Strategy of optimization by the method of experience and application plans to the wear resistance steel « hydrogenated »

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Abstract-*The work presented in this study focus on the application of the method of the plans of experiences (MPE) to the study and the optimization of the quantification of the wear of the steels (XC48, A60) under the effect of a factor of environment in the Occurrence Hydrogen. Modeling can draw inspiration from the mathematical models established by the (MPE) in order to analyze more deeply the phenomenon of the wear while taking account of the various relevant factors The Governing [1].*
This analysis may be qualitative :study of "screning" (determination of influential factors) or quantitative :methodology of the surfaces of answers (variation of responses according to the influential factors).In all cases ,it has for the purpose of determination of mathematical models approached the answers expressed in terms of the factors .These models are deducted from the values obtained of series of experiments .The definition of these plans of experiences determines the measurable quality of models. The multiple facets of the MPE are then used as the basis for the development of strategy to optimize [2,3].

Key words :The methods of the plans of experiences, Methodology response surfaces, optimization, distributed calculations, wear, hydrogen.

1. INTRODUCTION

One of the major issues of the Tribology is to control the friction and wear of the parts. In effect, the friction and wear which manifest themselves negatively to the good operation of assemblies and mechanical mounts and which generate resistance to displacement, the losses by friction, the energy dissipation, the elevation of temperature, the noise; thus causing adverse effects such as loss of rating, the loss of function[4] ;The emission of debris, the pollution of the environment, the plugging of the interfaces, the alteration of the mechanical properties of the components, the fluctuation of friction, the degradation of the surfaces and the seizing [5,6,7,8].In order to increase the reliability of the friction parts and the duration of life of tools, engineers often offer solutions to the level of the optimization of the design, the choice of materials and surface treatments and the lubrication. The issue security and economic machinery often requires prior validation by tests on front bench to integrate the new solution In this sense, it has developed experimentally our work to determine the evolution of the wear in function of the parameters of services such as the contact force between the two surfaces, the speed of relative movement of the two surfaces,the nature of the material of the workpiece (surface) under the effect of the few environmental elements such as hydrogen with respective impacts to hydrogen embrittlement,and the duration of operation [9,10].

2. EXPERIMENTATION

2.1 Materials The test parts

II.1.1 pawn wiper arm

Quick steel upper " ARS" type HS2-9-2:

C% = 0.95 to1.05; If%=0.70; Mn%=0.4 ;p%= 0.03 ;S%=0.03; Cr%= 3.50 to 4.50; MB%= 8.20 to 9.20; V%= 1.70 to 2.20; W%= 1.50 to 2.10.

(Hardness after quenching 68HRC = 1150 to 1200 daN/mm^2)

The steels used are (x1): A60 (New standard E 335 Re=335MPa, Rm=600MPa of Vickers hardness HV =118) and XC48 (New Grade C45- Re =375 to 580 MPa , rm=710 MPa

A% = 15 and Vickers hardness HV =224) [NF EN 10027-1].

2.2 Testing Time

It is chosen equal to one hour after a test "driver", taking into account the condition or the wear is theoretically the lowest and after that the experimental reading of the loss of mass is significant .

The test condition is established to:

X_1 (hardness)=1…..………...equivalent to118 HV

X_2 (speed)=+1……….…….equivalent to 0.4 m/s

X_3 (load)=+1………..….equivalent to 20 Newtons

X_4 (timeofloading)=-1……...equivalent to 2 hours

-the speed of sliding (X2) is selected on the machine in strokes per minute (C/min) but it is converted into meters per second (m/s) or [V(C/min) x 2L(M)] /60s (L is the length of the distance travelled by the Pin Wiper arm between the two points "death" of sliding) and which is 02 Levels 0.08 and 04 "m/s"

-The load (X_3) is in Newton is to 02 Levels 5 and 20 Newtons

-The loading time in hydrogen(X_4) is to 03 levels (2,4 and 6 hours) which is done by electrolysis of a solution of H_2SO_4 10% of concentration.

2.3 Results of tests performed on the samples « hydrogenated »

(experimental values of losses in mass (in gram) of samples loaded in hydrogen (H_2)):

