Composite Materials
2022; 6(1): 39-48
http://www.sciencepublishinggroup.com/j/cm
doi: 10.11648/j.cm.20220601.15

Industrial Abacus and Computer Interface for the Calculation of Thermal Properties of PVCs Loaded with Palm Kernel Shell Powder

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To cite this article:
Rolland Djomi, Chantal Marguerite Mveh, Joseph Voufo, Florent Biyeme, Nasser Yimen. Industrial Abacus and Computer Interface for the Calculation of Thermal Properties of PVCs Loaded with Palm Kernel Shell Powder. *Composite Materials*. Vol. 6, No. 1, 2022, pp. 39-48. doi: 10.11648/j.cm.20220601.15

Received: April 24, 2022; **Accepted**: May 12, 2022; **Published**: May 26, 2022

Abstract: Materials characterization is the part of materials science that allows engineers and researchers to value a material. Considering the quantity of materials and the number of existing property results, in order to make them accessible to solve the problem of material selection, it is important to find an easy way that should allow engineers to consult the data without needing enough sentences. Nowadays, the computer has become a reassuring library. Therefore, the work presented here consists in designing an industrial abacus model and a computer interface that should allow engineers and standardization teams, contractors and hardware dealers to calculate and save the thermal properties of PVC loaded with micronized palm kernel shell powder, although the dosage is known. The industrial elaboration of the loaded PVCs, its thermal characterization, the graphs representing the influence of the shell powder on the thermal properties of the PVCs as well as the mathematical models for the calculation of these properties according to the dosage with this shell powder have been the object of studies in the previous works. From the obtained results, we used a simple graphic method to design the industrial abacus and then the mathematical models of the previous works coupled with the Java programming language, NetBeans IDE 8.0.2 and Lauch4j, to design and implement an adequate computer interface. The results gave us for the abacus that it is simple and practical for workers in production plants and for the computer interface that it is easy to use, requiring neither special skills nor computer training. Practical examples have shown that the use of computer interfaces to calculate thermal properties gives a remarkable speed and accuracy allowing the engineers of construction sites and design offices to use it with confidence, unlike the abacus. These applications have made it possible to obtain that, the valorization of this model of calculation and conservation of the data will allow the researchers and the engineers to use this principle to safeguard the data in the future.

Keywords: Thermal Properties of PVCs Loaded, Graphical Extrapolation, Mathematical Models, Industrial Abacus, Computer Interface

1. Introduction

Engineers use materials in constructions according to specifications [1]. In order to respect them, engineers look for the performances and the general characteristic parameters of the materials they will use to satisfy their customers. Similarly, the materials sold on the market respect a certain number of properties that are specific to them. In the same way, the commercial departments as well as the departments of the standards of the companies need to reassure their customers who are the engineers of the building sites or the engineers of the design offices, of the quality of the parts which they place at their disposal. Also, the production technicians need to control the quality of the materials they produce and the information necessary for the adjustment of their machine [1, 2].

In the past, research has developed theoretical methodologies to achieve their objectives [3]. These methodologies require highly qualified personnel and considerable levels of education [1-4]. Added to this, these methodologies lead engineers to waste time to make the calculations which require considerable financial means for their maintenance. These methods are expensive for the economic operators and, consequently, make the constructions in general more expensive.

Today, in order to solve all these problems, the advent of computer science and the advancement of technology allow researchers to solve this problem [5, 6].

Computers are the fastest way to not only store the data from the research results, but it is also a very fast and reliable way to control and inform everyone about their concern [7, 8].

For this reason, in order to help the engineers of the construction sites and design offices, the production technicians and the standard teams, the hardware merchants as well as the economic operators, we proposed in this work to design an abacus and a computer interface that will take care of the results of the thermal properties of the PVCs to be elaborated and to be characterized according to their dosages with the powder of palm kernel shells. These abacuses and computer interfaces will allow:

1) Design engineers to be sure of the results of the PVCs they will obtain in their structural calculations;
2) Production engineers and technicians to produce the quality, type, accuracy and repeatability of PVCs ordered by the sales department;
3) Standards and commercial departments to ensure the loaded PVCs are in the stores and on the market;
4) Hardware dealers to control and give with confidence the PVCs that the engineers need and with their thermal parameters without wasting time;
5) Businessmen to increase their production, to supply the engineers with PVCs loaded with shell powder with confidence and to increase their profits without being bound to the intellectual levels of the workers.

To achieve these objectives, the results of the graphs representing the influence of micronized palm kernel shell powder [9] on the thermal properties of industrially extruded PVCs [10] obtained in the work of Chantal Marguerite Mveh and her team in "Mathematical models for the calculation of the thermal properties of PVCs as a function of the dosage of palm kernel shell powder from the results of experimental practice" [11] will be presented together with the tables of mathematical models obtained from interpolations of the results of the thermal properties of these graphs. Finally, the graphs will be used to design industrial abacuses (as was done by engineers after the manufacture of machine tools) [12] and the mathematical models, to design and implement a computer interface [13, 14], which should facilitate everyone to obtain these thermal properties without the need for either, a high intellectual level, or a large training in computer science, all this, inspired by the work of designing interfaces and computer software [13-15].

