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SOFTWARE FOR COMPUTING OF THE HYDRAULIC TURBINES CHARACTERISTICS

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ABSTRACT

The paper presents a Visual Basic software for computing of the turbines characteristics, based on spline curves generated by cubic polynomial function [1]. In a descriptive manner, there are presented the possibilities of the software: interface, menus, type of characteristics, tools, outputs, etc.

KEYWORDS

Software, turbine, characteristics, Visual Basic.

NOMENCLATURE

P_G – output power [MW]
η_{PL} – efficiency [%]
Q_P – turbine discharge [m³/s]
Q_o – turbine discharge at no load regime [m³/s]
H – turbine head [m]
α - wicket gates opening [deg]
β - runner opening [deg]
q – specific turbine discharge [m^3/kw.h]

1. INTRODUCTION

The world of hydraulic turbines is based on the energetical and cavitational characteristics, obtained by laboratory measurements and applied to the industrial prototype. The manual drawing of these characteristics is a long and, sometimes, subjective process. A particular software will increase the speed and the quality of the process. The original software was created in Visual Basic language and named **PrelDate**.

2. THE PRELDATE MAIN MENU

Figure 1 shows the **PrelDate** main menu. The option „**Date primare**" is reserved for the graphical and numerical representation of primary data. The option „**Caracteristici**" is reserved for the computing of the turbine characteristics.

The option „**Diagrama de exploatare**" offer tools for analysis of the turbine hill chart. The user preferences can be setup by the „**Preferinte**" option.

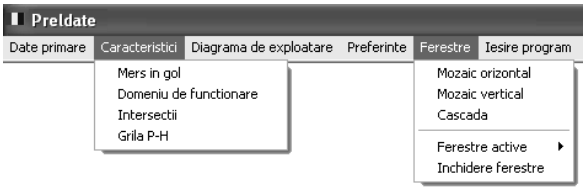

Figure 1. The **PrelDate** main menu

3. THE PRIMARY DATA

For the software **PrelDate** the primary data is grouped in curves with P_G as parameter, which include the following points: P_G, η_{PL}, Q_P, H, α, β.

Figure 2 shows the interface for primary data option of the software. For primary data the software **PrelDate** can draw the following curves: $\eta_{PL}=f(Q_P)$, $H=f(Q_P)$, $\alpha=f(Q_P)$, $\beta=f(Q_P)$, $q=f(Q_P)$, $\eta_{PL}=f(H)$, $Q_P=f(H)$, $\alpha=f(H)$, $\beta=f(H)$, $q=f(H)$, $\eta_{PL}=f(\alpha)$, $\eta_{PL}=f(\beta)$, $\alpha=f(\beta)$, with P_G as parameter. The primary data points can be exported to Excel or HTML file.

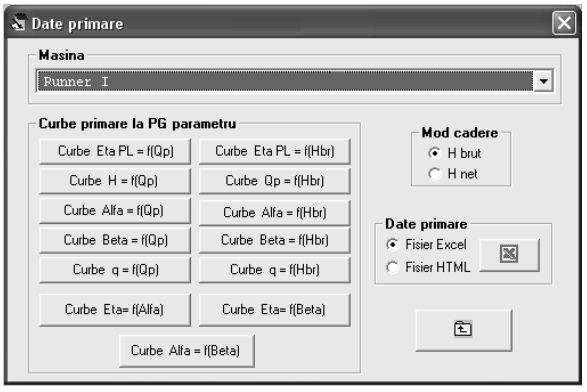

Figure 2. The interface for primary data

The software can select the type of the runner (machine) from list „**Masina"**.

From option button „**Mod cadere”** the software can select the type of the head.

Figure 3 shows an example for curves H = f(Q_P) for P_G as parameter.

