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RESEARCH ARTICLE

OPTIMIZATION CONDITIONS OF RECYCLING WASTE PLASTIC PET ON ASPHALT, BY USING APPLICATION OF RESPONSE SURFACE METHODOLOGY.

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Abstract

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In this study, different conditions of waste plastic PET (Polyethylene Terephthalate) recycling on asphalt were optimized. Response Surface Methodology (RSM) using the Doehlert Experimental design has been employed in the optimization. The independent variables considered were bitumen (5-8%), PET (0-12%), mixing temperature (150-160°C) and mixing time (20-30min). Four-second order polynomial models were generated. The responses obtained by the models were well described as: specificgravity ($Y._{SG}$), penetration ($Y._{P}$), softening point ($Y._{SP}$), and flash point ($Y._{FP}$) of the process with satisfactory fits in terms of absolute average deviation, bias factor and accuracy factor. The optimum responses were 1,05 g/cm³ as specific gravity ($Y._{SG}$), 60*(1/100mm) as penetration at 25°C, 100g and 5sec ($Y._{P}$), 50°C as softening point ($Y._{SP}$), and 244°C as flash point ($Y._{FP}$). The statistical relation between the four independent variables and the process responses was well described.

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Introduction:-

Plastic, polymers of variable compositions have become object of Common use and difficult digest by micro-organisms. These polymers are a source of environmental pollution **[1].** Chad is no exception from this type of pollutant due to the lack of a reliable household waste management policy, waste plastic made up of polyethylene terephthalate is thrown into the environment with no lesser consequences on the ecosystem **[2].** One of the best and most effective methods of managing of waste plastic is the possibility of incorporating it into construction processes **[3].** In general case, to recycle this waste, two processes emerge: the dry method (coating plastic on the hot aggregate and then mixing with asphalt) and the wet method (mixing powdery plastic waste with asphalt then mixing with aggregate) **[4].** Through these processes, PET are easily recyclable because of their high melting point (about 260°C)**.** The latter, is one of the characteristics which determines the choice of process considered in relation to the types of plastic waste to be recycled **[5].** The wet process is better for controlling the properties of the modified asphalt binder. Although this process requires specialized mixing and storage facilities **[6, 7].** Also, due to of its enhanced thermal behavior, the wet process is currently the most widely used for polymer asphalt modification. Composed of complex molecules, the adhesion of plastic waste into bitumen requires a specific time, generally around 20 to 30min **[5, 8, 9].** Likewise, in order to obtain perfect homogenization, the size of plastic plays an important role. It was suggested to use plastic size less than 2,36mm and the optimum asphalt ratio should be up to 10% **[10, 11].**

Despite the fact that plastic waste improves asphalt properties, this process has some limitations to explain the influences of the raw materials (waste PET and asphalt) on the best optimum condition.

Despite the fact that plastic waste improves asphalt properties, this process has some limitations to explain the influences of the raw materials (waste PETand asphalt) on the best optimum condition.

Thus, the present article is devoted to the study of the optimization conditions of recycling waste plastic PET on asphalt by using application of response surface methodology. The aim of process is to identify relation between the in-put parameter (factor) and their effect on the responses (output). This can help to choose the good factor for a specify researched characteristic.

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Materials and Methods:-

Material:-

The materials used within the scope of this article were:

1. Waste PET powder size 0 to 0,63mm
2. Asphalt with grade 60/70; 1,03g/cm³ as specific density, 46°C as softening point and 235°C as flash point.

To obtain PET on powder form, the plastic bottle was washed, dried and melted about 250°C which is PET melting point, then pouring at ambient air. After solidifying, the plastic was grinded and sifted. The plastic with granulometry included 0-0,63mm were used to mix with hot bitumen as shown in Figure 1. The suggested ratio of bitumen is 5 to 8% **[12].**

Methods:-

Wet process of recycling of waste plastic was done here. It is constituted by a mixture of PET plastic powder and the bitumen binder.

Mixing process

According to literature review, plastic waste can be used in hot mix to improve physical properties of bituminous, aggregate and mix by 'Dry Process' or 'Wet Process'. As we need to determine, the influence of some factors which can influence the tests analyses, we opt for wet process. Because of chemical characteristics of asphalt and PET, this method can give more information about optimization condition of recycling waste plastic on asphalt. The process was done by blending PET powder and asphalt. To get mix binder, PET obtained by substitution of asphalt in different ratio (0-12%) was added to hot asphalt. The mix was stirred for 20 to 30min with temperature about 150°C to 160°C as shown in figure 1. This process was intended to make some physicals analyses and to find out a good optimum condition of waste PET recycling on asphalt by using Doehlert Response Surface Methodology.