Table 1 : experimental values of losses in mass

(X_1)		(X_2)		(X_3)		(X_4)		Y_1	Y_2	Y_3	$\overline{Y}$
118	-	0.08	-	5	-	2	-	0.0062	0.0069	0.0071	0,00673333
118	-	0.08	-	5	-	6	+	0.0080	0.0078	0.0082	0.008
118	-	0.08	-	5	-	4	0	0.0075	0.0071	0.0077	0,00743333
224	+	0.4	+	20	+	2	-	0.0112	0.0118	0.0109	0,0113
224	+	0.4	+	20	+	6	+	0.0113	0.0119	0.0110	0,0114
224	+	0.4	+	20	+	4	0	0.0115	0.0121	0.0111	0,01156667
118	-	0.08	-	20	+	2	-	0.0127	0.0130	0.0122	0,01263333
118	-	0.08	-	20	+	6	+	0.0140	0.0138	0.0135	0,01376667
118	-	0.08	-	20	+	4	0	0.0135	0.0136	0.0130	0,01336667
118	-	0.4	+	5	-	2	-	0.0090	0.0101	0.0104	0,00983333
118	-	0.4	+	5	-	6	+	0.0108	0.0098	0.0101	0,04263333
118	-	0.4	+	5	-	4	0	0.0095	0.0083	0.0090	0,00893333
224	+	0.08	-	5	-	2	-	0.0048	0.0052	0.0061	0,00536667
224	+	0.08	-	5	-	6	+	0.0050	0.0047	0.0049	0,00486667
224	+	0.08	-	5	-	4	0	0.0055	0.0061	0.0058	0.0058
224	+	0.4	+	5	-	2	-	0.0065	0.0060	0.0069	0,00646667
224	+	0.4	+	5	-	6	+	0.0066	0.0069	0.0070	0,00683333
224	+	0.4	+	5	-	4	0	0.0064	0.0071	0.0068	0,00676667
224	+	0.08	-	20	+	2	-	0.0085	0.0090	0.0080	0.0085
224	+	0.08	-	20	+	6	+	0.0093	0.0097	0.0101	0.0097
224	+	0.08	-	20	+	4	0	0.0091	0.0085	0.0088	0,0088
118	-	0.4	+	20	+	2	-	0.0159	0.0151	0.0161	0.0157
118	-	0.4	+	20	+	6	+	0.0170	0.0177	0.0173	0,01733333
118	-	0.4	+	20	+	4	0	0.0161	0.0168	0.0159	0,01626667

2.4 Calculation of regression following the order of the table for the calculation of the plan: type (2^3 3^1)

In statistiques, the **method of the surfaces of answers (MSR)** aims to explore the relationships between he variables dépendantes and indépendantes involved in a expérience. It is due to the work of 1951 George Box and K.B. Wilson. The main idea of their method is the use of a sequence of experiments. Box and Wilson suggest to use a template to polynôme second degré, but concede that this model is only an approximation. However, the latter has the advantage of being easy to estimate and to apply, even when the information available on the current process is minimal.

*-Plan of experience of the compound type 2K 3K':*This type is used when it is expected the effects of quadratic a few parameters among the other as we can for example dissociate a plan of type 3^5 with (243 experiences), to a plan consisting of (23 . 32) with (72 experiences) or even simplify to a reduced plan of type23-1 of or the plan composed of (22 .32) with (36 experiences). With the coefficients B_0=Y-2/3B_{11}

X_1	X_2	…	Xn	Answer: Y
X_{11}	X_{12}	…	X_{1n}	Y_1
⋮	⋮	⋮	⋮	⋮
X_{n1}	X_{n2}	…	X_{nn}	Y_N

Table 2 : the coded values of the experimental parameters

N°.	X1	X2	X3	X4	X1 X2	X1 X3	X1 X4	X2 X3	X2 X4	X3 X4	X1 X2 X3	X1 X2 X4	X1 X3 X4	X2 X3 X4	X1 X2 X3 X4	X4*	$\overline{Y}$
1	-	-	-	-	+	+	+	+	+	+	-	-	-	-	+	1/3	6,733
2	+	-	-	0	-	-	0	+	0	0	+	0	0	0	0	-2/3	5.8
3	-	+	-	+	-	+	-	-	+	-	+	-	+	-	+	1/3	4,263
4	+	+	-	-	+	-	-	-	-	+	-	-	+	+	+	1/3	6,466
5	-	-	+	0	+	-	0	-	0	0	+	0	0	0	0	-2/3	13,366
6	+	-	+	+	-	+	+	-	-	+	-	-	+	-	-	1/3	9.7
7	-	+	+	-	-	-	+	+	-	-	-	+	+	-	+	1/3	15.7
8	+	+	+	0	+	+	0	+	0	0	+	0	0	0	0	-2/3	11.566
9	-	-	-	+	+	+	-	+	-	-	-	+	+	+	-	1/3	8,000
10	+	-	-	-	-	-	-	+	+	+	+	+	+	-	-	1/3	5,366
11	-	+	-	0	-	+	0	-	0	0	+	0	0	0	0	-2/3	8,933
12	+	+	-	+	+	-	+	-	+	-	-	+	-	-	-	1/3	6,833
13	-	-	+	-	+	-	+	-	+	-	+	-	+	+	-	1/3	12,633
14	+	-	+	0	-	+	0	-	0	0	-	0	0	0	0	-2/3	8,800
15	-	+	+	+	-	-	-	+	+	+	-	-	-	+	-	1/3	17.333
16	+	+	+	-	+	+	-	+	-	-	+	-	-	-	-	1/3	11.3
17	-	-	-	0	+	+	0	+	0	0	-	0	0	0	0	-2/3	7,433
18	+	-	-	+	-	-	+	+	-	-	+	-	-	+	+	1/3	4,866
19	-	+	-	-	-	+	+	-	-	+	+	+	-	+	-	1/3	9,833
20	+	+	-	0	+	-	0	-	0	0	-	0	0	0	0	-2/3	6,766
21	-	-	+	+	+	-	-	-	-	+	+	+	-	-	+	1/3	13,766
22	+	-	+	-	-	+	-	-	+	-	-	+	-	+	+	1/3	8.5
23	-	+	+	0	-	-	0	+	0	0	-	0	0	0	0	-2/3	16,266
24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1/3	11.4