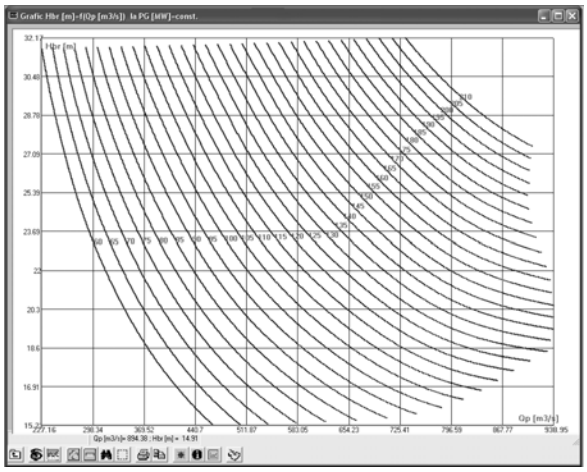

Figure 3. Curves H = f(Q_P) for P_G as parameter

Figure 4 shows an example for curves η_{PL}= f(H) for PG as parameter.

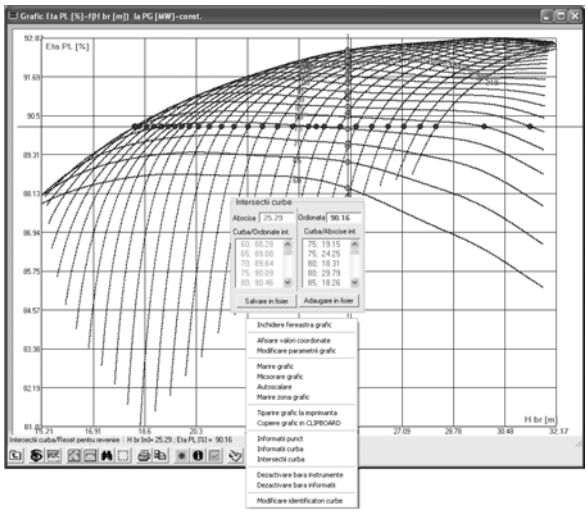

Figure 4. Curves η_{PL} = f(H) for P_G as parameter
Tools for graphic analysis

As a primary data, the software require also the following inputs:

- the no load regime curve Q_o=f(H), as a numerical input with (H,Q) coordinates;
- the functional domain curves Q_o=f(H), as a numerical input with (H,Q) coordinates;
- the graphical image of hill chart.

All primary data must be specified for every runner/machine included for the software.

4. TOOLS FOR GRAPHIC ANALYSIS

For every graphic generated by **PrelDate**, at the bottom of the window area is placed a toolbar with command buttons marked with specific icons, figure 4. The software **PrelDate** offer a popup menu, by right mouse click in the graphic area, with the same options like the command buttons.

The function of command buttons are:


Close the graphic window


View the table of primary data coordinates


Tool for modifying graphic parameters: width and colors of curves, the visibility and colors of the markers, the identification numbers of the points, the width, color of axes, the name and color of labels, the limits of grid, the decimals number, etc.


Zoom In


Zoom Out


Auto Zoom (Fit)


Zoom Area


Print the graphic


Copy graphic to clipboard


Info graphic points


Info curves points (intermediary points between graphic points)


Intersection of curves


Modify the curves label position

The „**Intersection of curves”** option is very powerfull: with a single mouse click, the software calculate the intersection off all curves from graphic area with the X and Y value of click point. This intersections points are marked with circles in the graphic area and the intersections coordinates are listed in a reserved window, named „**Intersectii/Curbe**”, which contain two text area, named „**Abscisa**” and „**Ordonata**” reserved for the manual input of X and/or Y value of intersection point. It is also possible to save the intersections coordinates to a file or added to an existing file.

The **Status Bar**, positioned on the bottom of graphic area, inform the user about the current command and current coordinate point.

5. THE OPTION MENU "CARACTERISTICI"

The option menu „**Caracteristici**" include a submenu with four option, figure 1:

Mers in gol	No load regime
Domeniu de functionare	The functional domain
Intersectii	Intersection
Grila P-H	P-H grille

5.1. The option „Mers in gol"

Figure 5 shows the interface for no load regime curve Q_o=f(H). **PrelDate** can divide this curve into points for a interval defined by H_{min}…H_{max} values with step **Pas H**.

