# DIGITAL LIBRARY OF BURNERS PROCESSE OF FAULTS OF THE BOILER

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Abstract: The digital library assists users by satisfying their needs and requirements for management, access, storage, and manipulation of information stored in the collections. In this paper will be created a faults library for the steam boiler, the accent being on the study of the burners. The paper propose the development of method based upon the existence of many models, each containing a fault and upon the existence of a model which reproduces the system correctly, without faults.

Keywords: Faults library, burners, steam boiler, protections, decisions.

## 1. INTRODUCTION

The concept of digital library appeared close to 1985 and is a library or an informing and documentation system which has electronic data collections and which uses informatics, automated procedures, for their exploitation. By introducing technology in the process of production and use of documents, the possibility for increasing productivity is created. In the Romanian specialty language, a more frequently concept is that of *digital library* (English term), which spreads in parallel with the terms of *electronic library* (concept derived from *electronic book*) and *virtual library*. Some Romanian authors have defined the *digital library* as a traditional library which provides the access to information and documents on a digital support, and others use this concept to define the "library without walls", the storage of information's and documents stored exclusively on digital support, accessible through electronic networks. The same tendency is met in the foreign literature, where William Saffady understand through *digital library* a *"collection of process able information by the computer or a storage for this information"* [Apud B., 1998], and also *"a library which keeps the whole collection or a substantial part of it into a process able form by the computer, as an alternative, as a supplement or a complement for printed and microfilmed traditional materials which in present dominate the library collections"* [Barber, D., 1996]. The method used in this paper is based upon the existence of many models, each containing a fault and upon the existence of a model which reproduces the system correctly, without faults.

### *1.1 Use and importance of the faults library.*

The most important effect of informatization of a library for the users it the possibility offered to them to consult the data bases of other libraries which sometimes are situated at distances of hundreds of kilometers.
The libraries are a component part of the research development through: creating internet public access points, creating multimedia centers in the libraries, access to a phenomenal mass of information.
The faults libraries allowes users fast access on digital support to information about types of possible faults which may appear in technological installations and in the automatization equipments, such as: faults of installations, faults of the transducers, faults of execution elements, faults of the automation equipments.
In this paper will be created a faults library for the steam boiler, the accent being on the study of the burners.

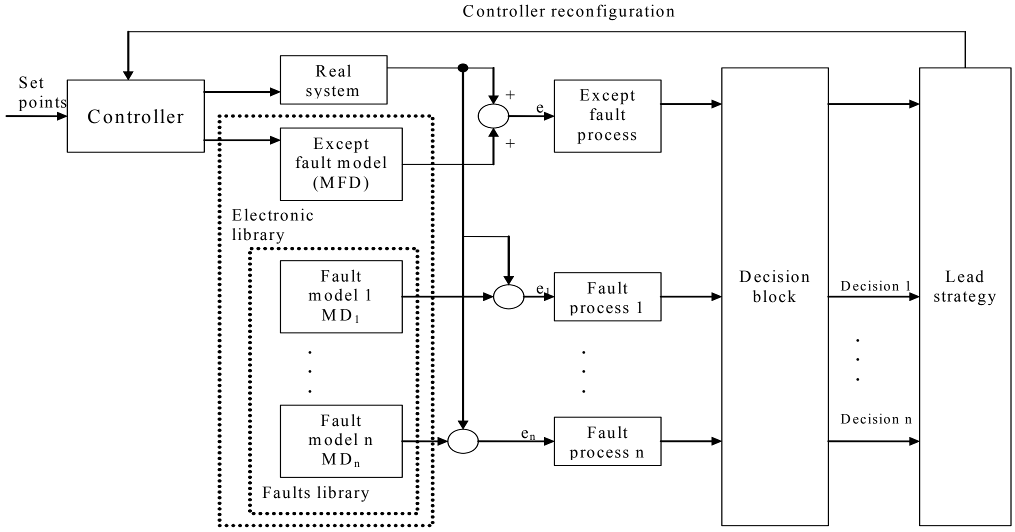


Fig.1. The structure of the detection and localization faults

The method used is based upon the existence of many models, each containing a fault and upon the existence of a model which reproduces the system correctly, without faults. The outputs of the real system are permanently compared with the outputs of the mathematical models and a decision block, resulting decisions regarding to the appeared faults.