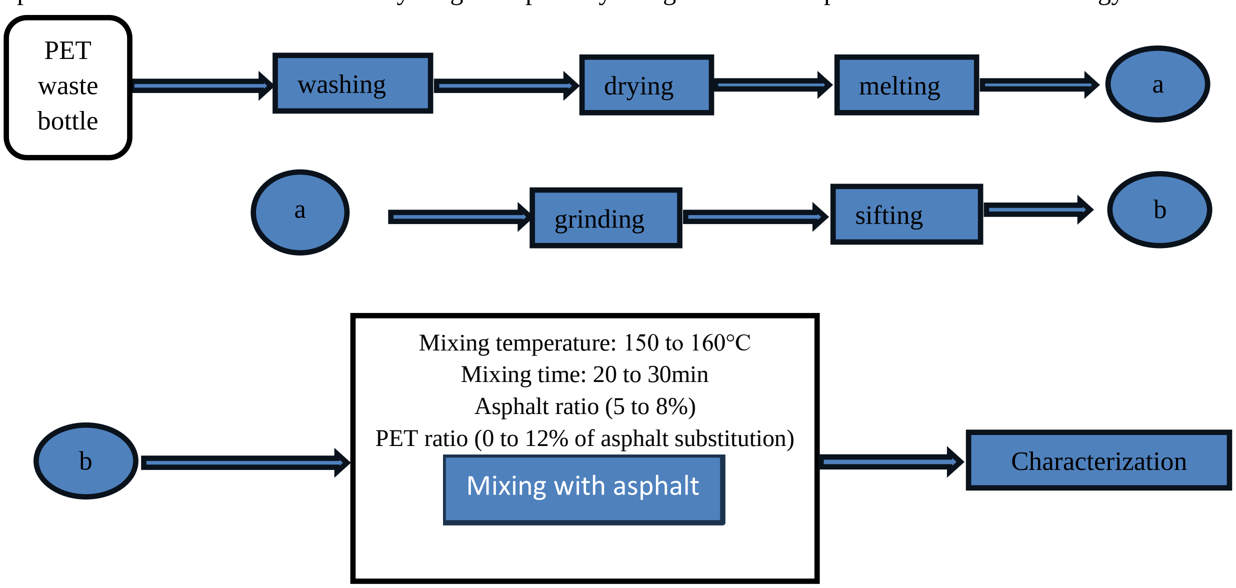

Figure1:- Schematic of recycling process of waste PET.

Response surface methodology (RSM)

Optimization studies using response surface methodology (RSM) were deeply investigated **[13, 14].** Furthermore, the optimum conditions could assist designers to manufacture simple unit operations that could limit or eliminate the tedious practice of recycling PET on asphalt (rate of waste PET, asphalt, mixing temperature and time).

Then absolute average deviation (AAD) and coefficient of determination (R^2) could draw to investigate the adequacy of the proposed models. The present study involves optimization of some parameters that are likely to affect asphalt which can be used for asphalt concrete formulation. The general practice of determining these optima is by one variable-at-time approach. One of the disadvantages of this approach is that it does not include interaction effects among the variables and is unable to determine the true optimum conditions. In order to overcome this problem, optimization studies were done using response surface methodology. RMS is a collection of mathematical and statistical technique that is useful for modeling and analyzing situations in which a response of interest is influenced by several variables, especially if there is a need to optimize the responses of a process. Doehlert matrix as an experimental design represents a uniform distribution of experimental points in space of coded variables as shown on table1. It is used particularly when there is a need to cover an experimental domain of any form of uniformly distributed points in order to explore the total domain (margins and interiors). Moreover, it permits to follow in a sequential manner in studying a response surface of second degree. Polynomial equations with and without interaction could be proposed as models for the mentioned processes. A few studies have been reported on the recycling of waste plastic on asphalt.

It seemed to be important to study the rate of optimal PET, obtained by asphalt substitution and the good mixing temperature and time which define the best binding. The objective of this study was to evaluate the influence of asphalt, PET, mixing temperature and time on asphalt modified, which can be used to make concrete asphalt formulation. The second preoccupation was to assess the good binding condition to obtain the best properties in terms of the response functions: specific gravity ($Y_{.SG}$), penetration ($Y_{.P}$), softening point ($Y_{.SP}$), and flash point ($Y_{.FP}$).

Table1:- Doehlert experimental design of four independent variables employed to recycle PET.

Run N°	Asphalt (%) X_1‘(x_1)	PET (%) X_2‘(x_2)	Mixing Temperature (°C) X_3‘(x_3)	Mixing Time (min) X_4‘(x_4)
.1	7 (0.000)	6 (0.000)	155 (0.000)	25 (0.000)
.2	8 (1.000)	6 (0.000)	155 (0.000)	25 (0.000)
.3	5 (-1.000)	6 (0.000)	155 (0.000)	25 (0.000)
.4	7 (0,500)	11 (0.866)	155 (0.000)	25 (0.000)
.5	6 (-0,500)	1 (-0.866)	155 (0.000)	25 (0.000)
.6	7 (0.500)	1 (-0.866)	155 (0.000)	25 (0.000)
.7	6 (-0,500)	11 (0.866)	155 (0.000)	25 (0.000)
.8	7 (0,500)	8 (0.289)	159 (0,816)	25 0.000)
.9	6 (-0,500)	4 (-0.289)	151 (-0.816)	25 (0.000)
.10	7 (0,500)	4 (-0.289)	151 (-0.816)	25 (0.000)
.11	7 (0.000)	9 (0.577)	151 (-0.816)	25 (0.000)
.12	6 (-0,500)	8 (0.289)	159 (0.816)	25 (0.000)
.13	7 (0.000)	3 (-0.577)	159 (0.816)	25 (0.000)
.14	7 (0.500)	8 (0.289)	156 (0.204)	29 (0.791)
.15	6 (-0.500)	4 (-0.289)	154 (-0.204)	21 (-0.791)
.16	7 (0.500)	4 (-0.289)	154 (-0.204)	21 (-0.791)
.17	7 (0.000)	9 (0.577)	154 (-0.204)	21 (-0.791)
.18	7 (0.000)	6 (0.000)	158 (0.612)	21 (-0.791)
.19	6 (-0.500)	8 (0.289)	156 (0.204)	29 (0.791)
.20	7 (0.000)	3 (-0.577)	156 (0.204)	29 (0.791)
.21	7 (0.000)	6 (0.000)	152 (-0.612)	20 (0.791)