It is also possible to view the curve Q_o=f(H), with a mouse click on the button „**Curba Q_o=f(H)**". The divided points can be exported to Excel, HTML or text file.

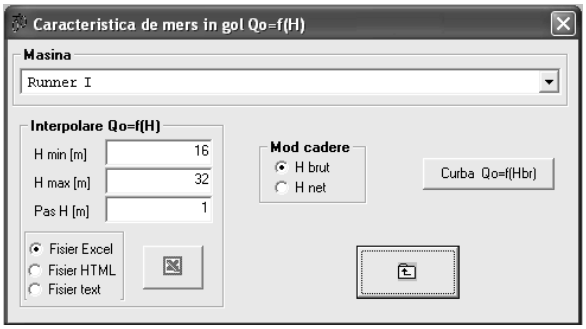

Figure 5. The interface for option „**Mers in gol**"

5.2. The option „Domeniu de functionare"

Figure 6 shows the interface for the functional domain. For every H of the interval defined by H_{min}…H_{max} values with step **Pas H**, **PrelDate** will calculate the following values: H, Q_o, $P_{G\ min}$, $Q_{P\ min}$, $q_{\ min}$, $\eta_{\ PL\ min}$, $P_{G\ opt}$, $Q_{P\ opt}$, q_{opt}, $\eta_{\ PL\ opt}$, $P_{G\ max}$, $Q_{P\ max}$, $q_{\ max}$, $\eta_{\ PL\ max}$, where „min" and „max" represents the minimal/maximal values for intersections of the functional domain curves with every H of the interval. The „opt" reference is associated with the optimal values for every H of the interval.

All these points can be exported to Excel, HTML or text file.

With a mouse click on the button „**Curbe domeniu de functionare**" the user can view only the functional domain curves H = f(Q_P) or the functional domain curves overwrite with curves H = f(Q_P) for P_G as parameter and Q_o=f(H), figure 7, for a mouse click on the button „**Curbe domeniu+PG=ct.+ Qo**".

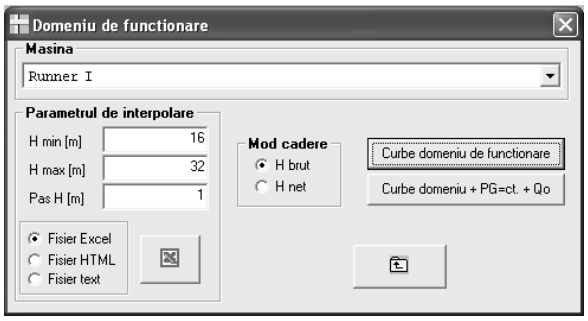

Figure 6. The interface for option „**Domeniu de functionare**"

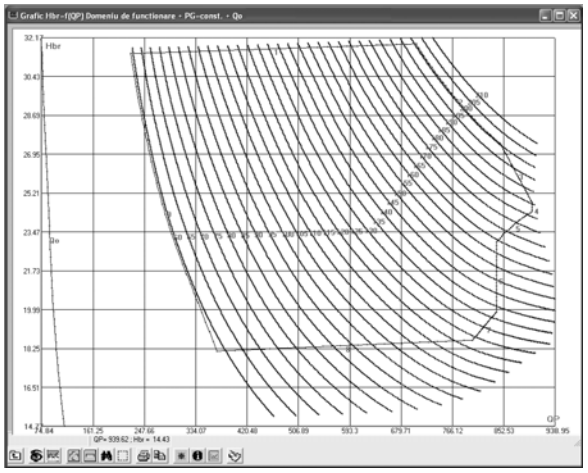

Figure 7. The functional domain curves overwrite with H=f(Q_P) for P_G as parameter and Q_o=f(H)

5.3. The option „Intersectii"

Figure 8 shows the interface for the option menu „**Intersectii**". **PrelDate** will calculate the intersection curves between the hill chart diagram and the intersection parameter, which can be: head „**Cadere**", discharge „**Debit**", power „**Putere**", wicket gates opening „**Alfa**", runner opening „**Beta**". The numerical results can be exported to Excel, HTML or text file.

