

# **STATISTICS AND INDUSTRIAL RESEARCH. OPTIMIZING SIMULTANEOUSLY THE CARATTERISTICS OF A ZIEGLER – NATTA CATALYST**

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## OBJECTIVE AND INITIAL SITUATION

THE **OBJECTIVE** IS **MAXIMIZING**, IN THE RANGE OF EQUIPMENTS CAPABILITY, THE 3 FUNDAMENTAL CHARACTERISTICS OF THE CATALYST.

THE **INITIAL SITUATION** IS THE AVAILABILITY OF 41 BATCHES DATA, ARRANGED AS FOLLOWS:

Batch N.	INDEPENDENT VARIABLES						DEPENDENT VARIABLES		
	X1	X5	X2	X6	X3	X4	Y1	Y2	Y3
21004 - 02 - 2	2	150	0,1	120	30	60	48	98	0,4

## INITIAL DATA EXPLORATION

TO EVALUATE THE DATA GOODNESS, AIMED AT OBTAINING SIGNIFICANT INFORMATIONS FROM SOME KIND OF REGRESSION ANALYSIS, THE FOLLOWING CORRELATION MATRIX HAS BEEN PRODUCED:

	X1	X5	X2	X6	X3
X5	-0,04				
X2	-0,18	0,03			
X6	-0,06	0,34	0,23		
X3	0,02	-0,1	-0,1	-0,5	
X4	-0,02	0,13	0,11	0,42	-0,3

THAT, IN FACT, SHOWS SOME COLLINEARITIES

## MULTIPLE LINEAR REGRESSION ON HISTORICAL DATA

TO HAVE AN IDEA, EVEN IF INSUFFICIENT, ABOUT THE PHENOMENON, BUT, ESSENTIALLY, TO SHOW TO PRODUCTION PEOPLE, IN QUANTITATIVE TERMS, ITS INSUFFICIENCY, A STEPWISE REGRESSION HAS BEEN RUN, WITH FOLLOWING RESULTS:

$$y_1 = 14,5 + 10,4 x_1 + 0,271 x_4 + \varepsilon$$

$$y_2 = 100 + 0,0104 x_4 - 0,0240 x_6 + \varepsilon$$

$$y_3 = 0,387 + 0,000781 x_4 + \varepsilon$$

BEING THE VARIATION INTERVALS OF THE TWO INDEPENDENT VARIABLES, RANGING BETWEEN 2 – 3; 30 – 60; 110 – 120, RESPECTIVELY FOR

$x_1, x_4, x_6$

THESE EQUATIONS, FOR COMPARISON PURPOSES, ARE TRANSFORMED IN TERMS OF STANDARDIZED VARIABLES. THE CAPITAL  $Y$  MEANS THAT WE REFER, NOW, TO THE AVERAGE RESPONSE, FOR THE SAME REASON:

$$X_1 = \frac{x_1 - 2,5}{0,5} \quad X_4 = \frac{x_4 - 45}{15} \quad X_6 = \frac{x_6 - 115}{5}$$