A methodology for their use and an example of application leading to simplicity in the handling of the abacus and the interface will be presented.

2. Materials and Experimental Methods

2.1. Materials

The tubes are produced industrially by extrusion in a company producing and marketing plastic materials for construction in Yaounde, Cameroon (SOFAMAC). Unloaded PVC tubes called F0, then PVC tubes loaded with micronized palm kernel shell powder with the following dosage percentages: 4.01% called F4.01, 12.54% called F12.54, 23.03% called F23.03, 32.01% called F32.01, 38.02% called F38.02 and 51.01% called F51.01 were obtained [10]. These PVCs F0, F12.54, F32.01 and F51.01 were thermally characterized by C. M. Mveh and his team in Global Journal of Researches in Engineering [11]. Thermal properties were obtained and graphs of the influences of palm kernel shell powder on the thermal properties of the obtained PVCs were represented. From these graphs, the mathematical models for the calculation of thermal properties from the dosage with palm kernel shell powder and vice versa were developed. From these results obtained therefore, an industrial abacus and a computer interface to solve this problem will be designed and realized.

2.1.1. Materials for the Design of the Abacus

Figures 1, 2, 3 are the graphs presenting the influences of the palm kernel shell powder on the thermal properties of PVC, abacuses designed from the graphs obtained from the thermal properties of the work of Chantal Marguerite Mveh and her team [11].

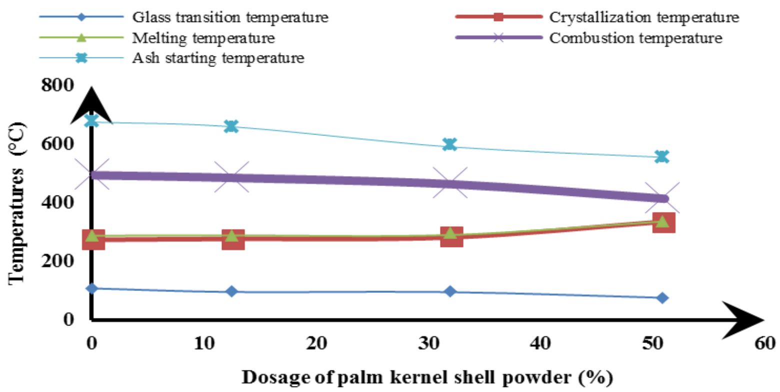

Figure 1. *Influence of shell powder on thermo differential phase change temperatures of PVCs.*

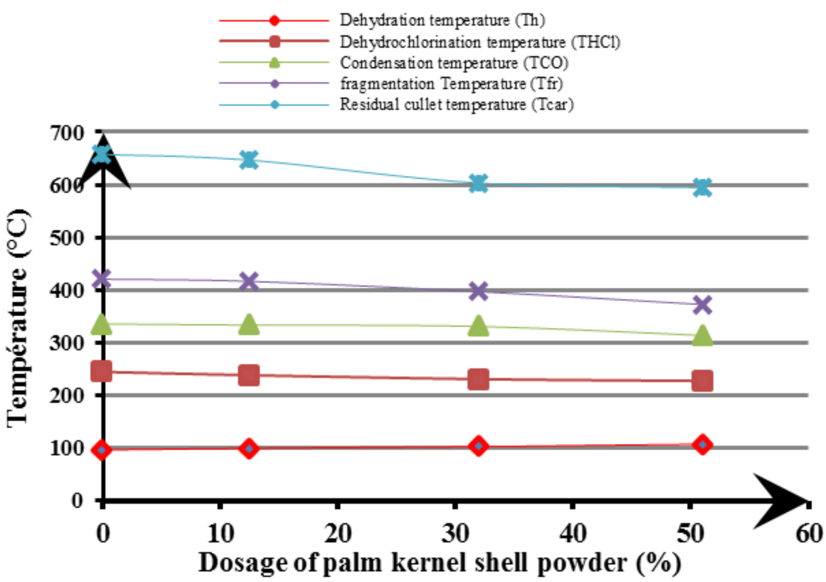

Figure 2. *Influence of the shell powder on the thermogravimetric phase change temperatures of PVC.*