x: coded value of variables and X: the real value of variables

Physicochemical analysis of asphalt binder

Determination of Specific Gravity

This test is defined as the ratio of the mass of a given volume of a material to equal volume of water. The specific gravity is one of the fundamental proprieties of bitumen binder. It informs us about the mineral impurity which can be present in bitumen specimen. Specific gravity is going with Archimedes Principle: If a solid material is first weighed in air and then weighed after immersing it in water, then the difference in the two weights gives the volume of water displaced by the solid material. Generally, pycnometer was used to calculate the density as the following formula **[15].**

$$SG = \frac{(C-A)}{(B-A)-(D-C)} \qquad (1)$$

With

A: Weight of pycnometer
B: Weight of pycnometer filled with water
C: Weight of pycnometer part filled with bitumen
D: Weight of pycnometer + Bitumen + Water

Determination of Penetration

This test is used to get information about consistency and the grade of asphalt by penetration test. It gave information about the hardness or softness of asphalt by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds under specified temperature, load and duration of loading **[16].**

Determination of Softening point

The softening point of bitumen or tar is the temperature at which the substance attains a particular degree of softening. It can be defined also as the temperature at which a bitumen can no longer support a steel ball with 3,5g as the weight and fallat which a standard ball passes through a sample of bitumen in a mold and falls through a height of 2.5 cm in certain condition. This test helps to know the temperature up to which a bituminous binder should be heated for various road use applications. Softening point is determined by ring and ball apparatus **[17].**

Determination of Flash point

Depending of asphalt grades, this hydrocarbon leaves out volatiles, mostly at high temperatures. This fact can be characterized by a flash point. It is defined as the lowest temperature at which the vapor of bitumen momentarily catches fire in the form of flash under specified test conditions. This test provides information on the level of light components in a given mixture **[18].**

Validation and Optimizationof waste PET recycling

Validation

To express the fit of second-degree equations, the determination coefficient R^2 was used. This coefficient of determination was insufficient for model validation on its own **[19].** The absolute average deviation (AAD) was required to validate a model, as was the use of the bias factor and the accuracy factor **[14].** As a result, the model validation criterion was calculated using the formulas:

$$AAD=\frac{\sum_{i=1}^{n}\left(\frac{/Yi,exp - Yi,theo/}{Yi,exp}\right)}{n} \qquad (2)$$

$$B_f=10^{1/n\sum_{i=1}^{n}\log\left(\frac{Yi,theo}{Yi,exp}\right)} \qquad (3)$$

$$A_f=10^{1/n\sum_{i=1}^{n}/\log\left(\frac{Yi,theo}{Yi,exp}\right)/} \qquad (4)$$

Where:

- AAD, absolute average deviation; Bf, bias factor; Af, accuracy factor; Yi, Theo, response obtained using the model; Y_i, exp, response obtained via experiment and n, number of trials.
- The acceptable values of those applications must be within the following ranges: AAD, 0-0.3; B_f, 0.75-1.25, and A_f, 0.75-1.25

Optimization

The response surface methodology using Doehlert experimental matrix was used to optimize recycling of PET on asphaltic road. Minitab version 19, Sigma Plot version 14 and Excel, were used for statistical analysis, regression models and graphical optimization. Besides, the fit of models was verified by the coefficient of determination (R^2), the absolute average deviation (AAD), B_f (Bias Factor) and A_f, (Accuracy Factor).

Four independent variables namely Asphalt (X_1: 5-8%), PET (X_2: 0–12%), Mixing Temperature (X_3: 150-160°C) and the Mixing Time (X_4: 20-30min) were chosen. The ranges of independent parameters were selected based on literature review and preliminary studies. Twenty-one different experiments were presented in according to the experimental design for the four parameters. The experiments were figured in coded (x) and real (X) values.