## 2. THE ANALYSIS OF THE EXPLOATATION REQUIREMENTS AT BURNERS

The *fault* is a physical imperfection of an element of the system which leads to a permanent, temporary or intermittent wrong working. Abnormal working regimes are characterised through deviations from the normal schemes or through variations of the parameters outside established limits of normal working. Usually, outrunning these limits is preventively signaled, with two steps of preventive signals: attention signal (when outrunning the normal working domain) or alarming signal (when acceptable working limits have been outrun).

In this case, one must interfere through manual commands from the distance or automated commands. The dangerous working regimes are the ones which can lead to destroying the equipments or to accidents.

The events which influence in an unwanted way the working of the installations and which need intervention for remedy of the efficient staff or maintenance staff are called damages.

The protection function is the efficient function of the automated installations through which, in case a dangerous working regime appears in the termomechanical installation, is commanded automatically the brought of the installation in safety state, through stopping or isolating the equipments or though other commands, in order to prevent their damage.

The deterioration of one protection can lead to two ways of specific manifestations of the installation with stand-by working regime: *false operating* and *refuse to operate.*

Because false operating can lead at most to stopping the equipments, it is considered non-dangerous equipment, and the refuse to operate, which can lead to damages, is considered dangerous fault. It is recommended that the protection installations to have absolute independence compared to the rest of the automated installations, including the *signal transducers* and supply with electrical energy.

The command signals of the protections will act priority against all other signals came from other automated equipments.

### *2.1. Normal working conditions for the boiler.*

*The protection function of the boiler* is an efficient function within the control system through which, in case a dangerous working regime appears, the boiler is to be automatically brought into safety conditions by isolating the boiler on the combustion circuits (gas, coal) through closing the stopping devices of the burners (on gas, oil, or oil and gas) or through starting the back-up equipments. To start the boiler, both the water-steam circuit and the corresponding burned gases channels must work normally. *Normal working parameters of the water-steam circuit are within the following limits:* steam temperature after left/right vaporizer < MAX; left/right vivid steam temperature < MAX; water supply volume > MIN, temporized; steam temperature after left/right injection 3 < MAX; left/right intermediary steam temperature < MAX; ignition and cooling air pressure > MIN; not actioned stop button for damage; burned gases pressure in not dangerous limits; air pressure after RAP1 (rotating air preheater1) > MIN; air pressure after RAP2 (rotating air preheater2) > MIN; AV1 (Air Ventilator 1) or AV2(Air Ventilator 2) started; BGV1 (Burned Gases Ventilator 1) or BGV2 started.

