Development of Software for Calculation of Waste Materials in Graphic Industry

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Abstract. Graphic industry is well known for producing a large amount of waste both during the production process as well as after using certain graphic products. The major issue is that this waste consists of various components: printing paper, colors and varnishes, isopropyl alcohol and oil compounds, as well as other, more or less damaging and dangerous chemical substances. The first step towards solving this problem is to calculate the amount of waste which will appear at the end. However, it is observed that there is no program for precise calculation of this waste material which could substantially facilitate its prediction although printing houses do have the waste material data. Based on this information, we have developed the first software for calculating not only the amount, but also the types of different waste during the process of preparation, printing and finishing according to the input data, such as paper consumption and printing technique. Thus it is possible to predict the capacity of waste management. The software was developed in the integrated development environment of the Microsoft Visual Studio, in the programming language Visual C#. Application of this software significantly speeds up the process of calculating waste materials in the graphic industry, which has been proven in one large printing house that has precise values of the waste materials for the previous year. By comparing the obtained values in the software with the real values of the waste material in the analyzed printing house, it is evident that the developed model provides rather precise data on the amount of waste material in the graphic industry.

Keywords: graphic industry, waste, software, calculation waste.

1. Introduction

While conducting the thorough research on waste material in the graphic industry and its literature, the authors have not discovered any work on the development of the software for calculating the waste material in printing presses based on paper consumption. This work is based on a developed private mathematical model (Savić, 2015), which can calculate the amount of waste at the end of the process on the basis of the input data (paper consumption). Since this model is not easily applicable due to the complex calculation, a simple software based on this model has been developed in order to speed up the calculation process. In order to test the model and the software in practice, the largest printing house on the territory of Serbia which deals with offset printing will be analyzed here. The values of the input material, as well as the values of the waste material will be measured and the deviations calculated by applying the model will be given.

The most common waste materials in offset printing which can be calculated in this way are: printing paper, colors and varnishes, isopropyl alcohol and oil compounds. The wide range of chemical substances used in graphic industry requires special calculation of: the colors based on organic solvents, heat set colors in offset printing, machine washing agents, moistening solution in offset printing. Isopropyl alcohol is used in offset printing as an agent for moistening the rollers, whereas oil derivatives with a very low flash point are used for washing parts of the equipment.

This calculation is necessary because volatile compounds have significant influence on the environment, primarily on the atmosphere. From a local point of view, this is formation of toxic compounds. Toxic effects of organic solvents in people can cause a coma and respiratory disorders, irritation of mucous membrane and eyes, gastritis, hypotension, cardio depression, brain, liver and kidney damage at a later stage.

By obtaining precise calculation, printing houses could have data on planning their waste management, whereas locally, the plant capacity could be determined.

2. Development of the software for determining the amount of waste

Having in mind that calculations of the amount of waste in the graphic industry are often very complex, we have had an idea to develop a software with the help of which the application of the model could be much easier. The software was developed in the integrated development

environment of the Microsoft Visual Studio, in the programming language Visual C#.

2.1 Paper consumption

The starting point is the final equation of the waste paper (Savić, 2015):

$$D = N_p \cdot [10 \cdot A + 19 \cdot B + n_p(a + b) \cdot 6 + f \cdot A \cdot B] + + t_a \cdot A \cdot B \cdot s \cdot d \quad (1)$$

Where:

- A is press sheet width,
- B is press sheet length,
- n_p represents number of sheets in a press sheet,
- a is page length,
- b is page width,
- t_a represents waste press sheets in preparing the machine, to be read according to the type of the machine and the complexity of work (The values of t_a are presented in Table 1.),
- s is number of shifts (tasks) on the machine,
- d is number of work days,
- f represents percentage of waste material in the press sheets, to be read from Table 2.

Table 1. T_a values depending on multiple factors, obtained experimentally

Machine	t_a in press sheets
Monochrome	50–100 (per color - pass)
Two-color	50–100 (per pass)
Four-color	150–250

Table 2. F values depending on machine structure and number of proofs (BPIF, 2012)

Machine	f to 10,000 of proofs	f over 10,000 of proofs
Monochrome and two-color	3% 0.03	2% 0.02
Four-color	8% 0.08	6% 0.06

2.2 Consumption of other resources

Color consumption [kg] per press sheet can be calculated according to the equation:

$$B = \frac{2n_p 0{,}75(a \cdot b)10^{-6} f_p}{f_b} \quad (2)$$

Where:

- fp is print area coverage, determined on the basis of the number of colors on the proof (Savić, 2011);
- 0.75 is correction factor of print area dimensions (with no margins).
- color consumption factor fb is determined experimentally (Novaković, 2012).