The response functions (Yi) measured were specific gravity ($Y._{SG}$), penetration ($Y._{P}$), softening point ($Y._{SP}$), and flash point ($Y._{FP}$). These were related to the coded values (x_i) by the second order polynomial that shown in equation (5).

$$Yi = bo + \sum_{i=1}^{k} biXi + \sum_{i=1}^{k} biiXi^2 + \sum_{i=1}^{k-1} * \sum_{j=i+1}^{k} bijXiXj \qquad (5)$$

The coefficients of the polynomial were represented by x_0 (constant term), x_i (linear effects), x_{ii} (quadratic effects) and x_{ij} (interaction effects). X_i and Xj are the independent variables. The analyses of variance were generated and the effect and regression coefficients of individual, quadratic and interaction terms were determined. The significances of all terms in the polynomial were judged statistically at a probability (P) of lower than 0.05 ($P<0.05$). The regression coefficients were then used to make statistical calculation to generate contour map and response surface graphs from the regression models.

Recycling Procedure

In each experiment of recycling of used PET plastic on asphalt,500g of mixed of the cooked sample were used to get information about Gravity at 27°C, Penetration at 25°C, 100g 5sec in 1/100mm, Softening point (°C) and Flash Point (°C).

Table2:- Influences of Asphalt, PET, mixing temperature and mixing time on the responses of recycling used plastic on asphalt.

Run No	Gravity (g/cm³)	Penetration at (25°C, 100g 5sec in 1/100mm)	Softening point (°C)	Flash Point (°C)
1	1,06	58	48	245
2	1,06	58	48	245
3	1,06	58	48	245
4	1,10	44	55	258
5	1,03	67	46	235
6	1,03	67	46	235
7	1,10	44	55	258
8	1,08	53	50	252
9	1,05	60	48	243
10	1,05	60	48	243
11	1,10	52	54	255
12	1,08	53	50	252
13	1,04	66	46	240
14	1,08	52	53	254
15	1,04	62	47	236
16	1,04	62	47	236
17	1,07	57	53	248
18	1,05	60	47	240
19	1,08	52	53	254
20	1,05	62	47	242
21	1,09	55	49	246

Results and Discussion:-

The influence of operating parameters (Asphalt, PET, Mixing Temperature and Mixing Time) on the recycling of PET in the asphalt was determined. The finding was provided in Table2. The models linked singular factors, quadratic and interactions of the parameter effects to response variables were consisted of:

(6) $Y_{SG} = 22{,}8 - 0{,}022\ X_1 + 0{,}0249\ X_2 - 0{,}250\ X_3 - 0{,}1986\ X_4 + 0{,}00169\ X_1{*}X_1 + 0{,}000291\ X_2{*}X_2 + 0{,}000710\ X_3{*}X_3 + 0{,}000179\ X_4{*}X_4 - 0{,}00000\ X_1{*}X_2 + 0{,}00000\ X_1{*}X_3 + 0{,}00000\ X_1{*}X_4 - 0{,}000158\ X_2{*}X_3 + 0{,}000121\ X_2{*}X_4 + 0{,}001229\ X_3{*}X_4$

(7) $Y_P = -282_1 + 3{,}8\ X1 + 26{,}7\ X_2 + 31{,}8\ X_3 + 27{,}5\ X_4 - 0{,}29\ X_1{*}X_1 - 0{,}1108\ X_2{*}X_2 - 0{,}086\ X_3{*}X_3 - 0{,}032\ X_4{*}X_4 + 0{,}000\ X_1{*}X_2 - 0{,}000\ X_1{*}X_3 - 0{,}000\ X_1{*}X_4 - 0{,}1571\ X_2{*}X_3 - 0{,}121\ X_2{*}X_4 - 0{,}165\ X_3{*}X_4$

(8) $Y_{SP} = 1024 + 0{,}8\ X_1 + 0{,}04\ X_2 - 11{,}27\ X_3 - 7{,}92\ X_4 - 0{,}060\ X_1{*}X_1 + 0{,}0888\ X_2{*}X_2 + 0{,}0334\ X_3{*}X_3 + 0{,}0599\ X_4{*}X_4 + 0{,}0000\ X_1{*}X_2 - 0{,}000\ X_1{*}X_3 + 0{,}000\ X_1{*}X_4 - 0{,}0079\ X_2{*}X_3 + 0{,}0425\ X_2{*}X_4 + 0{,}0323\ X_3{*}X_4$

(9) $Y_{FP} = 1222 - 0{,}8\ X_1 + 6{,}80\ X_2 - 11{,}6\ X_3 - 7{,}8\ X_4 + 0{,}061\ X_1{*}X_1 - 0{,}0518\ X_2{*}X_2 + 0{,}0335\ X_3{*}X_3 + 0{,}0067\ X_4{*}X_4 - 0{,}000\ X_1{*}X_2 + 0{,}000\ X_1{*}X_3 - 0{,}000\ X_1{*}X_4 - 0{,}0235\ X_2{*}X_3 - 0{,}0426\ X_2{*}X_4 + 0{,}0506\ X_3{*}X_4$

With, $Y._{SG}$: Gravity; $Y._P$: Penetration; $Y._{SP;}$ $Y._{FP}$: Flash Point; X_1: Asphalt; X_2: PET; X_3: Mixing Temperature and X_4: Mixing Time.