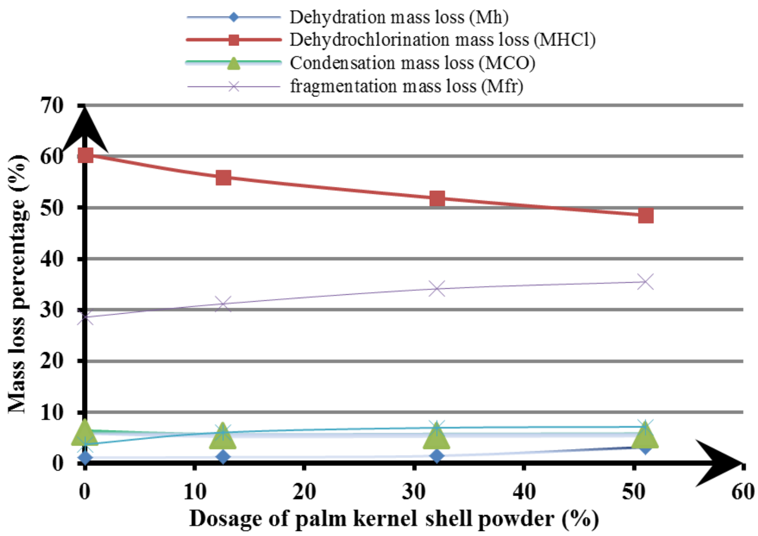

Figure 3. *Influence of the shell powder on the mass losses at the thermogravimetric phase changes of PVC.*

2.1.2. Materials for the Design of the Interface

Tables 1 and 2 present the mathematical models for the calculation of the thermal properties of PVC as a function of the dosage with palm kernel shell powder obtained from the work of Chantal Marguerite Mveh and her team [11].

Table 1. *Mathematical models for the calculation of the differential thermal properties of PVC.*

Properties	Mathematical models
Glass transition temperature (Tg)	y = -0.0011x3 + 0.0774x2 - 1.768x + 108.71
Crystallization temperature (Tcf)	y = 0.0013x3 - 0.0547x2 + 0.7164x + 274.71
Melting temperature (Tf)	y = 0.0012x3 - 0.0537x2 + 0.553x + 288.71
Combustion temperature (Tc)	y = -0.0005x3 + 0.0116x2 - 0.7907x + 494.71
Ash temperature (Tce)	y = 0.0022x3 - 0.1685x2 + 0.4783x + 675.71

Table 2. *Mathematical models for the calculation of the thermo differential properties of PVC.*

Properties		Mathematical models
Phase transition temperatures.	Deshydration (Th)	y = 7E-05x3 - 0.0046x2+ 0.2759x + 96.71
	Dehydrochlorination (THcl)	y = 5E-05x3 + 0.0011x2 - 0.5097x + 244.71
	Condensation (Tco)	y = -0.0004x3 + 0.0195x2 - 0.3494x + 335.71
	Fragmentation (Tfr)	y = 0.0003x3 - 0.0332x2 + 0.0446x + 420.71
	Ash (Tcar)	y = 0.0017x3 - 0.1198x2 + 0.3405x + 657.71

Properties		**Mathematical models**
Diminution de masse aux transitions	Mass loss at Deshydration (M_h)	y = 4E-05x3 - 0.0016x2 + 0.0256x + 1.176
	Mass loss at Dehydrochlorination (M_{Hcl})	y = -6E-05x3 + 0.0072x2 - 0.4287x + 60.411
	Mass loss at Condensation (M_{co})	y = -3E-05x3 + 0.0031x2 - 0.0864x + 6.0513
	Mass loss at Fragmentation (M_{fr})	y = -5E-06x3 - 0.0016x2 + 0.2282x + 28.601
	Mass loss at Ash (M_{car})	y = 6E-05x3 - 0.007x2 + 0.2612x + 3.7613

2.2. Practical Experimental Methods

2.2.1. For the Abacuses

(i). Design of the Abacuses

The distribution of points representing the thermal results of PVCs loaded with palm kernel shell powder for all formulations are placed and arranged in a single graph. The regression lines corresponding to the different properties of the PVCs are plotted and then enlarged as was done by Matéra and Agatti, Morh and many others in the literature as they approached the design and implementation of the machine tools after the mathematical models were established [2-7, 12]. The axes are scaled. Properties with the same units are grouped on the same axes. The graph thus obtained takes the name of industrial abacus which will make it possible to determine directly the thermal properties of the PVC when we know the dosage with the powder of shell of palm kernel or conversely, to determine the dosage with the powder of when the calculation of structure makes it possible to know one of the thermal properties [13, 14, 16].

(ii). Use of the Abacuses

2 cases of problems for the research of thermal properties of PVC loaded with palm kernel shell powder using the abacuses are encountered namely:

1) Case where only the dosage is known:

Problem: Search, buy, sell, produce, use or know the thermal properties of a PVC for which we already know perfectly the dosage with palm kernel shell powder.

Methodology of the resolution.

1) To locate the proportioning of the PVC with the powder of shells of palm kernel (on the horizontal axis);
2) Draw a vertical line passing through this dosage: this line will cut all the trend lines at one (1) point;
3) At the various points where each trend line meets, draw horizontal lines to the temperature or mass decrease axis respectively;
4) These lines will intersect the temperature axis or the mass decrease axis;
5) From the graduations, read the values of the temperatures or the decreases of mass;
6) From the legends, identify the corresponding properties;
7) From the legends, identify the corresponding properties; Draw the table of values of the properties of the loaded PVC you are looking for.

Examples of application 1: Find (buy, sell, produce, know, use) the properties of PVC whose dosage with palm kernel shell powder is 6.1%.

Methodology of the resolution.