Other resources here are calculated in the following way. Based on color consumption, the number of proofs and the number of different tasks, oil solvent consumption (P17) is calculated as follows:

$$V_{P17} = f_{P17} \cdot B / \rho_{P17} \quad (3)$$

Where:

- f_{P17} is factor of resource consumption P17 (Savić, 2011);
- B is mass of color consumption,
- ρ_{P17} is specific mass of resources P17.

Consumption of hydrogen treated oil is calculated in a similar way (P21):

$$V_{P21} = f_{P21} \cdot B / \rho_{P21} \quad (4)$$

Where:

- f_{P21} represents factor of resource consumption P21, (Savić, 2011);
- ρ_{P21} represents specific mass of resources P21.

The mixture of dearomatized hydrocarbons (RG-31) is calculated as follows:

$$V_{RG31} = f_{RG31} \cdot B / \rho_{RG31} \quad (5)$$

Where:

- f_{RG31} is factor of resource consumption RG-31 (Savić, 2011);
- ρ_{RG31} is specific mass of resources RG-31.

Consumption of isopropyl alcohol is calculated according to the equation:

$$V_{IA} = f_{IA} \cdot B / \rho_{IA} \quad (6)$$

Where:

- f_{IA} is factor of isopropyl alcohol consumption (Savić, 2011);
- ρ_{IA} is specific mass of isopropyl alcohol.

A part of the program code with the implemented formulae of the model is shown in Figure 1.

By using form designers that support drag-and-drop method of creating the controls, we have implemented the user interface. The controls TextBox, Label and Button have been used.

The implemented user interface within the integrated development environment of the Microsoft Visual Studio is shown in Figure 2.