The results of the analysis of variance, goodness of fit and the adequacy of models are summarized in Table 3. The data showed a good fit with the equation5, which were statistically acceptable at $P < 0.05$ level. The values of coefficient of determination (R^2) for the SG, P, SP and FP are respectively 93,39%; 96,19%, 98,46% and 97,48%. These values of R^2 showed that the proposed models of all responses are adequate. In fact, it was suggested that, for a good fit of a model, R^2 should be at least 80.0% **[19].** On the one hand, it was reported that the closer the value of R^2 to the unity, the better the empirical models. On the other hand, the absolute average deviation (AAD), bias factor (B_f) and accuracy factor (A_f) must be including the range of 0-0.3; 0.75-1.25, and 0.75-1.25 respectively **[14].** According to table3, the values for, SG, P, SP and FP confirm the adequacy of the models. So, the models could be used to generate surface response curves to explain the influence of the independent factors on the responses studied.

Table3:- Regression coefficients, coefficient of determination (R^2), absolute average deviation (AAD), bias factor (Bf) and accuracy factor (Af) for the four responses of PET recycling.

Coefficient/factors	Specificity Gravity(g/cm³)	Penetration (25°C, 100g 5sec in 1/100mm)	Softening Point (°C)	Flash Point (°C)
CONSTANTE	1,0532	59,29	48,026	244,69
FACTORS	**P VALUES**			
X1	1,000	1,000	1,000	1,000
X2	**0,000**	**0,000**	**0,000**	**0,000**
X3	0,498	0,883	**0,027**	0,388
X4	0,267	0,124	**0,009**	0,298
X1*X1	0,780	0,822	0,878	0,934
X2*X2	0,453	0,203	**0,009**	0,285
X3*X3	0,191	0,435	0,328	0,589
X4*X4	0,735	0,774	0,118	0,917
X1*X2	1,000	1,000	1,000	1,000
X1*X3	1,000	1,000	1,000	1,000
X1*X4	1,000	1,000	1,000	1,000
X2*X3	0,745	0,164	0,801	0,691
X2*X4	0,810	0,282	0,223	0,494
X3*X4	0,110	0,283	0,478	0,549
R^2	**93,39%**	**96,19%**	**98,46%**	**97,48%**
AAD	**0,00**	**0,02**	**0,01**	**0,00**
B_f	**1,00**	**1,00**	**1,00**	**1,00**
A_f	**1,00**	**1,02**	**1,01**	**1,00**

P<0.05/ AAD, 0-0.3 / B,0.75-1.25/ A_f, 0.75-1.25

Specific Gravity

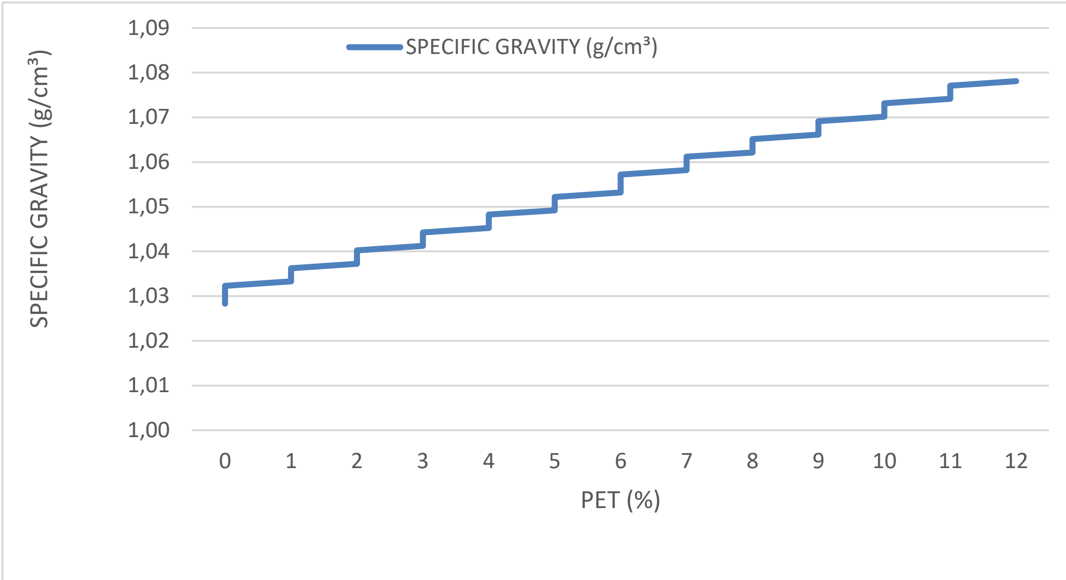

Figure 2:- Variation of specific gravity as function of PET.

Response surface plots and the model constants for SPECIFIC GRAVITY value of recycling waste PET on asphalt are presented in Figure2. It is clearly observable that the specific gravity increased significantly (P=0.000, Table3) from 1,03 to 1,08 g/cm³ as the PET ratio increased from 0 to 12%, that's a 4,7% increase.