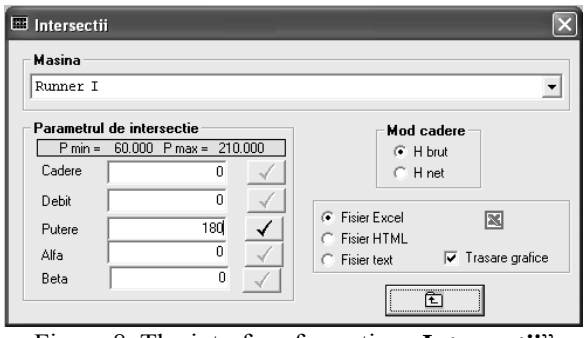

Figure 8. The interface for option „**Intersectii**"

Figure 9 shows an example of curves obtained for power intersection with value 180 MW.

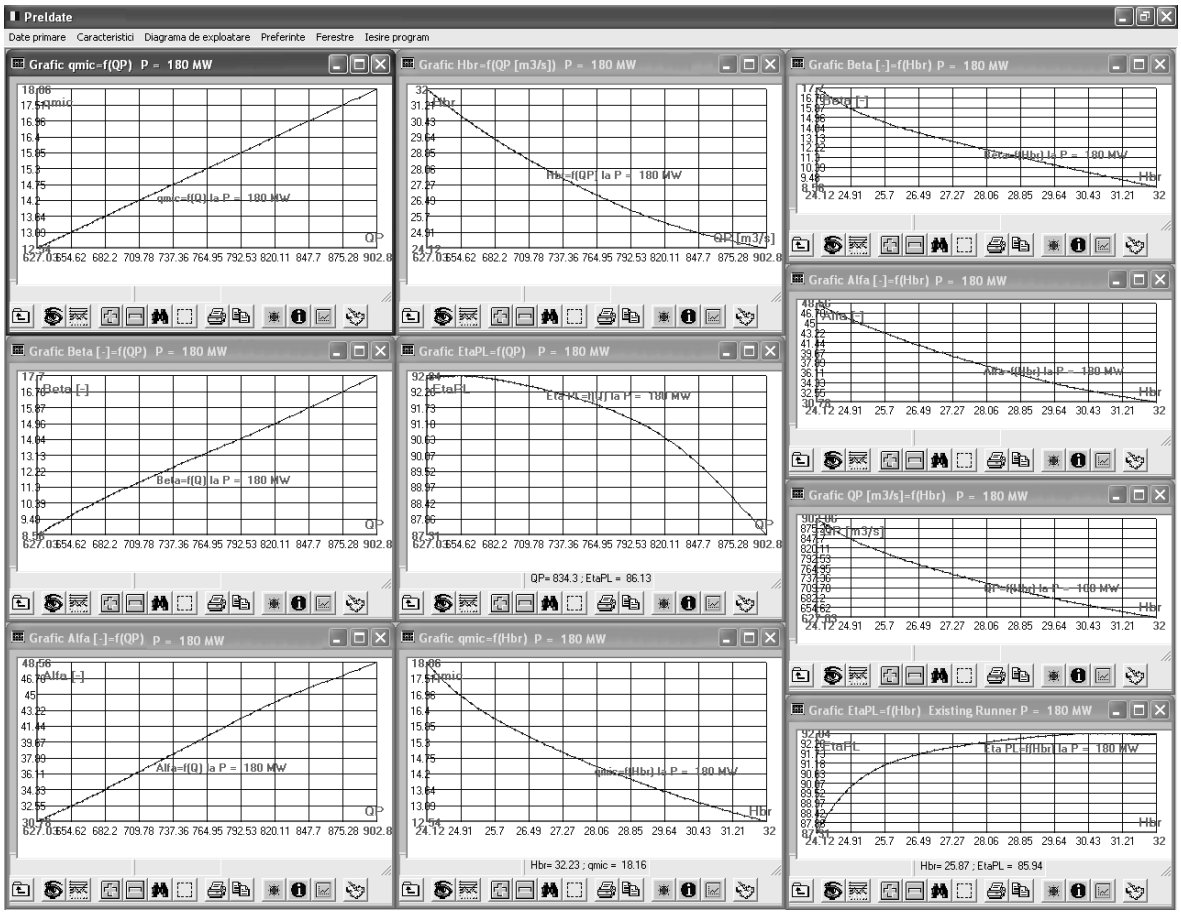

Figure 9. Curves obtained for power intersection parameter with value 180 MW

For head intersection parameter the software will compute the following curves: $\eta_{PL}=f(Qp)$, $P_G=f(Qp)$, $\alpha=f(Qp)$, $\beta=f(Qp)$, $q_{mic}=f(Qp)$, $\eta_{PL}=f(P_G)$, $Qp=f(P_G)$, $\alpha=f(P_G)$, $\beta=f(P_G)$, $q_{mic}=f(P_G)$.

For discharge intersection parameter the software will compute the following curves: $\eta_{PL}=f(H)$, $P_G=f(H)$, $\alpha=f(H)$, $\beta=f(H)$, $q_{mic}=f(H)$, $\eta_{PL}=f(P_G)$, $H=f(P_G)$, $\alpha=f(P_G)$, $\beta=f(P_G)$, $q_{mic}=f(P_G)$.

For power intersection parameter the software will compute the following curves: $\eta_{PL}=f(H)$, $P_G=f(H)$, $\alpha=f(H)$, $\beta=f(H)$, $q_{mic}=f(H)$, Eta PL=f(Qp), $H=f(Qp)$, $\alpha=f(Qp)$, $\beta=f(Qp)$, $q_{mic}=f(Qp)$.