2.5. Determination of the mathematical model describing the wear of Samples « hydrogenated »

Table 3 : calculation of coefficients of regressions

N°.	X1	X2	X3	X4	X1 X2	X1 X3	X1 X4	X2 X3	X2 X4	X3 X4	X1 X2 X3	X1 X2 X4	X1 X3 X4	X2 X3 X4	X1 X2 X3 X4	Xi*	$\bar{Y}$ *(mg)*
1	-	-	-	-	+	+	+	+	+	+	-	-	-	-	+	1/3	*6,733*
2	+	-	-	0	-	-	0	+	0	0	+	0	0	0	0	-2/3	*5,800*
3	-	+	-	+	-	+	-	-	+	-	+	-	+	-	+	1/3	*4,263*
4	+	+	-	-	+	-	-	-	-	+	-	-	+	+	+	1/3	*6,466*
5	-	-	+	0	+	-	0	-	0	0	+	0	0	0	0	-2/3	*13,366*
6	+	-	+	+	-	+	+	-	-	+	-	-	+	-	-	1/3	*9,700*
7	-	+	+	-	-	-	+	+	-	-	-	+	+	-	+	1/3	*15,700*
8	+	+	+	0	+	+	0	+	0	0	+	0	0	0	0	-2/3	*11,566*
9	-	-	-	+	+	+	-	+	-	-	-	+	+	+	-	1/3	*8,000*
10	+	-	-	-	-	-	-	+	+	+	+	+	+	-	-	1/3	*5,366*
11	-	+	-	0	-	+	0	-	0	0	+	0	0	0	0	-2/3	*8,933*
12	+	+	-	+	+	-	+	-	+	-	-	+	-	-	-	1/3	*6,833*
13	-	-	+	-	+	-	+	-	+	-	+	-	+	+	-	1/3	*12,633*
14	+	-	+	0	-	+	0	-	0	0	-	0	0	0	0	-2/3	*8,800*
15	-	+	+	+	-	-	-	+	+	+	-	-	-	+	-	1/3	*17,333*
16	+	+	+	-	+	+	-	+	-	-	+	-	-	-	-	1/3	*11,300*
17	-	-	-	0	+	+	0	+	0	0	-	0	0	0	0	-2/3	*7,433*
18	+	-	-	+	-	-	+	+	-	-	+	-	-	+	+	1/3	*4,866*
19	-	+	-	-	-	+	+	-	-	+	+	+	-	+	-	1/3	*9,833*
20	+	+	-	0	+	-	0	-	0	0	-	0	0	0	0	-2/3	*6,766*
21	-	-	+	+	+	-	-	-	-	+	+	+	-	-	+	1/3	*13,766*
22	+	-	+	-	-	+	-	-	+	-	-	+	-	+	+	1/3	*8,500*
23	-	+	+	0	-	-	0	+	0	0	-	0	0	0	0	-2/3	*16,266*
24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1/3	*11.4*
Coeff.	B1	B2	B3	B4	B12	B13	B14	B23	B24	B34	B123	B124	B134	B234	B1234	B44	*Sum* $\bar{Y}$
	-1.53	*0. 9*	*2.87*	*-0.023*	*0.037*	*0.4*	*-0.50*	*0.49*	*-1.12*	*0.53*	*-0.22*	*0. 38*	*-0.35*	*0.33*	*-0.58*	*-0.320*	*231.622*

Mathematical model is presented using statistical methods, in the form polynomial, , which is a part of the series of Taylor: y i = β i X i i (x: Matrix of the input data , β = matrix of regression coefficients and Y= matrix of output data)

-Regression.Analysis :

Once the mathematical model obtained (regression equation) , we proceeded to the statistical analysis of the results in order to check the meaning of these regression coefficients and the adequacy of the modeled ,according to the algorithm of box-Wilson[11]:

The mathematical model global describing the wear (Y) in function of the parameters influential and of their interactions:

Y(Xi)=231,87-1,53x1+0,9X2+2,87X3-0,023X4+0,037X1X2+0,4X1X3+0,17X1X4+0,49X2X31,12x2x4+0,53X3X4-0,22X1X2X3+0,38X1X2X4-0,35x1x3x4+0,33X2X3X4-0,58X1 X2X3-0.32X42…………………………………….....(1)

2.6. Variance of reproducibility [11]

$$S2rep= \frac{\sum_{i=1}^{N} S_i^2}{N}$$

S2rep= [(34.1/24]=1.42

2.7. Values of the distributions of the regression coefficients [11]

$$S^2(BI)= \frac{S_{rep}^2}{N \cdot m}$$

S2 (BI)= [1.42]/ 24*3= 0,0197

2.8.test of "student" [11]

The **Student t test**, or **test *t***, is a set of tests d'hypothèse where parametric statistics calculated follows a loi de Student when thehypothèse nulle is true. A Student t test can be used in particular to statistically test the assumption of equality of the hope of two random variables following a normal law and variance unknown. It is also very often used to test the nullity of a coefficient in the framework of a régression linéaire[12].

$-t_{(\alpha, fy) = [\alpha=0.05, N(M-1)]} = T_{(\alpha, fy)} = t_{[\alpha=0.05, 48]=2,0086}$

Acceptable coefficient must be greater than or equal to | BI:|
T, $fy_{,\alpha}$. *S2* (BI) =| bi | = 2,0086 0,0197*=0,0396

-Considering only the regression coefficients significant, the model will have the form:
Y(Xi)=231,87-1,53x1+0,9X2+2,87X3+0,4X1X3+0,17X1X4+0,49X2X3-1,12x2x4+0,53X3X4-0,22X1X2X3+0,38X1X2X4-0,35x1x3x4+0,33X2X3X4 -0,58X1 X2X3X4-0,32 x42 ……………….……(1.1)

2.8.Test of Cochrane [11]

Gmax = $\frac{S^2(\max)}{\sum_{i=1}^{N} S_i^2}$ = (0.028 / 3.41) =0, 0082

Lower than the factor of theoretical Cochrane GTH =0,1907 [Table 2 Annex] for (M=3 and n=24) which leaves us say that the dispersions are "homogeneous".

2.10.Test of Fischer [11] :

The test Fisher, or F-test, is a test d'hypothèse statistic that allows you to test the equality of two variances by making the report of the two variances and verifying that this report does not exceed a certain theoretical value that is sought in the table de Fisher (or a table of Snedecor).

Fexp = $\frac{S_{rés}^2}{S_{rep}^2}$

Note: For the test we place the numerator the larger of the two variances.

If on the contrary we place the numerator the smaller of the two, the report F can be expressed as a percentage. For example a F of 94% or 0.94 means that the two variances are very close[12].

Total (Ŷ-Ymoy)2 = 11922046,3 Mg2

Fexp = $\frac{S_{rés}^2}{S_{rep}^2}$

$S^{2res} = \frac{\sum_{i=1}^{N} (\hat{Y}_{iu} - \overline{Y}_i)^2}{N-L}$

Or is the number of the coefficients are significant

It is recalled that the unit of this sum ($\overline{Y}$ -Ŷ)^2 is in Mg2

(multiplied by 10-6)..for the conversion of the unit in GR2

S^{2res} = [11,9220463/ (24-15)]= [11,9220463/ 9]= 1,324

And beyond it is deduced that the factor of "Fischer "Experimental (Fexp) of the relationship:

Fexp= (1,324 / 1.42)= 0,932

Fth (factor of theoretical Fischer is "pulled" of Table 3 Annex

Fth is the point whose coordinates are F1 = N-L and F2=N (M-1)

-f1=10 and F2 = 48 and after the table of Fischer F2= 48 is between the values

Remarkable of F2 (40 and 60) which gives with F1 =10 The 02 fth values = (1.99; 2.08), which allows us to say that Fexp < fth where the mathematical model describes the phenomenon in a proper manner.