1) Draw on the abacuse a vertical line of red color passing by 6.1% on the axis of the dosages with the powder of palm kernel shells.
2) Draw horizontal red lines on the chart that stop at the intersection of the vertical red line and the various trend lines and intersect the temperature axis at one (1) point. These are the relevant phase transition temperatures.
3) To draw on the chart horizontal lines of red color which stop on the meeting of the red vertical line and the various lines of tendency and which intersect the axis of the decreases in mass in one (1) point. These are the mass decreases at the phase transitions.
4) Finally, fill in the table representing the results of the properties of the PVC loaded with 6.1% of the palm kernel shell powder.

2) Case where only one (1) property is known.

Problem: Structural calculations have given us one (1) thermal property of PVC. We need to know the dosage and other unknown properties.

Methodology of the resolution.

1) Locate the relevant trend line from the legend;
2) Locate the property on its axis and draw a horizontal line that will meet the trend line concerned;
3) Draw a vertical line joining this point of the two (2) lines;
4) This straight line will meet both the axis of the dosage of PVC with hull powder and all the trend lines of the other properties;
5) On each point where the trend line meets the vertical line, draw any horizontal lines;
6) On the axis of the dosages and from the graduations read the value of the dosage;
7) On the vertical temperature axis, read the different phase transition temperatures;
8) On the vertical axis of the decreases in mass at the phase transitions, read the value of the decreases in mass;
9) Get the table of values of the properties of the PVC you are looking for.

Application example 2: A PVC loaded with palm kernel shell powder should lose 1.5% of its mass upon dehydration. What is the dosage with the shell powder and all the thermal properties:

Methodology of the resolution.

1) Draw on the abacus a horizontal line of black color passing by 1.5 on the axis of the decreases of mass to the transitions of phase and which stops on the line of tendency corresponding to the loss of mass to the

dehydration;

2) Then, draw on the chart a black vertical line passing through the meeting point of the horizontal line and the dehydration trend line. This line intersects the axis of the dosages at a point. It is therefore the dosage with the palm kernel shell powder of the PVC sought.
3) Similarly, this vertical line of black color cuts all other trend lines:
4) Draw on the chart the horizontal lines joining the points of meeting of the black vertical line and the lines of tendency of the temperatures with the axis of the temperatures: it is the results of the temperatures to the changes of phase of the PVC concerned.
5) In the same way, draw on the chart the horizontal lines leaving the points of meeting of the black vertical line and the lines of tendency of the decreases of masses for the axis of the decreases of mass: it is the results of the decreases of mass.

2.2.2. For the Interfaces

This graphical user interface (GUI) has been realized to answer the need for an interactive tool allowing to quickly calculate the thermal properties of our composite, according to the dosage.

(i). Functional Specifications

The following functionalities are paramount:

1) The interface must be user-friendly and easy to use.
2) Useful feedback must be provided to the user.
3) Calculation errors must be avoided at all costs.
4) Saving of results must be obtained.

(ii). Interface Design

The computer implementation figure 6 was done using the Java programming language, while the graphical interface was designed using Scene Builder v1.0 and the styling completed using CSS (Cascading-Style sheet). NetBeans IDE 8.0.2 was used to manage and compile the various files into a Java executable, while Lauch4j was used to create a Windows executable file.

(iii). Installation of the Software

1) Extract the compressed folder figure 7 by double clicking on the software.
2) Enter the folder and double click on V4 of type folder.
3) Enter the folder and double click on the executable file interface_V4.exe of type application.
4) The interface figure 8 is displayed and ready to be used.

(iv). Use of the Interface

1) Enters a number representing the dosage of PVC with palm kernel powder figure 9;
2) The system calculates the material properties;
3) The system displays the results of the thermal properties of the material.

(v). Application Example of the Interfaces

Calculate the thermal properties of a PVC loaded with 47.91% of palm kernel shell powder.

(vi). Future Extensions

Future versions of this program will incorporate an option to calculate the percentage composition range from a given value or set of values of material properties.