For wicket gates opening intersection parameter the software will compute the following curves: $\eta_{PL}=f(H)$, $Qp=f(H)$, $P_G=f(H)$, $\beta=f(H)$, $q_{mic}=f(H)$, $\eta_{PL}=f(Qp)$, $H=f(Qp)$, $P_G=f(Qp)$, $\beta=f(Qp)$, $q_{mic}=f(Qp)$.

For runner opening intersection parameter the software will compute the following curves: $\eta_{PL}=f(H)$, $Qp=f(H)$, $P_G=f(H)$, $\alpha=f(H)$, $q_{mic}=f(H)$, $\eta_{PL}=f(Qp)$, $H=f(Qp)$, $P_G=f(Qp)$, $\alpha=f(Qp)$, $q_{mic}=f(Qp)$.

5.4. The option „Grila P-H”

Figure 10 shows the interface for the option menu „**Grila P-H**”. For this option, **PrelDate** will calculate the intersection points between parameters head and power, in the interval defined by $H_{min}…H_{max}$ values with step **Pas H** for head parameter and the interval defined by $P_{min}…P_{max}$ values with step **Pas P** for power parameter.

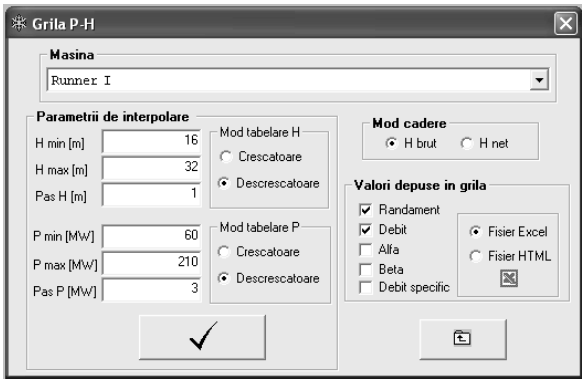

Figure 10. The interface for option „**Grila P-H**”

For every intersection point the software will calculate the values of efficiency η_{PL}, discharge Qp, wicket gates opening α, runner opening β and/or specific turbine discharge q_{mic}.