3. GRAPHS AND DISCUSSIONS

3..1. First case

If it maintains the two parameters(X_1; X_2) constant at their average values , the model will have the form : $Y(X_3 , X_4)$ and a response surface (*Figure1*):

$Y(X_3,X_4)=231,87+2,87X_3+0,53X_3X_4 -0.32X_4$ …………………………………..………..(1.1.1)

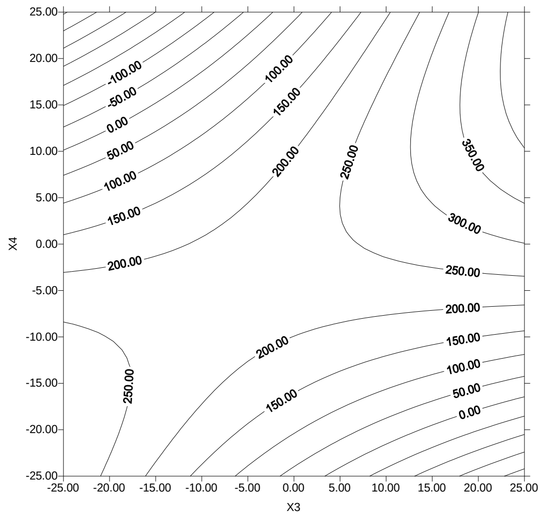

Figure 1-1 : effect of the load and the time of loading in hydrogen on the Wear

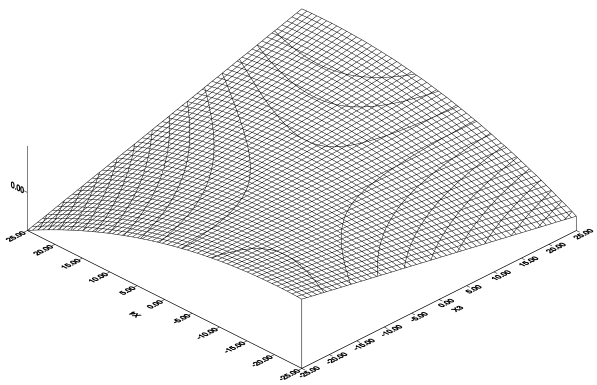

Figure 1-2 : effect of the load and the time of loading in hydrogen on the Wear

There is in this figure that with an increase in the load between [20 to 6.2] newtons and with a variation of the loading time of [2 to 3.36] hours, wear decreases non linearly and slowly. She believes linearly and quickly when the loading time decreases of 6 to 5.52 h with an increase in the load from 5 to 8n; while it grows non linearly and quickly to a variation of 5.52 to 3,76h with a decrease in load from 8 to 45,65N.it decreases non linearly and slowly when the load rises from 16.4 to the maximum load 20N with a decrease of the loading time of 6 to 3,76h, it also increases linearly and rapidly with the increase of the loading time of 2 to 2.36 hours simultaneously with the decrease of the load of 20 to 16,4N then it grows non linearly and rapidly from 16.4 up to 7,7N at the time Where the loading time goes from 2.36 to 3.8 hours.

The overall pace of the graph tends toward an optimum point which is a "minimax" whose coordinates are (10.54 N; 3.56 h) where is worth 0,2779 g.

3.2. Second case

If it maintains the two parameters (X_1; X_3) constant at their average values , the model will have the form $Y(X_2 , X_4))$ and a response surface (*Figure2*):

$Y(X_2,X_4)=231,87+0,9X_2-1,12X_2X_4-0,32X_4$ ……………………...……..…………...(1.1.2)

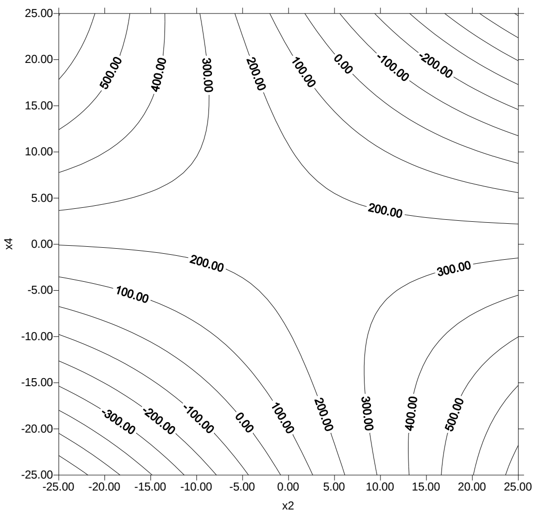

Figure 2-1 : Effect of speed and the time of loading in hydrogen on the Wear

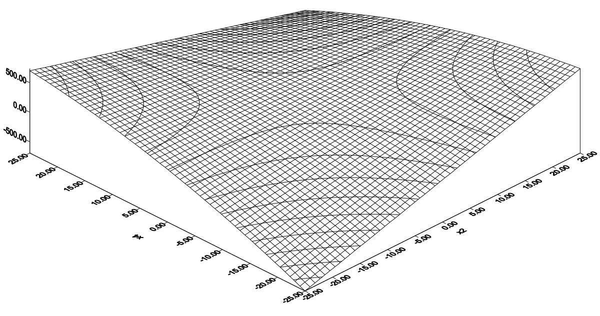

Figure 2-2 : Effect of speed and the time of loading in hydrogen on the Wear

The fall of the speed of 0.4 to 0,304m/s and the increase of the loading time of 2 to 3,84h results in a decrease non-linear and slow the wear of same as when the speed increases from 0.08 to 0,179m/s with a reduction of the loading time of 6 to 4,24h .while the wear believes linearly and quickly to a simultaneous increase of speed between 0.08 and 0,124m/s and the time of loading of 2 to 2,32h; the wear continues to grow non-linearly and slowly and the speed 0,124 to 0,281m/s with an increase of the loading time of 2.32 to 4h ,the wear believes linearly and quickly to a decrease in the speed of 0.4 To 0,352m/s continues but in a non-linear and slow when the speed decrease of 0.352 to 0,201m/s with the decrease of the loading time of 5.6 to 4,2h.