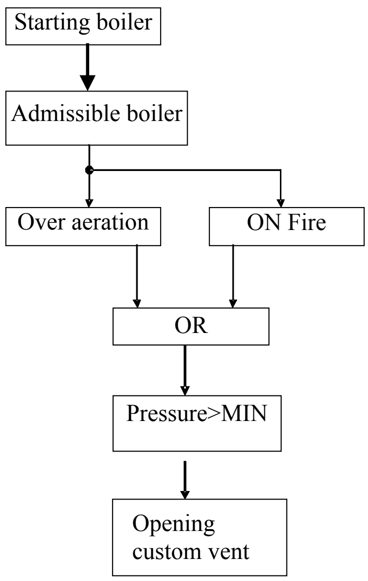


Fig.2. The organigram of the states

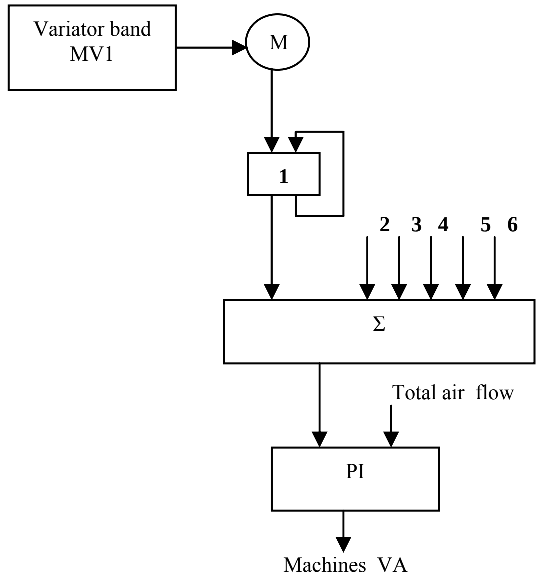


Fig.3. Adjusting the air-coal proportion

If one of the conditions above is not fulfilled, one of the following happens: stop of the mill (gringind machine); close of the energy supply; close of the general FCV (Fast Closing Ventils) for gas; close of the gas/fuel oil FCVs at all burners. Starting the fuel oil and gas boiler needs the following conditions to be fulfilled: allowance of boiler; finished ventilation or burning fire; command air pressure > MIN. If one of the above is not fulfilled: the general gas FCV closes; the general fuel oil FCV closes; the gas/fuel oil FCVs of all burners will close.
Starting on fuel oil needs the following conditions to be fulfilled: allowance of fuel; fuel oil pressure > MIN; button for stop in case of damage at fuel oil not actioned.
In the organigram below, these aspects can be observed (fig.2).
If one of the above is not fulfilled: the general fuel oil FCV closes; the fuel oil FCV-s of all burners close. A protection action is also the action of reducing the task of the boiler in case of unleashing an air or gas ventilator, at stopping of a RAP, or ar unleashing turbine or generator, signal elaborated by the protection system being transmitted to the task regulator of the boiler.
The interne perturbations, considered to be the most important, are the qualitative variations of the fuel, which determine variations of the steam's parameters because the time constants of the burning process modify and because the optimal fuel/air proportion modifies, which means the necessity to connect at least the fuel and air adjustment loops.

*2.2. Adjusting the air-coal proportion.*

At the working of the coal burner, adjusting the burning air volume is made globally, for the entire boiler, by activating the directing devices of the VA. The automated adjustment of the burning air volume is to be made proportionally with the coal volume introduced in the boiler (revolution movement of the supply bands).
The automated adjustment of the burning air volume is to be made proportionally with the coal volume introduced in the boiler (revolution movement of the supply bands). The revolution signal from each coal supply band is past through a delay circuit which considers the gathering phenomenon's which happen inside the mill and then is introduces into a sum device.
The output signal from the sum device will be compared to the total air volume introduced in the boiler to be burned, measured with the help of the belts' tubes and will be processed by the air volume regulator, which will finally command the directional devices of the VA. No matter the type of boiler or the working scheme, the protection of the boiler determines the disconnection of the fuel supply of the boiler's burning point.
This thing is possible by stopping the coal mills and of the gas and fuel oil burners. To avoid the situations that can lead to detonations in the burning point or even explosions which can lead to damaging the boiler, there must be a correct burning at the burners.
*For a correct working and to avoid explosions, the working of the boiler won't be allowed when a part of the adjustment installation for the burning process is working automated (for example fuel supply) and the other part works on manually (air supply).*

*2.3. Protections which determine disarming the general gas FCPs.*

Protections which determines the disarm of the general gas FCVs are: minimal air fuel pressure; minimal air action pressure; minimal gas fuel pressure; both air or gas ventilators stopped; minimum water supply volume (with temporization);

damage button for burners (in the boiler hall); damage button "extinguish fire" (in the control room); these protections is prescribed to command also the start of the main and pilot burners.
The fuel oil burners will stop in the following situations: general fuel oil FCV closed; low pressure of the fuel oil on the burners group (with temporization); no flame; minimal air fuel pressure; minimal air action pressure; injector ins't introduced; both air or gas ventilators stopped; minimal volume of water supply (with temporization); damage button for burners (in boilers hall); damage button "extinguish fire" (in the command room).