The numerical results can be exported to Excel or HTML file. The option buttons „**Mod tabelare H**" and „**Mod tabelare P**" will impose the ascending or descending order of intersection points of parameters head and power.

6. THE OPTION MENU "DIAGRAMA DE EXPLOATARE"

Figure 11 shows the interface for the option menu „**Grila P-H**", which include the following sections:

- section (a) – the hill chart area H=f(Qp);
- section (b) – include text controls for head „**H [m]**", discharge „**QP [m3/s]**", power „**PG [MW]**", efficiency „**η [%]**", wicket gates opening „**α [–]**", runner opening „**β [–]**" and specific turbine discharge „**q [m³/kw.h]"**; the function of the text controls is to show the calculated value of parameter or to impose the value for intersection with the hill chart graphic;
- section (c) – include four buttons for export numerical results to Excel or HTML file, delete the calculated point in the hill chart area and close the graphic window;
- section (d) – is a list control filled with the following numerical values: H, Q_P, P_G, η_{PL}, α, β, q, for every calculated point in the hill chart area;
- section (e) – is a text area filled with the following numerical values: H, Q_P, P_G, η_{PL}, α, β, q, for the every calculated point in the hill chart area, shown when the cursor mouse move over the point.

In figure 11 is exemplified the calculated points for P_G=182 MW („h" reference).

In the same figure is exemplified the calculated points for η_{PL}=91 % („f" reference) and the optimal values of efficiency for H domain of the hill chart („g" reference).

Calculated point in the hill chart area and associated numerical values can be obtained with the following methods:

- click mouse in the hill chart area – which will get the mouse coordinate (H, Qp) from the hill chart area and will transmit calculated numerical values to text controls of section (b) and to the list of section (d);
- by input value in one of the text control head „**H [m]**", discharge „**QP [m3/s]**", power „**PG [MW]**", efficiency „**η_{PL} [%]**", wicket gates opening „**α [–]**", runner opening „**β [–]**" – will generate the intersection curve between the parameter with the hill chart area and will transmit calculated values to