The increased of specific gravity of asphalt, was probably one the hand, due to, the asphalt consistency was greatly influence when asphalt ratio increased. On the other side, this increased can be explained by the added of more quantity of impurities (PET). Our results corroborate those published else where a similar trend was observed **[20].**

Penetration

Response surface plots and the model constants for PENETRATION value of recycling waste PET on asphalt are presented in Figure3. It was clearly observable that the PENETRATION decreased greatly (P=0.000, Table 3) from 82*(1/100mm) to 33*(1/100mm) as the PET ratio increased from 0% to 12%, that's a 40% decrease.

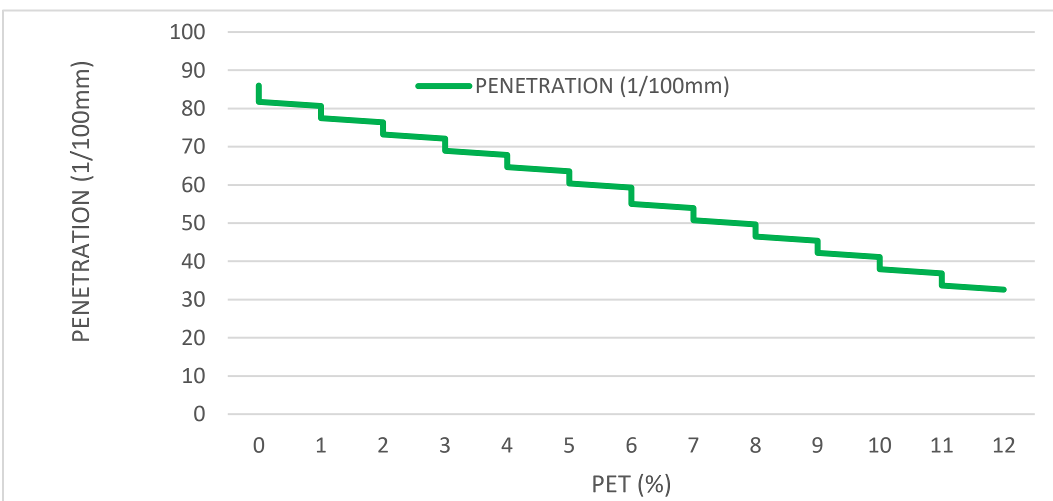

Figure 3:- Variation of penetration as function of PET.

This decreased value of penetration was probably because of the PET influence on asphalt, which increased the stiffness of asphalt binder. The great decreased in penetration with the increase of PET ratio could be attributed to the transformation of binder to be less susceptible to temperature and to resist from deformation. In addition, the presence of plastic increases the hardness of the bitumen, which causes it to change grade from high to low grade **[3, 21].**

Softening Point

Response surface plots and the model constants for SOFTENING POINT value as function of, mixing time and mixing temperature and PET are presented in Figure4 and figure5. It was observable that on the one hand, the SOFTENING POINTdecreased greatly (P=0.027, Table 3) from 57°C to 37°C as the mixing temperature increased from 150°C to 160°C. At the same moment, softening point decreased with an increase on mixing time (P=0.009, Table 3). This situation can be explained by the non-Newtonian fluid behave of asphalt. In fact, at low temperature and brief mixing time, asphalt was more consistency so their softening point get up. However, when their mixing temperature and time increased, this induces a disordered moving of the electrons contained in the latter, causing the bitumen to lose its consistency and become very soft, therefore its softening point decreased.

On the other hand, the SOFTENING POINT slightly decreased (P=0.000, Table 3) from 48,05°Cto 48,02°C as the PET ratio increased from 0% to 5%, then slightly increased up to 48,15°C when PET ratio tends to 12%. The slightly decreased of softening point was probably caused by conjugate effect of mixing temperature and mixing time on the mix asphalt-PET. It was evident, that the increased of this conjugate effect reduce the consistence of asphalt, so the later lose their ability to bind plastic PET. Furthermore, the increased of softening point with the increase of PET ratio, provides sufficient evidence that bitumen hardens and therefore becomes a less sensitive binder face of climatic hazards, especially in the face of increases in ambient temperature. Those results confirm the published litterateur review, where similar remarks were observed **[21, 22].**