In this case the wear has an optimum point which is a minimax to Real Coordinates (0.23 m/s; 4.06 h) or it is equal to the value of 0,2257 g.

3.3. Third case

If it maintains the two parameters (X_1; X_4) constant at their average values , the model will have the form $Y(X_2 , X_3)$ and a response surface (*Figure 3*):

$Y(X_2,X_3)=+0,9231,87X_2+2,87X_3+0,49X_2X_3$ ……..……………………………..…..(1.1.3)

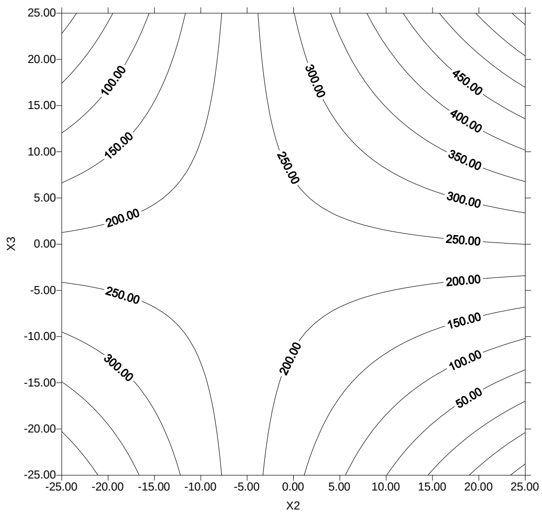

Figure 3-1 : effect of the speed and load on the Wear

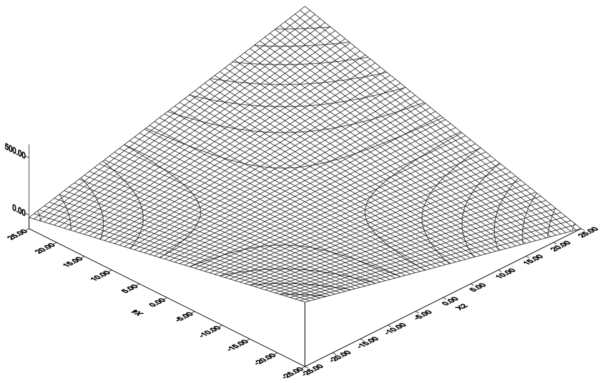
Figure 3-2 : effect of the speed and load on the Wear

This graph we see that the Wear increases not linearly and slowly when the speed decreases from 0.4 to 0.22m/s with a decrease in load of 11.6 to 5n, this outline of the wear is repeated when the speed increases from 0.08 to 0,188m/s and at the same time or the load decreases from 20 to 18,2N.

The wear drops non linearly and slowly with the decrease in the speed of 0,4m/s at 0,214m/s and the fall of the load of 20 to 12.5N, this configuration is reproduced with the decrease of the load between 11.3 and 5N and an increase in the speed of 0.08 to 0,192m/s. This representation shows that the Wear has a point of optimum of actual coordinates (0.203 m/s; 11.95 N), which is a Minimax or its value is 0,2673 g.

3.4. Fourth Case

If it maintains the two parameters (X_2; X_3) constant at their average values , the model will have the form ($Y(X_1 , X_4)$) and a response surface (*Figure 4*):

$Y(X_1,X_4)=231,87-1,53X_1-0,5X_1x4-0.32X4$……………………………………..(1.1.4)