*2.4. Stopping the coal mills.*

Stopping the coal mills through protection may happen in the following situations: - both air or gas ventilators stopped; minimum water supply volume (with temporization); damage button (for each mill - near the aggregate); damage button "extinguish fire" (in the command room); engine electrical protection; high temperature in the mill's separator (with temporization); low oil pressure after cooler (with temporization); maximal oil temperature at the adjustable couple; maximal oil temperature in bearings; adjustable couple in position > 0 and low revolution of the mill (with temporization).
In case of the fuel oil burners the circuit for blow off steam and pulverize fuel oil is checked and put to work; the use only of the tested and checked injectors is forbidden; working of the fuel oil injectors without introducing air into the burner is also forbidden; working of the fuel oil injectors without introducing pulverization fluid is forbidden (for those with auxiliary fluid); the scheme of bringing steam to the injectors must exclude entering of the fuel oil in the steam pipe, the parameters (temperature, pressure) of the fuel oil and pulverization steam must be between values established by instructions.
At the 1035t/h boiler, the coal is burned as dust. The prepation the coal dust is made with the help of 6 mills, combined with hammers and ventilator. The supply with coal of each mill is made with the help of belt suppliers which are placed under the coal bunkers and can be isolated from them tith the help of some sibere, manually drove with wheel and chain.
The variation of the coal volume at the mill is done by variation of the supplier speed with the help of a chain variator. The supplier may isolate itself by the mill to be able to make repairs with the help of some manual shutter. Drying of the coal is made with the help of the burned gases inhaled from the burning point.
The inhaled burned gases from the burning point, together with induced primary hot air for adjustment of the temperature at mill's output, is also the transportation environment for the coal dust.
On the main air channel is mounted an adjustable (manually or automated) shutter.
In case the temperature exceeds 180°C at mill's output, the hot air (primary) shutter is completely opened and in the mill is induced cold atmospheric air.
On the mill's breathe in path there is a manual siber, with which the mill can isolate itself for repairs. The 6 mills of the boiler and the dusted coal burners that go with them are placed in such a way around the boiler that their axels are tangent to an imaginary circle with a 1500 mm, with the center in the center of the burning point.
At the start of the mill there are the following blockings (allowances):
- the hydraulic couple in position S=0, this thing being necessary to ensure the idly start of the electric engine;
- the pressure of the lubricating oil at the reductor higher than 1,0 bar - allowance to start from the boiler's protection.

Starting through protection the mill takes place if one of the situations below exists: pressure of the lubricating oil after the cooler is lower than a bar (with a temporization of 20s); vibrations of the mill's bearings higher than 200um (with a temporization of 10s); revolution of the mill lower or equal with 370 rot/min and the hydraulic couple not closed, with temporization 400s at start; with temporization 10s in working; temperature at the mill's separator higher than 200$^{o}$C (temporization 60s); temperature of the output oil for the hydraulic couple higher than 110$^{o}$C; boiler protection.
No matter we talk about a natural circulation boiler or about a forced crossing one, generally *the task adjustment loop* follows to maintain constant the steam pressure at the boiler's output, modifying the fuel quantity and the air for burning volume.

## 3. ADJUSTING THE FUEL VOLUME

*3.1. Loop control diagram.*

For the boilers which work on *fuel oil*, we use a *cascade loop control*, which contains a main task regulator (*PID* type) and a fuel regulator (*PI type*) in following loop. The stability of the loop may be increased by introducing in the adjustment the steam volume signal as a perturbation. It is observed that in this case, the quantity of coal is represented by the sum of revolutions of the redler belts. *The execution elements* are revolution variators of the belts (which may be frequency converters or mechanical variators for revolution) and the shutter for the gas volume adjuster. These are commanded through some proportional regulators. The main task regulator (*PID steam pressure regulator*) and the volume of steam took over from the turbine establish a reference value for the fuel quantity (gas + coal), which is then compared to the sum of gas and coal volumes, and the obtained signal is introduced in the fuel regulator which will determine increase or decrease of the fire power of the boiler.