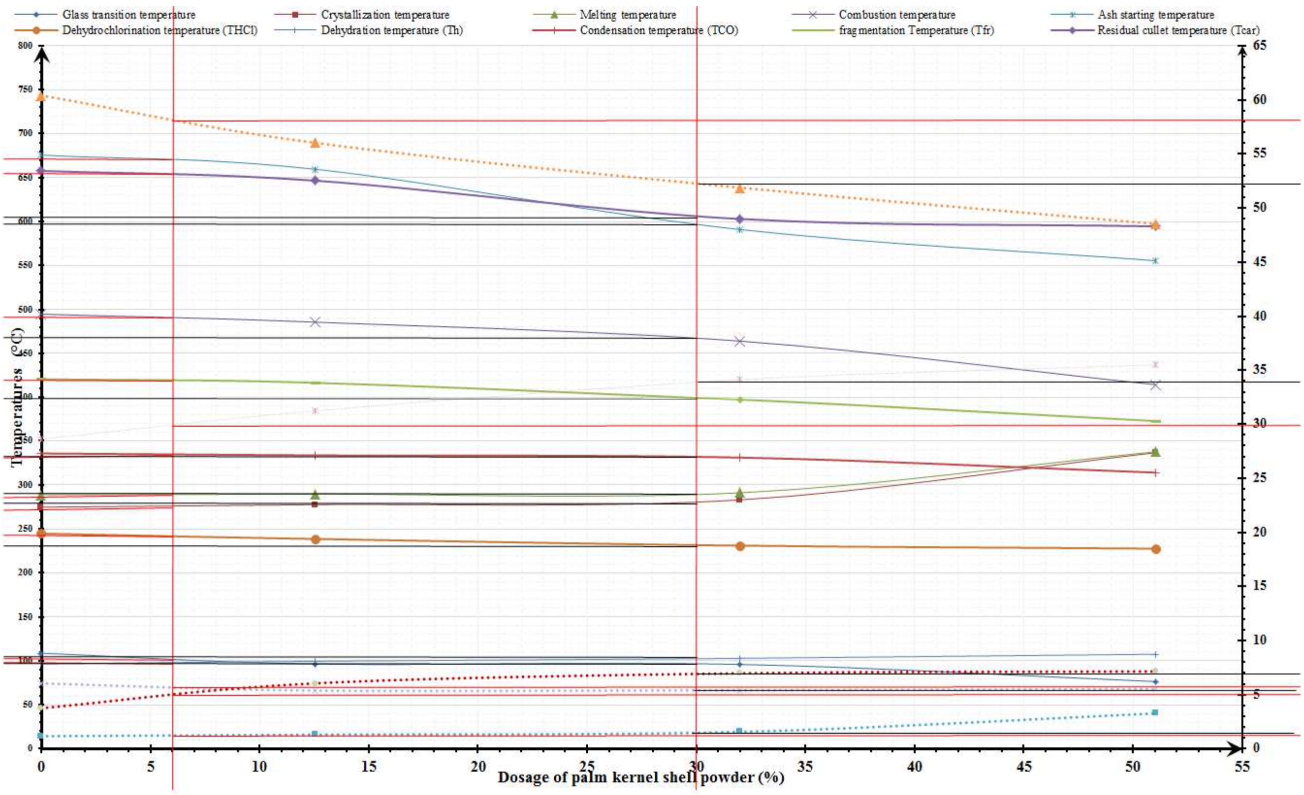

Figure 4. Result of abacus for the determination of the thermal properties of PVCs as a function of the dosage witch palm kernel shell powder.

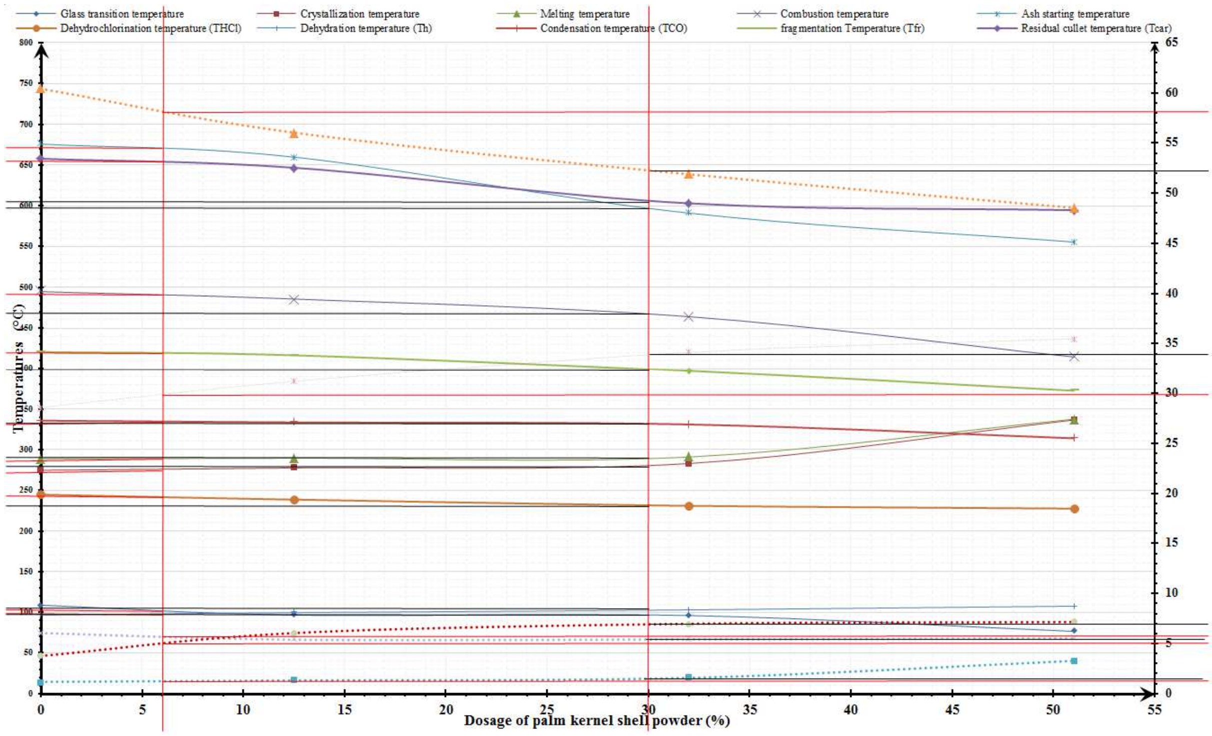

Figure 5. *Application of the use of the abacus for the determination of the thermal properties of PVC as a function of the dosage with palm kernel shell powder.*