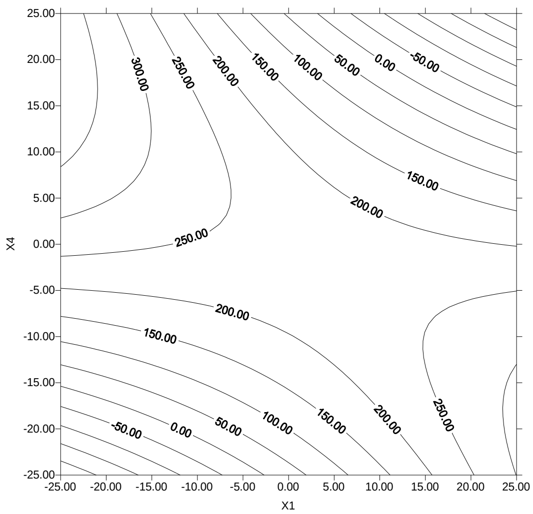

Figure 4-1 : effect of hardness and the time of loading in hydrogen on the Wear

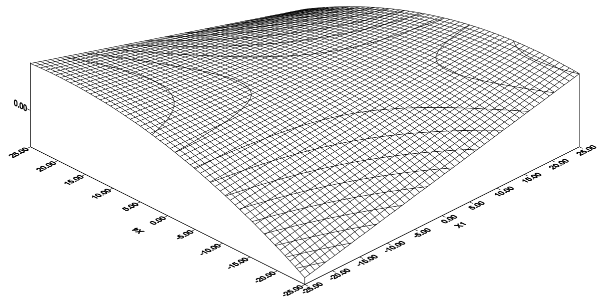

Figure 4-2 : effect of hardness and the time of loading in hydrogen on the Wear

In this case, the Wear presents a optimum point which is a minimax whose coordinates are (179.26 Tax Hv; 3.75 h) or its value is equal to 0.067 g.

The wear believes linearly and quickly with a simultaneous increase in the hardness of 118 to 155.1 HV and the time of loading of 2 to 2,6h , increasing respectively the hardness of 155.1 to 204,92 HV and the time of loading of 2.6 up to 3,6h , the wear continues to grow but in a non-linear and slow ,while it decreases non linearly and slowly with an increase in the load from 118 to 139.2 HV with a decrease in the time of loading of 6 to 3,88H , this decay is also reproduced in the same way for a decrease of the loading time of 3.6 to 2h and a decrease of hardness of 224 to 213.4 HV.

The maximum value of the hardness 224 to 194,32 HV and a decrease in the time to 6 to 5,3h wear quickly believes and linearly and continues its growth but not linearly and slowly for a simultaneous decrease of the hardness of 194,32 145,56 to HV and the time of loading from 5.4 to 4h.

3.5. Fifth Case

If it maintains the two parameters (X_2; X_4) constant at their average values , the model will have the form ($Y(X_1 , X_3)$) and a response surface (*Figure 5*):

$Y(X_1, X_3)= 231,87-1,53X_1+2,87X_3 +0 ,4X_1X_3$ ……………………………….…………..(1.1.5)

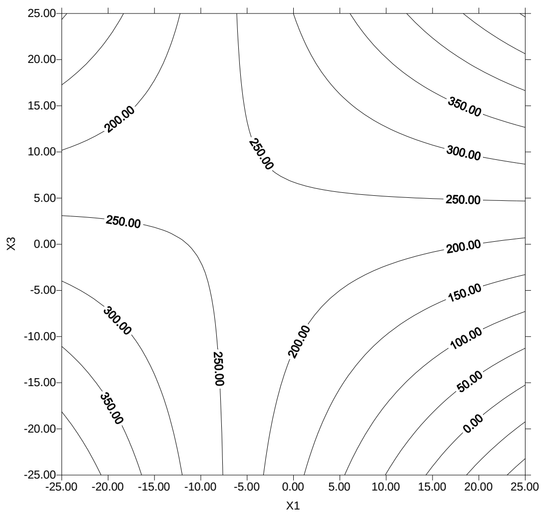

Figure 5-1 : effect of hardness and of the load on the Wear

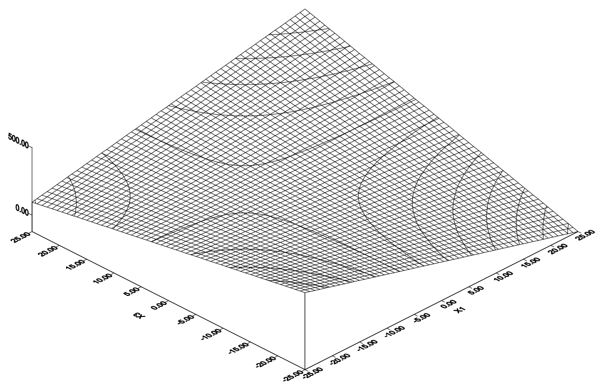

Figure 5-2 : effect of hardness and of the load on the Wear

Of this graph, one observes a non-linear growth and slow the wear when the hardness increases the load of 5to 12.72 N and the hardness decreases from 224 to 163,58 HV , the evolution of the 'wear remains in the same manner when the hardness drops of 144.5 to 118 HV with a decrease of the load of 20 to 15.5 N; however the wear decreases non and non-linearly and slowly for a simultaneous increase and respective of the hardness and the load between [118; 155.1] HV and [5 ;13.4]n and also when the hardness and the load decrease respectively of 224 to 158,28 HV and 20 to 14 N.