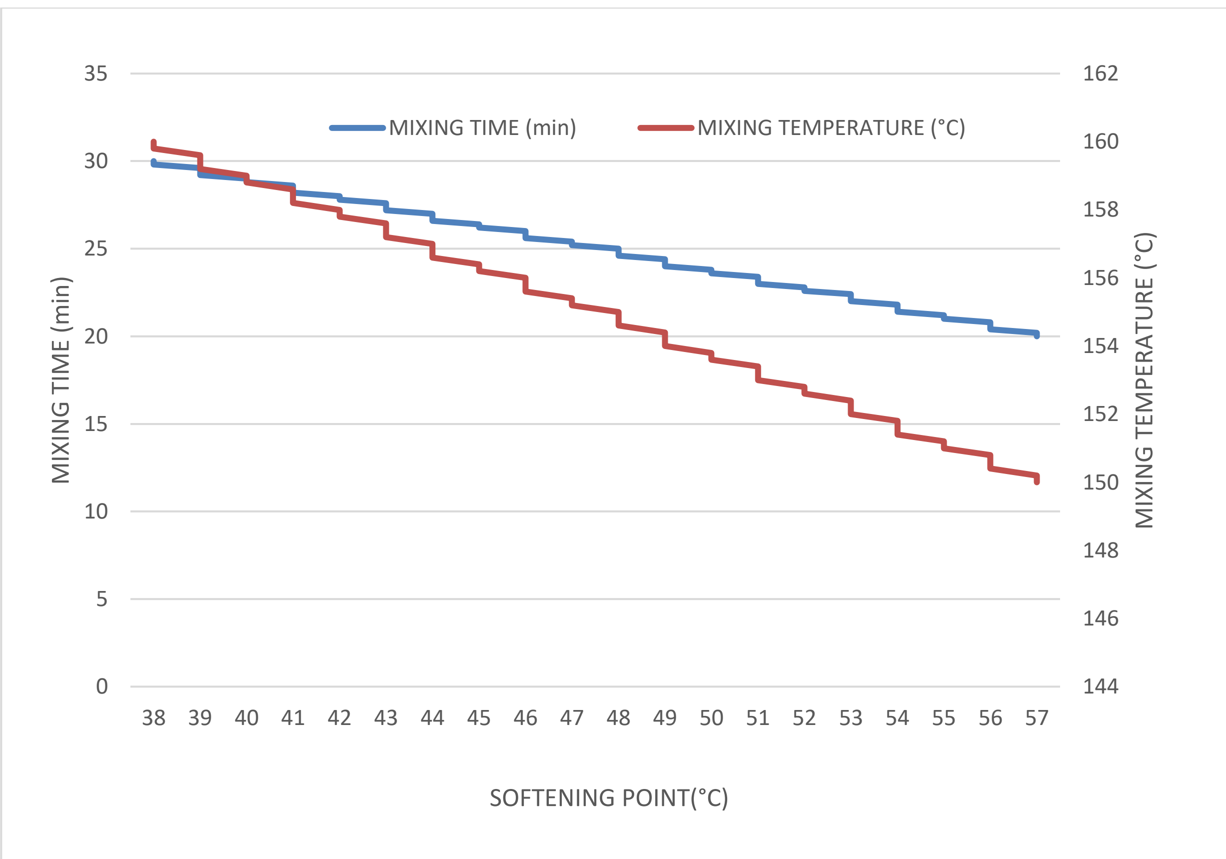

Figure 4:- Variation of softening point as function of mixing time and mixing temperature.

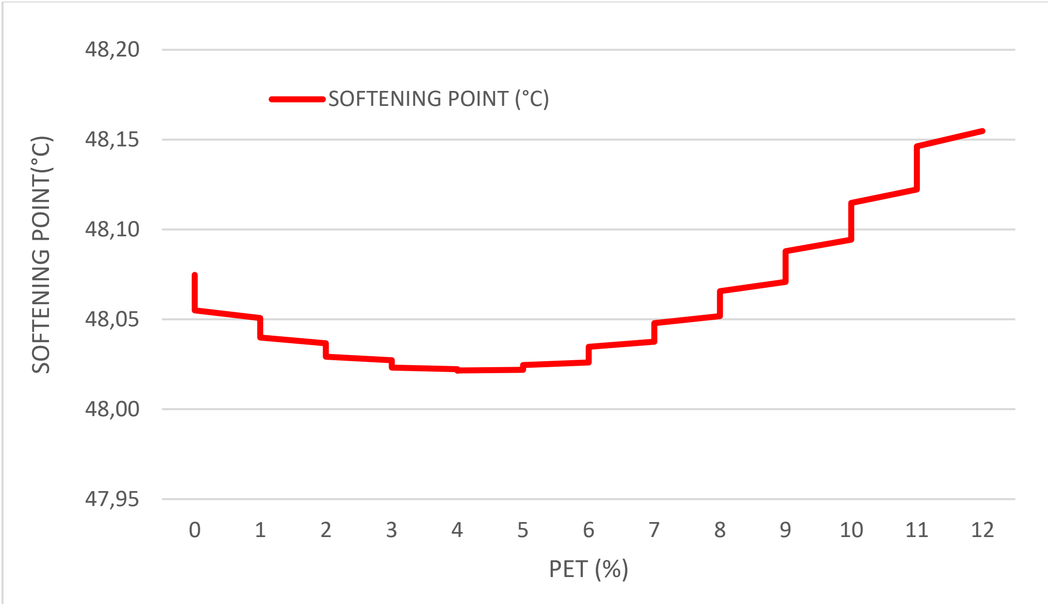

Figure 5:- Variation of softening point as function of PET.

Flash Point

Response surface plots and the model constants for FLASH POINT value of recycling waste PET on asphalt are presented in Figure6. It is It is clearly observable that the FLASH POINTincreased (P=0.000, Table 3) from 238°C to 251°C as the PET ratio increased from 0 to 12%. That's an increase of 5,17%.