Table 3. *Results of the properties of PVC dosed with 6.1% of the shell powder from the abacus.*

properties			values	units
Thermogravimetric analysis results	Temperature at phase transitions	Dehydration temperature (Th)	99.7	°C
		Dehydrochlorination temperature (THCl)	248	°C
		Condensation temperature (TCO)	333	°C
		Fragmentation (T_{fr})	669	°C
		Ash starting temperature (T_{car})	671	°C
	mass decrease at phase transitions	Dehydration mass loss (Mh)	1.25	%
		Dehydrochlorination mass loss (MHCl)	57	%
		Condensation mass loss (MCO)	5.5	%
		fragmentation mass loss (Mfr)	30.9	%
		loss of mass of residual cullet (Mcar)	5.6	%
Results of thermodifferential analysis	Temperature at phase transitions	Glass transition temperature (Tg)	100	°C
		Crystallization temperature (Tcf)	275	°C
		Melting temperature (Tf)	288	°C
		Combustion temperature (Tc)	492	°C
		Ash starting temperature (Tce)	658	°C

Table 4. *Results of the properties of PVC loaded with palm kernel shell powder with a mass decrease at phase transition of 1.5%.*

DOSAGE			30	%
properties			**values**	**units**
Thermogravimetric analysis results	Temperature at phase transitions	Dehydration temperature (Th)	103	°C
		Dehydrochlorination temperature (THCl)	231	°C
		Condensation temperature (TCO)	331	°C
		Fragmentation temperature (T_{fr})	397	°C
		Ash temperature (T_{car})	591	°C
	mass decrease at phase transitions	Dehydration mass loss (Mh)	1.5	%
		Dehydrochlorination mass loss (MHCl)	52	%
		Condensation mass loss (MCO)	5.4	%
		fragmentation mass loss (Mfr)	34	%
		loss of mass of residual cullet (Mcar)	7	%
Results of thermodifferential analysis	Temperature at phase transitions	Glass transition temperature (Tg)	96	°C
		Crystallization temperature (Tcf)	283	°C
		Melting temperature (Tf)	291	°C
		Combustion temperature (Tc)	464	°C
		Ash starting temperature (Tce)	603	°C

3. Results and Discussion

3.1. Results for the Abacuses

3.1.1. Results of the Design and Use of the Abacuses for the Determination of the Thermal Properties of PVC Loaded with Palm Kernel Shell Powder

Figure 4 shows the industrial abacus designed with on the horizontal axis the dosing with palm kernel shell powder and on the vertical axis:

1) On the left, the results of the thermal properties at the phase change temperatures of the PVCs (these lines are continuous lines then each phase change temperature has its color).
2) On the right, the results of thermal properties of mass decrease at phase transitions of PVCs (these lines are broken lines and then each mass decrease at phase transitions of PVCs has its color).

3.1.2. Results of the Use of the Abacuses

2 problems for the research of thermal properties of PVC loaded with palm kernel shell powder using the abacus are encountered:

1) To seek the properties of the PVC knowing the dosage with the palm kernel shell powder.
2) Search for the dosage and other unknown properties knowing a specific thermal property.

3.1.3. Results of the Example of Application of the Abacuses

2 types of results are to be known from the abacus figure 5.

Results of the application example 1: (*II-2-1-2*): *Table 3* shows the results of the properties of the PVC dosed with 6.1% of the shell powder.

Results of application example 2: (*II-2-1-2*): *Table 4* shows the results of the properties of PVC loaded with palm kernel shell powder which loses 1.5% of its mass at phase transition.

3.2. Results for the Computer Interface

3.2.1. Results for the Interface Design (II-2-2)

The algorithm of figure 6 was obtained using the data of the hardware section 2.1.2 [15, 16].

From the algorithm, figure 7 was obtained representing the WinRAR file with the application obtained after the development of the algorithm [15, 17, 18].

It is obtained in the compressed file an application that allows to display the interface of figure 8. It is simple and easy to install.

By introducing the data of the dosage whose thermal properties are searched, we obtain the figure 9 immediately representing the results requested.

This application has been designed to be easy to use by anyone who does not have computer knowledge. Also, with the advent of cell phones, the engineers of the building sites have the possibility of using it being well in the building site, as well as the engineers of the standardization [18, 19].

The application example in Figure 9 shows that the calculated properties are reliable. The calculations are fast, so that the engineers do not waste time [15, 18].