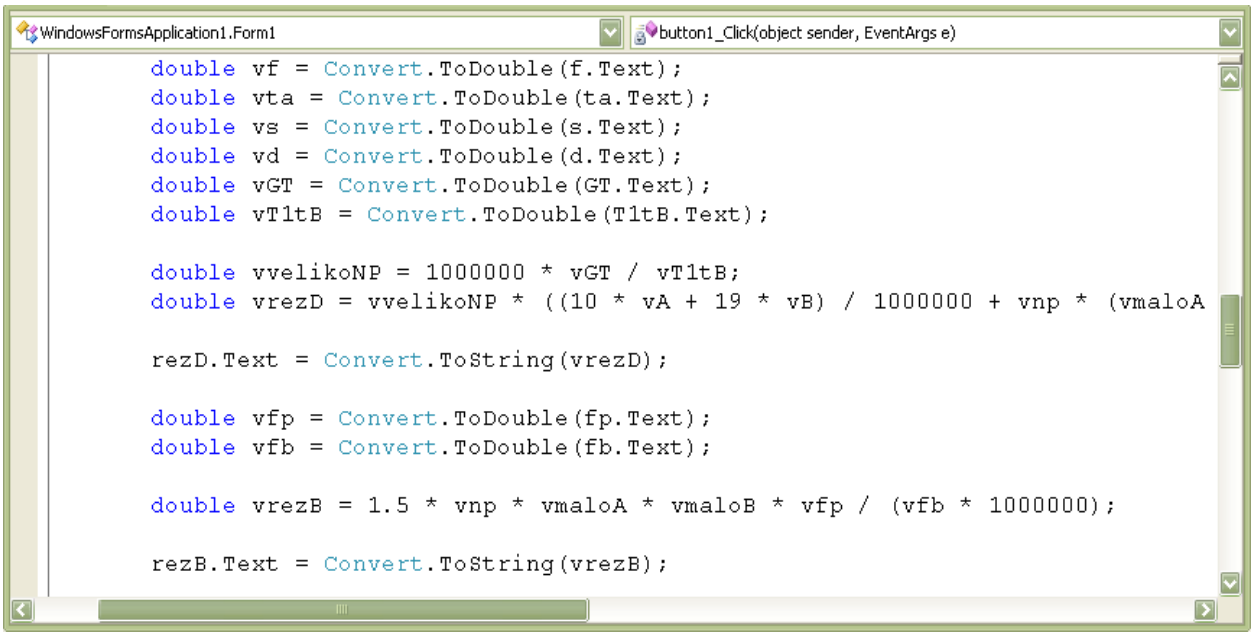

Figure 1. Part of the program code of the developed software

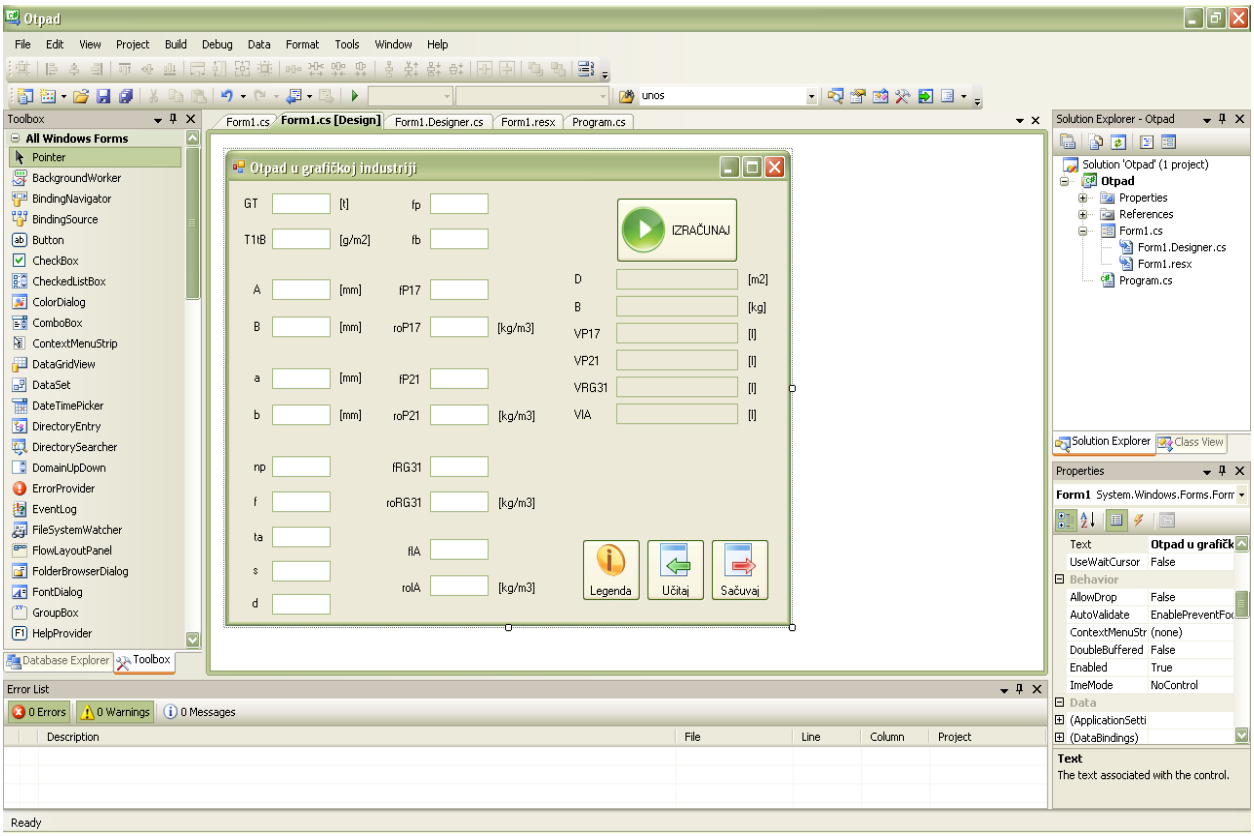

Figure 2. Implemented user interface within integrated development environment of the Microsoft Visual Studio

3. Application of software for determining the amount of waste

After starting the software, a form with a larger number of text fields for entering the data necessary for the calculation is obtained. Once the data have been entered, by pressing "CALCULATE" (Serbian "IZRAČUNAJ"), the software does the calculation according to the formulae presented in the model and shows the results in the fields under the abovementioned key.

It is possible to obtain a detailed description for every field by pressing "Legend" (Serbian "Legenda").

In order to test the software, the company Rotografika, Serbia, which deals with offset printing, will be analyzed. This company has four-color printing machines with B1 paper-size press sheets (1000 x 707mm) with the initial paper size of 1034 x 747 mm.

The following values required for the calculation of the amount of waste materials are entered into the software:

- GT – annual consumption of paper in tons = 17,196.84 t,
- T1tB – grammage of press sheets per m^2 =80g/m2,
- A – press sheet width = 1034 mm,
- B – press sheet length = 747 mm,
- a – page length = 250 mm,
- b – page width = 176 mm,
- np – number of pages in a press sheet = 16,
- f – percentage of waste material in press sheets = 0.06,
- ta– waste press sheets after preparing the machine = 200,
- s – number of shifts (tasks) on the machine = 4,
- d – number of work days = 360,
- fp – print area coverage = 1,
- fb – color consumption factor = 568.8,
- fP17 – factor of resource consumption P17 = 0.01,
- roP17 – specific mass of resources P17 = 0.88 kg/m^3,
- fP21 – factor of resource consumption P21 = 0.011,
- roP21 – specific mass of resources P21 = 0.88 kg/m^3,
- fRG31 – factor of resource consumption RG-31 = 0.036,
- roRG31 – specific mass of resources RG-31 = 0.8 kg/m^3,
- fIA – factor of isopropyl alcohol consumption = 0.1,
- roIA – specific mass of isopropyl alcohol = 0.786 kg/m3,

By entering these values and pressing "CALCULATE" (Serbian "IZRAČUNAJ"), the values like those in Figure 3 are obtained.

