol and their supplementary devices.
[2] OIML R 117:1995, Measuring systems for liquids other than water.
[3] OIML R 117:2007-Part1, Measuring systems for liquids other than water.
[4] NML CEE-76/766, Tabele alcoolmetrice (Alcoholometric Tables).
[5] OIML R 22:1995, International Alcoholometric Tables.
[6] NTM-8-01-82: Folosirea alcoolmetrelor şi a tabelelor alcoolmetrice (The use of alcoholometers and alcohol tables). (in Romanian)
[7] SR Ghid ISO/CEI 99:2010 - Vocabular internațional de metrologie. Concepte fundamentale şi generale şi termeni asociați (VIM) (International vocabulary of metrology - Basic and general concepts and associated terms). (in Romanian)
[8] SR Ghid ISO/CEI 98-3:2010- Incertitudine de măsurare. Partea 3: Ghid pentru exprimarea incertitudinii de măsurare (Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement). (in Romanian)
[9] OIML G1-100:2008, Evaluation of measurement data - Guide to the expression of uncertainty in measurement.
[10] OIML G1-101:2008, Evaluation of measurement data - Supplement 1 to Guide to the expression of uncertainty in measurement.

[11] *Motit, H.M., Ciocirlea-Vasilescu, A.*, Debitmetrie industriala (Industrial flowmeters), Editura Tehnica, Bucuresti, 1988, (in Romanian)
[12] *Ciocirlea-Vasilescu, A.*, Metrologie industriala, vol.3 - Aplicatii in domeniul debite, (Industrial Metrology, vol.3 - Applications in the field of Flow rates) Editura Cvasidocumentatia & Printech s.r.l., Bucuresti, 2008. (in Romanian)
[13] *Motit, H.M.*, Contoare (Meters), Editura ARTECNO, Bucuresti, 1997. (in Romanian)