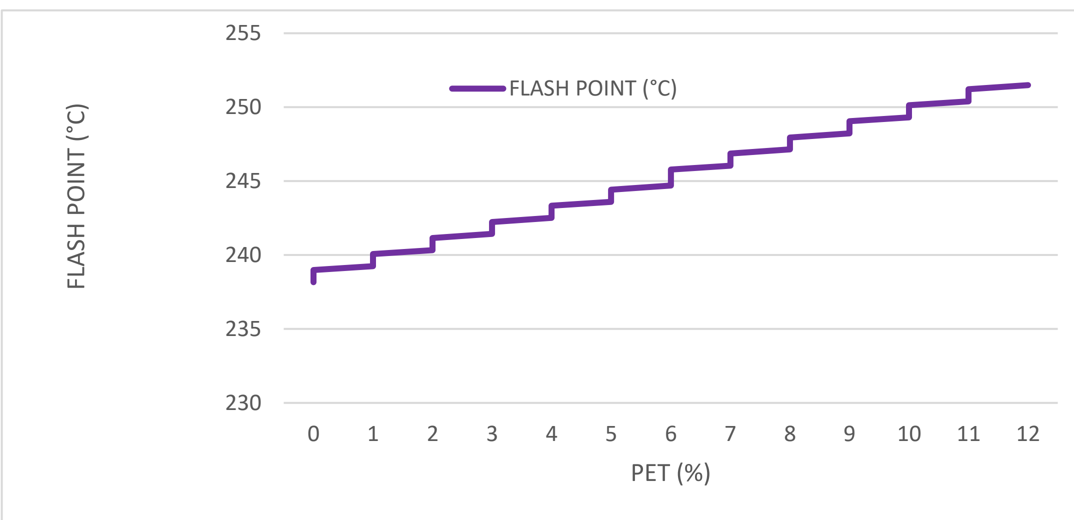

Figure 6:- Variation of softening point as function of PET.

The increased of flash point with the increase of PET ratio was evidently due to the less sensitize temperature of the mix asphalt. In fact, when the temperature increased, asphalt viscosity decreases greatly, up to lose their binder ability to maintain plastic with adequate way, so powder plastic fall by gravity effect, and forms a deposit. This escapes the volatile amount of asphalt to get way. Therefore, the flash point increased. This fact confirms previous research on this subject **[20].**

Optimization

With the aim to point out the optimal conditions PET recycling on asphalt concrete, a graphical optimization was conducted using Sigma Plot Software **[23].** Such a methodology consists of overlaying curves of the four contour plots obtained from the Doehlert experimental design according to the specific criteria imposed. The optimum conditions were defined in order to get best way and better understanding of recycling of PET on Asphalt requirements (table4).

Table 4:- Physic and chemical characteristics of plain asphalt.

Asphalt characteristic	Specific Density (g/cm³)	Penetration at (25°C, 100g 5sec in 1/100mm)	Softening Point (°C)	Flash Point (°C)
Specification	ASTM D70	ASTM D5	ASTM D36	ASTM D92
Acceptable value	1,0-1,1	60-70	43-56	>230

To achieve the optimal condition of recycling of PET, multi-response optimization was done using Minitab **[24].** SG, P, SP and FP all optimized for this purpose. At the end of this Minitab optimization, the compromise was as follows: Asphalt ratio was 5%, PET ratio was 5% of asphalt substitution, Mixing Temperature was 151°C and Mixing Time was 28min. This combination produced responses were 1,05 g/cm³ as specificity gravity ($Y._{SG}$), 60*(1/100mm) as penetration at 25°C, 100g and 5sec ($Y._{P}$), 50°C as softening point ($Y._{SP}$), and 244°C as flash point ($Y._{FP}$). The composite desirability in the study is 0.84 which was close to 1, indicating in one hand, that the parameters appeared to produce favorable results for all responses as a whole. Individual desirability, on the other hand, indicated that the responses such as SG, P, SP and FP were more effective in term of target, respectively 1; 0,74; 0,99 and 0,67.

Conclusion:-

The goal of this work was to contribute to the valorization of PET on asphalt. By the way, it was difficult to determine the influences of X parameters such as Asphalt, PET, Mixing Temperature and Mixing Time on the physical properties responses (Y), so the need of diversifying process was important. Mixing Temperature is one of essential factor in the design and subsequent production of asphalt mixtures. It was influencing workability of the asphalt mixtures. For that reason, the response surface methodology (RSM) was used to recycle used plastic (PET) on asphalt concrete, which allowed us to define the effects of parameters interaction and their impact on the response such as Specificity Gravity, Penetration, Softening Point and Flash Point. The optimization was consisted to get a good fit according to asphalt characterization norm. The resulted in the quadruplet was: Asphalt 5%, PET rate 5% (obtain by mass substitutionof asphalt), Mixing Temperature 151°C, and Mixing Time 28min. The resulting was 1,05 g/cm³ as specificity gravity ($Y._{SG}$), 60*(1/100mm) as penetration at 25°C, 100g and 5sec ($Y._{P}$), 50°C as softening point ($Y._{SP}$), and 244°C as flash point ($Y._{FP}$).

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