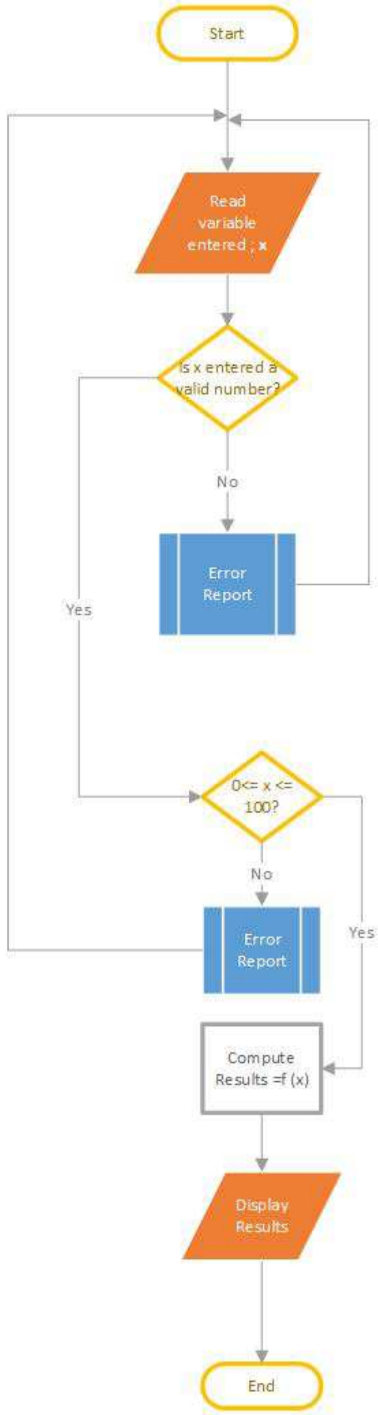

Figure 6. *Algorithm of the design.*

Figure 7. *Compressed file obtained.*

3.2.2. Results of the Interface

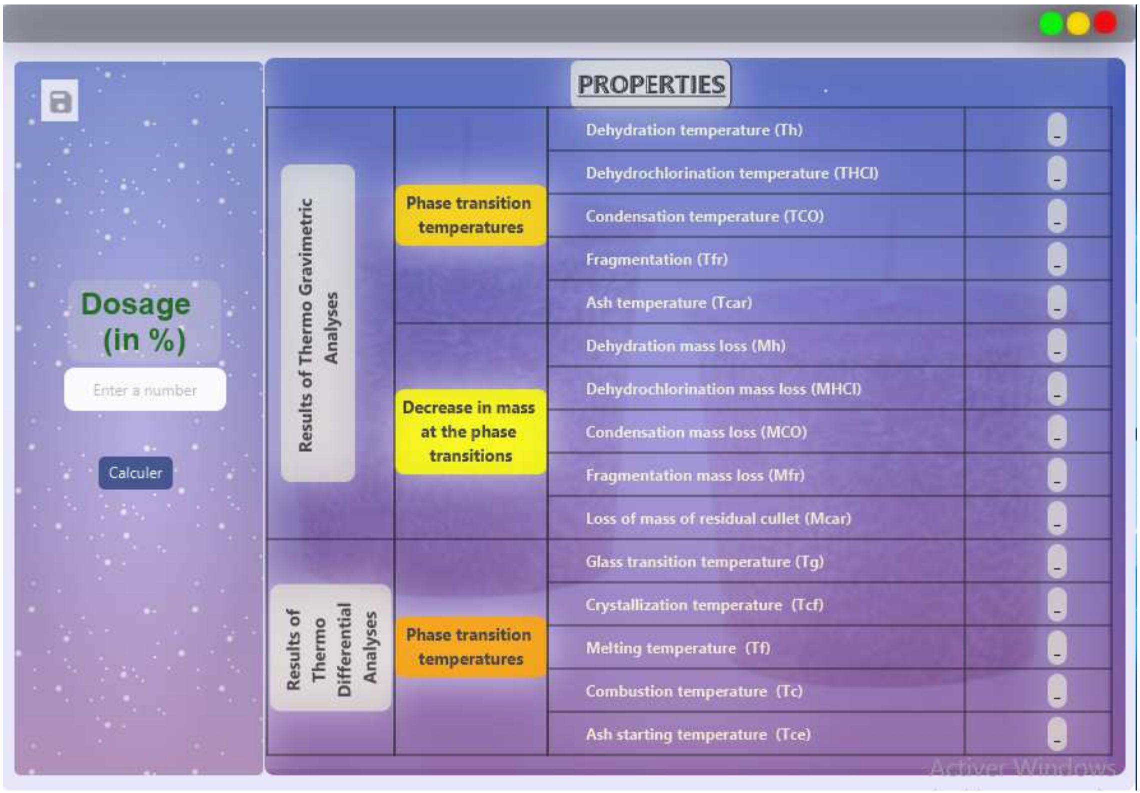

Figure 8. *Presentation of the interface installation.*

3.2.3. Results of the Interfaces Application Examples

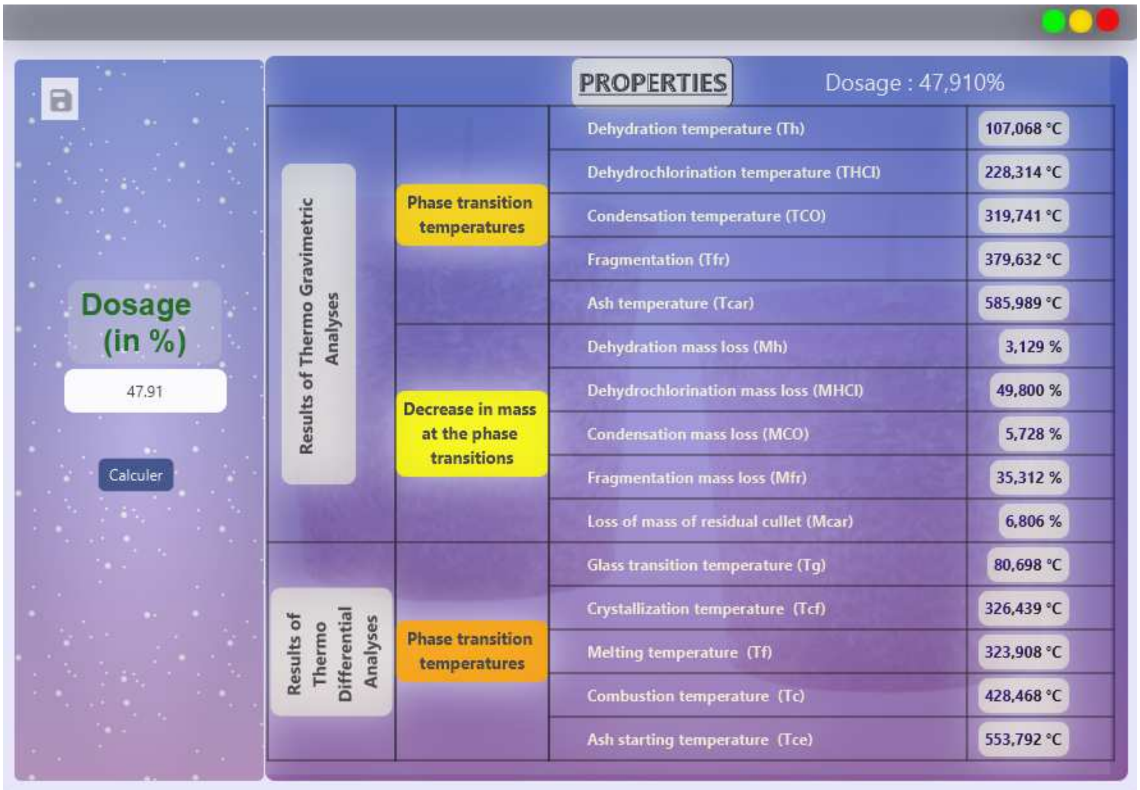

Figure 9. *Result of the interface application example.*

4. Observations

The results of the abacus measurements compared to the results of the computer interface measurements show that the abacus measurements give results rather close to the real values, whereas the results of the interface measurements give rather real results. These observations show that one should be careful when using the abacus for precision work. This means, in other words, that the abacus should not be used to obtain precise results. This means that the abacuses should not be used to obtain accurate results. For this reason, a computer interface has been associated with it in order to limit errors in structural calculations. Finally, it should be noted that the abacuses are much more limited for applications in companies, especially for workers in the production plant, because it is the engineers who have the competence to adjust the machines of the production line shaping [4, 5, 7].

5. Conclusion

In previous works, it has been shown that palm kernel shells exist in abundance in Asia, America and Africa, especially in Cameroon. The exploitation and processing of palm kernel shells for use as load in the production of synthetic polymer matrix plastics has been demonstrated. PVC was used to produce tubes by extrusion by varying the dosage with the palm kernel shell powder load. Thermal characterization of all these PVC loaded with shell powder at all formulations was done and the results that were obtained showed that they follow consistent mathematical laws. Mathematical models that allow engineers and technicians of plastics production to determine the properties of the plastics loaded with the shell powder when the dosage of PVC with this powder is known and vice versa, have been developed.

The above results show that the manipulation of mathematical models requires advanced knowledge and education. Moreover, this methodology wastes a lot of engineers' time and requires a team focused only on this work. This is costly for the company's managers.

The diagrams that allowed the development of the mathematical models, were designed and transformed to make an industrial abacus model that should allow us to simply determine either the thermal properties or the dosage with the shell powder of the loaded PVCs. In the same way, the mathematical models obtained with the Java programming language, NetBeans IDE 8.0.2 and Lauch4j were used to design and increment a computer interface that should manage these calculations with confidence, security and speed. At the end of the design, a user guide and a practical example of the use of each of the techniques of this calculation was given.

The analysis of the results allowed us to note that these methodologies are simple, practical and do not require an advanced level of study for its handling.

Declaration of Interests

The authors declare that they have no competing interests.

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