The wear is equal to 0,8825 g at the optimum point of coordinates (155,79 HV; 13.64 N) characterizing a minimax.

3.6. Sixth Case

If it maintains the two parameters (X_3; X_4) constant at their average values , the model will have the form ($Y(X_1 , X_2)$) and a response surface (*Figure6*):

$Y(X_1,X_2)=231,87-1,53X_1+0,9X_2$ ……………………………………………..(1.1.6)

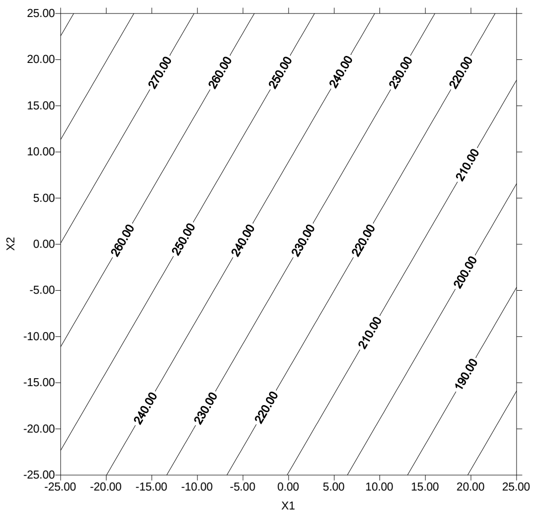

Figure 6-1 : effect of hardness and speed on the Wear

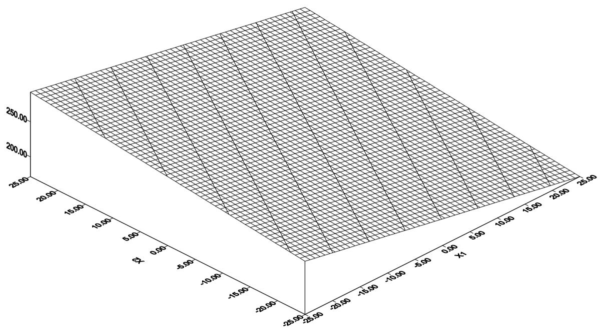
Figure 6-2 : effect of hardness and speed on the Wear

In this case, the graph presents no optimum and the wear increases continuously and rapidly with the decrease of the hardness and the increase in the speed.

4 CONCLUSION

In s interesting to the effect that can cause the environment settings (hydrogen and sea water) on the wear of steels consider and at the end of the bibliographic research among the different work related to the wear of materials of mechanical construction and following the various tests (sixty twelve " 72 = 24 x 3 readings") carried out at the experimental component of the thesis, it has been observed that the wear is and will remain a phenomenon difficult to quantify and control but very possible to mitigate by bringing a few optimal regulations on the influential parameters on this phenomenon as (hardnesses of parts in contact , speed of service relating between parts in contact, the loads applied to the contact surfaces and [The duration of loading in hydrogen] of the contact surfaces) .

The experimental study has allowed us to establish the relationship of these parameters with the wear is the Express by a mathematical model resulting from a statistical method of planning of experiences;
This model is represented graphically in laying down in each case two parameters among the four considered to their average value in order to allow us the visualization of the effect that can apply the other two parameters not set, this operation we offered six graphs of the six probable cases called "Surface of response "allowing us to observe the following:

- In five of the six cases observed , the wear has an optimum point which is a "mini max" that one can calculate these coordinates by numerical methods (Method of Cramer…)[11,12].
- The actual values of the factors influencing the wear equivalent to the coordinates "coded" "mini max" allows you to point out that the wear is the most important in the vicinity of the average values of different factors

- The wear is proportional with the speed, the load and the duration of loading in hydrogen, but inversely proportional with the hardness . (that is to say that the growth of the wear is linked to the growth of the speed , of the load and the duration and that the decrease of the wear is linked to the growth of the hardness) .
- The wear significantly decreases with the simultaneous decrease of the speed and load applied while maintaining a medium hardness and the duration of loading in hydrogen average (see response surface of the sixth case in Figure *VI*) .

- The time of loading in hydrogen associated with each of the other three parameters induced to "minimax" of wear as the note to the (second, fourth and fifth) case and that can only mean the effect weakening of the hydrogen on the contact surface.

- The loading time affects less on wear when the hardness of the material is important as the proves the graphical configuration of the fifth model reduces or wear is the most low (0.067 g) at the optimum point corresponding.

- the effect of the hydrogen on the holding to the wear of steels is linked much more to the hardness of the steel, therefore its metallurgical structure is becoming poorer in carbon when the hardness increases is this interaction can be explained by the decrease in the structural gaps which constitute a home site for small hydrogen atoms responsible for the superficial embrittlement of the steel leading to his bad behavior to wear.

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