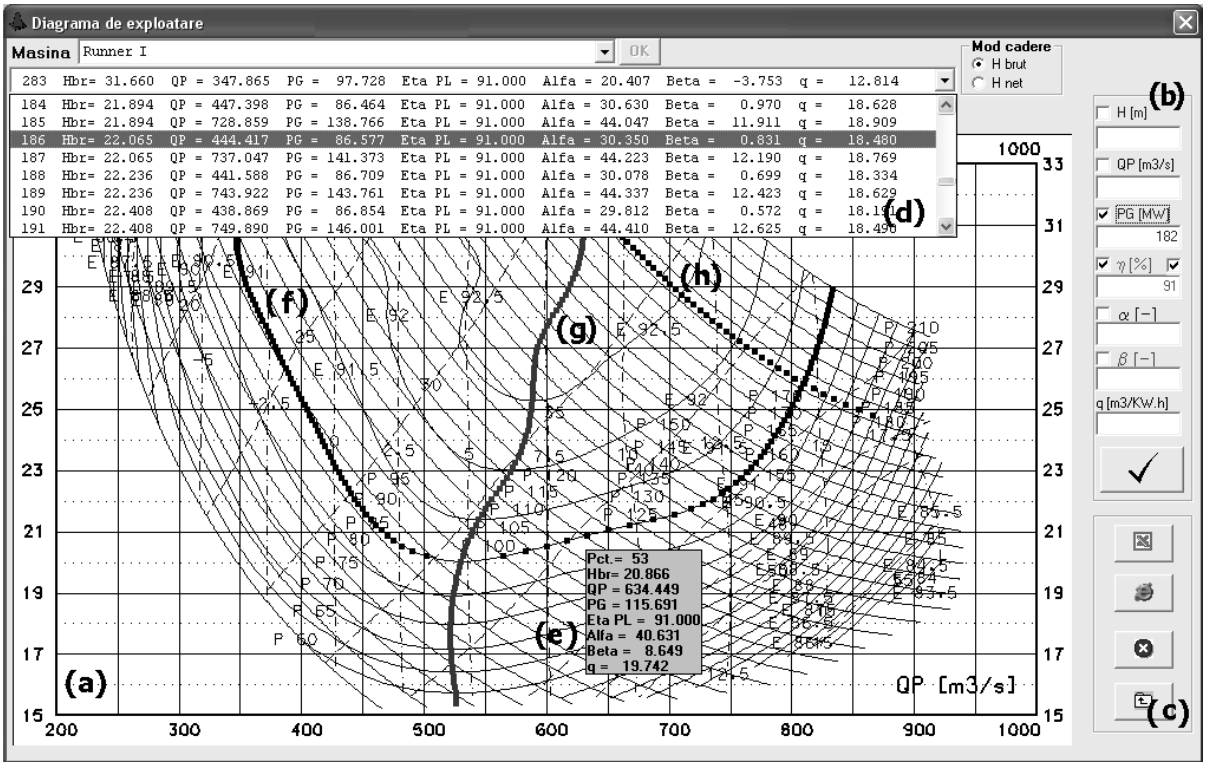

Figure 11. The interface for option „**Diagrama de exploatare**"

the list of section (d);

- by input value in two of the pairs text control head „**H [m]**" and discharge „**QP [m3/s]**", head „**H [m]**" and power „**PG [MW]**", discharge „**QP [m3/s]**" and power „**PG [MW]**" or wicket gates opening „**α [–]**" and runner opening „**β [–]**" - will generate the intersection point between two intersection parameters and will transmit calculated numerical values to the list of section (d).

Calculated points will be marked with circle in the hill chart area.

If the user select another runner/machine from list „**Masina"**, the hill chart area will be updated with the correspondent graphical image and all previous calculated point will be deleted.

7. THE OPTION MENU "PREFERINTE"

Figure 12 shows the interface for the option menu „**Grila P-H**", which include the following options:

- **Nr.puncte** – the number of interpolation between the interval of $H_{min}…H_{max}$;

- control **Activare** – which will activate the limits imposed in the text controls H_{min} and H_{max} ; so, the H interpolation values will be generated between the limits $H_{min}…H_{max}$ with step **Pas H** instead of the H values generated by the control **Nr. Puncte**;

- **Factor zoom** – will impose the zoom factor in hill chart area, between limits 2…6;

- **Marime marcatori puncte** – will impose the size of circle for calculated points in hill chart area, between limits 2…9;

- **Director program** – inform the user about the software folder;

- **Director date program** – inform the user about the primary data folder;

- **Director salvare fisiere** – inform the user about the saving results folder and offer the possibility to select the drive / folder for saving results.

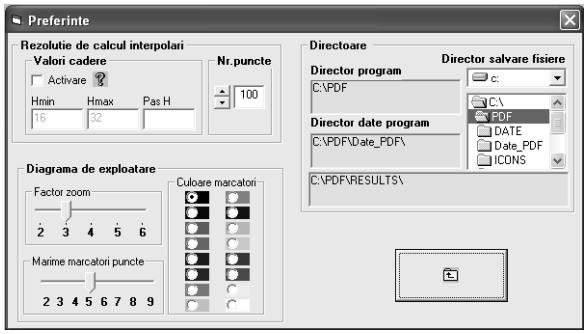

Figure 12. The interface for option „**Preferinte**"

8. THE OPTION MENU "FERESTRE"

This option include a submenu for arrange the windows in horizontal / vertical tiled or cascade windows. Also, the submenu offer the possibility to show the list of active windows or close windows.

9. CONCLUSIONS

The present paper describe the software **PrelDate**, a complex software for computing of the hydraulic turbines characteristics, based on spline curves generated by cubic polynomial function. The results of the software consist in graphical curves and numerical results which can be exported to Excel, HTML or text files.

Due to the possibility of selecting the type of the runner (machine) from list „**Masina"**, the software can manage a library of hydraulic turbines characteristics.

With minimal modifications, the software **PrelDate** can be applied for other turbomachines characteristics.

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