Figure 3. Obtained values of the amount of waste materials by applying the software

By applying the software, the following values of the amount of waste materials are obtained, which is shown in Figure 3.

Waste paper area: D = 24,249,204.8 m^2.

Since the average paper weight is 80 g/m^2, the total weight of waste paper amounts to 1,939,938.4 kg, i.e. 1,939.94 tons.

Color consumption per press sheet: B = 0.0018565 kg. Color consumption of 399,082 kg is obtained for the total number of press sheets in production.

This is used as the basis for calculation of the amounts of other waste chemical substances:

V_{P17} = 4,535 l,

V_{P21} = 4,989 l,

V_{RG31} = 17,959 l,

V_{IA} = 50,774 l.

All entered data can be recorded in a text file by pressing "Save" (Serbian "Sačuvaj"). The file represents an XML document with one root element in which all other elements and their contents are preserved. Every element has its input and output tag with the data name whose value is indicated between these tags, as shown in Figure 4.

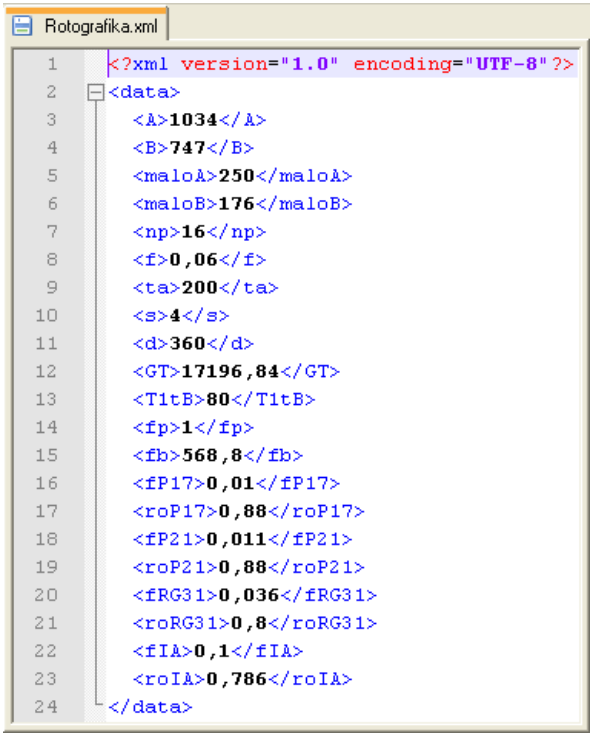

Figure 4.XML document with the saved data

By pressing "Load" (Serbian "Učitaj"), the data from the selected text file are loaded into the form fields for a new calculation or possible corrections.

4. Conclusion

It is a well-known fact that there are numerous softwares dealing with waste management. However, this software is easily applicable and specifically designed for the

calculation of waste material in printing houses. The application of this software can substantially speed up the process of calculating waste materials in offset printing.

In the company Rotografika, the measured mass of waste paper is 2,000 t, whereas according to the model, it is 1,939.94 t. Partial deviations are present, but only marginally. The printing house measurements show that the annual color consumption is 400,000 kg, whereas the calculated value is 399,082 kg. Therefore, the measured deviations comparing to the calculated ones are in this case also minimal.

The measured amounts of other waste chemical substances are: V_{P17} = 5,000 l; V_{P21} = 5,645 l; V_{RG31} = 17,900 l; V_{IA} = 50,500 l. It is noticeable that the first two agents have significant deviations comparing to the calculated ones in the model, whereas the second two agents have minimal deviations. The reason for that lies in the fact that the first two resources are used for hand washing, so it is obvious that there are no precisely measured amounts, but the optional ones.

It is evident that the developed software provides rather precise data on the amounts of waste material in offset printing. Deviations are possible because the tasks are not always the same, but on the whole, it is possible to determine all waste materials in printing based on the amount of the input paper. This is extremely useful information, for both employers and supervisory authorities, because employers can predict the recycling material and know what to expect, which leads to savings. Likewise, supervisory authorities can determine the exact amount of waste material, control the disposal of this waste, and thus reduce the pollution of the environment.

Further research will develop the model and work on its wider application and testing its precision.

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