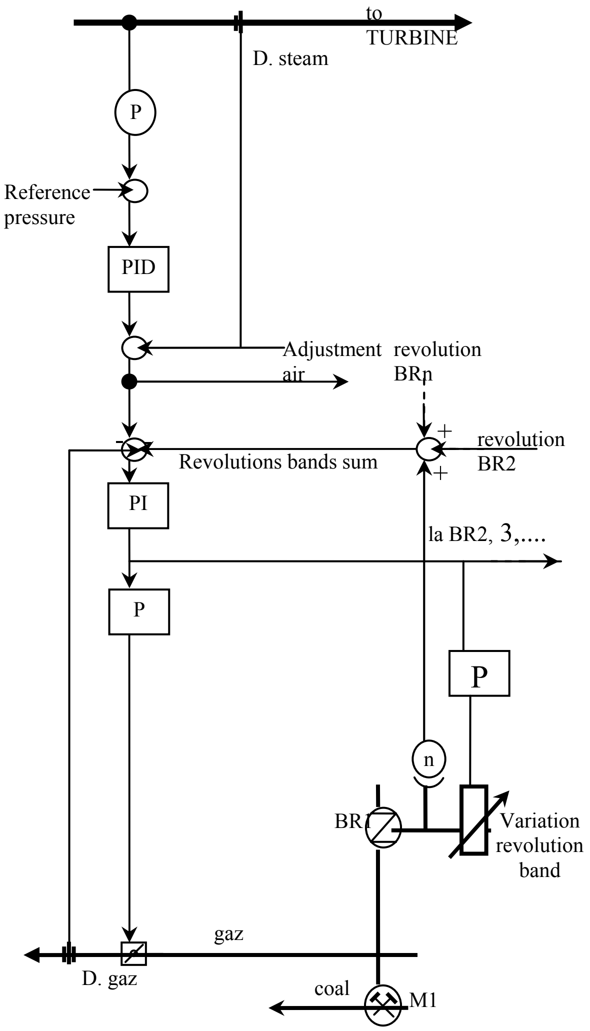


Fig.5. Loop of the regulation in waterfall from boiler in gases and coal

*3.2. The mathematical model of the automated process.*

The following equations are deduced from the material evaluation and thermo evaluation:

- the transfer function for the transporting belt:

$$H_{BT} = e^{-\tau_b s} = \frac{B_M}{B_B}, \ \tau_b = \frac{l_B}{v_B} \qquad (1)$$

- the equation of the coal mass:

$$m_B(t) = \frac{V_M \cdot C_B}{g_2} \cdot B_2(t) \qquad (2)$$

- Applying the Laplace transformation, it results through simple transformations the transfer function of the coal mill:

$$H_M = \frac{1}{T_M s + 1} = \frac{B(s)}{B_M(s)} \qquad (3)$$

The equations of the vaporization process:

- equation of the thermo evaluation for the burning point zone (4):

$$\rho_g C_g V_g \frac{d\theta_g}{dt} = k_G \cdot D_G + k_C \cdot B_C + \rho_A C_A \theta_A A -$$
$$- \rho_g C_g \theta_g G_e - h_{gF} S_{gF} (\theta_g - \theta_F) - a S_{gF} \theta_f^4$$

where: $B_C$ - Coal volume, $D_G$ - gas volume, A – air volume to be introduced in the mill and burned, $\theta_A$ – temperature of the air for burning at entrance, $G_e$ – volume of burned gas evacuated from the burning point, $\theta_g$ – temperature of the burning gases, $\theta_F$ – temperature of the boiler's pipes, $\theta_f$ – temperature of the flame, $h_{gF}$ – coefficient for heat exchange between the burning gases and the metal of tie burner's pipes, $S_{gF}$ – surface through which the heat exchange takes place, a – coefficient for heat exchange through radiation, ρ - density, and C is the specific heat.

The evaluation equation for the boiler's pipes (5):

$$\rho_F C_F V_F \frac{d\theta_F}{dt} = h_{gF} S_{gF} (\theta_g - \theta_F) +$$
$$a S_{gF} \theta_f^4 - h_{FW} S_{FW} (\theta_F - \theta_W)$$

The thermo evaluation equation for the vaporization zone (6):

$$\rho_W C_W V_W \frac{d\theta_W}{dt} = h_{FW} S_{FW} (\theta_F - \theta_W) +$$
$$\rho_{iW} * C_{iW} \theta_{iW} Q_{iW} - \rho_{eW} C_{eW} \theta_{eW} Q_{eW}$$

The equations are not linear, so for the projection of the real system, the following simplified block diagram will be used, with the coefficient values: $T_g$=10 s, $T_f$=30s, Tw=50s, $\tau = 10s$

## 4. EXPERIMENTAL RESULTS

*Possible faults that may appear during burning* process: variation of the caloric power of the fuel which appears in the mathematical model, meaning equation (4) through factor $k_G$, and in the block diagram $k_{G1}$ and variation of the heat transfer coefficient through convection and radiation which appears in equations (4), (5) and (6) through the terms $h_{gF}$, $h_{FW}$ , and in the block diagram $k_{g5}$ , $k_{F2}$ and $k_{DF}$. The response forms at a step input of the fuel flow in normal conditions (with predetermined coefficients) and in different possible faults are illustrated in the following figures. In figure 7 is presented variation fuel flow in normal conditions. In this case the heat transfer coefficients have the predetermined values. In the figures 8 and 9 is presented the response of the processe with the convection heat transfer coefficients decreased with 25% and respectvely 50%. This situation of the decreased heat transfer coefficients correspond at the incomplete burnerd of the fuel.

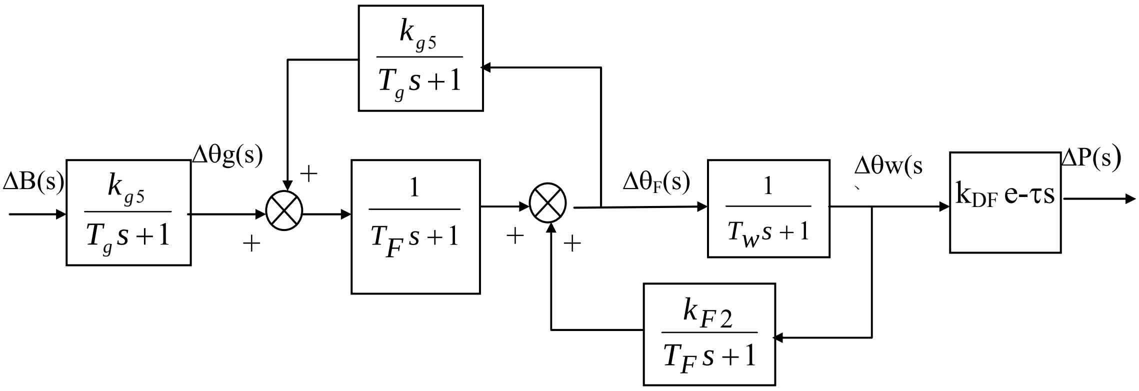


Fig.6. The block diagram

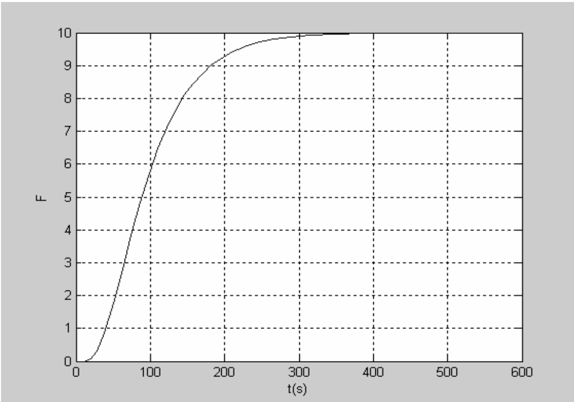


Fig.7. Variation fuel flow in normal conditions

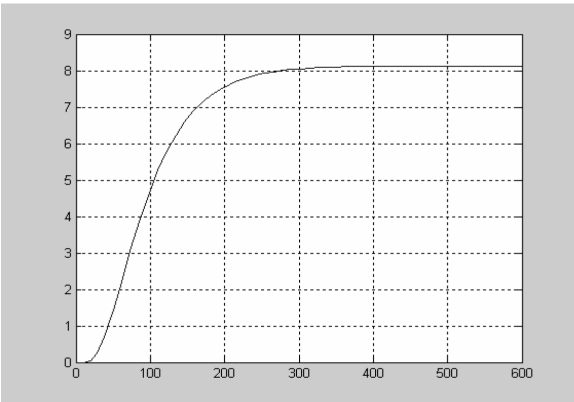

Fig.8. Variation fuel flow in first condition

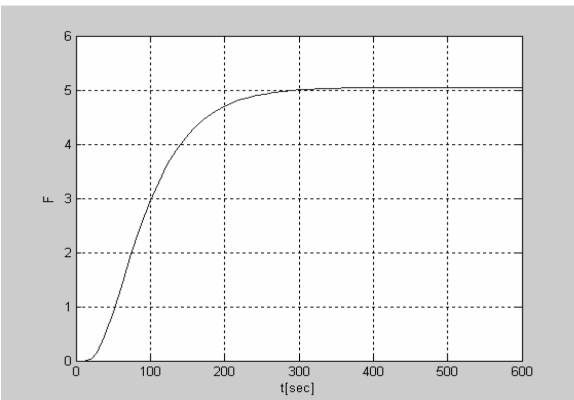


Fig.9. Variation fuel flow in second condition

## 5. CONCLUSIONS

The faults libraries created allow fast access on digital support to information about types of possible faults which may appear in technological installations and in the automatization equipments, such as: faults of installations, faults of the transducers, faults of execution elements, faults of the automation equipments. The method used is this paper based upon the existence of many models, each containing a fault and upon the existence of a model which reproduces the system correctly, without faults. The outputs of the real system are permanently compared with the outputs of the mathematical models and a decision block, resulting decisions regarding to appeared faults.

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