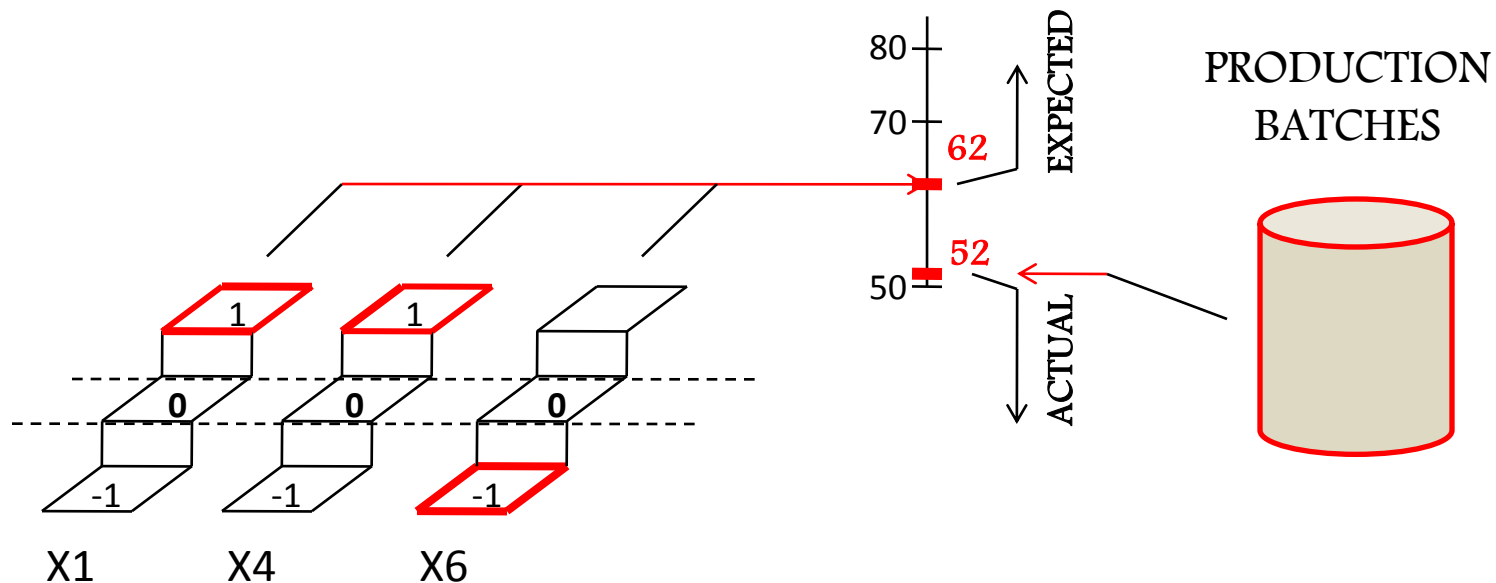
$$Y_1 = 52,695 + 5,2X_1 + 4,065X_4$$

$$Y_2 = 97,708 + 0,156X_4 - 0,12X_6$$

$$Y_3 = 0,422 + 0,011715X_4$$

## COMPARISON BETWEEN EXPECTATIONS AND REALITY FOR Y1

THE QUALITY OF THE CATALYST REQUIRES MAXIMIZING ALL OF THE THREE RESPONSES; HENCE, ON THE BASIS OF PREVIOUS EQUATIONS, THE MAXIMUM OBTAINABLE VALUE WOULD BE **61,960**. BUT, THE PRODUCTION IN THESE CONDITIONS DID NOT CONFIRM, REALLY, THE EXPECTATIONS, WITH DATA AROUND **52,00**.



## WHY?

THE EQUATIONS ARE EVIDENTLY NOT CORRECT, DUE TO SOME VISIBLE COLLINEARITY AMONG INDEPENDENT VARIABLES, LACK IN THE LINEAR MODEL, EXTERNAL CONDITIONS VARIABILITY DURING DATA GATHERING, OR POSSIBLE ERRORS DURING GATHERING AND REGISTRATION OF DATA. DUE TO ALL THESE QUESTIONS IT IS CONFIRMED HOW IT NOT RECOMENDED TO TAKE DEFINITE CONCLUSIONS BY HYSTORICAL DATA.

AN EXPERIMENTAL PLAN TO BE DEVELOPED IN THE PILOT PALNT HAS BEEN, THEN DESIGNED, TAKING INTO CONSIDERATION THE LIMITED AMOUNT OF RESOURCES. (LIMITED AMOUNT OF AVAILABLE TIME).

20 BATCHES HAVE BEEN ALLOWED. CONSIDERING THAT 6 INDEPENDENT VARIABLES WERE OPERATING IT HAS BEEN CHOSEN THE FOLLOWING PLAN:

## EXPERIMENTAL PLAN $2^{6-2}$ WITH 2 CENTRAL PPOINTS

X5	X2	X6	X1	X3	X4	Y1	Y2	Y3
-1	-1	1	-1	1	1	48	98,3	0,442
1	1	1	-1	1	-1	49	98,1	0,422
-1	-1	-1	-1	-1	-1	56	97,9	0,425
-1	-1	1	1	1	-1	58	97,8	0,429
-1	1	1	1	-1	1	55	98	0,41
1	1	-1	1	-1	-1	49	98	0,426
1	-1	-1	-1	1	-1	58	97,9	0,439
1	-1	1	-1	-1	1	42	97,9	0,442
-1	1	-1	-1	1	1	46	98,2	0,436
1	-1	-1	1	1	1	54	98,5	0,416
0	0	0	0	0	0	65	98	0,428
-1	-1	-1	1	-1	1	54	98	0,439
-1	1	1	-1	-1	-1	56	97,9	0,44
1	1	-1	-1	-1	1	49	98,1	0,445
1	1	1	1	1	1	55	98,1	0,42
-1	1	-1	1	1	-1	52	97,5	0,367
0	0	0	0	0	0	65	98	0,428
1	-1	1	1	-1	-1	57	98	0,404

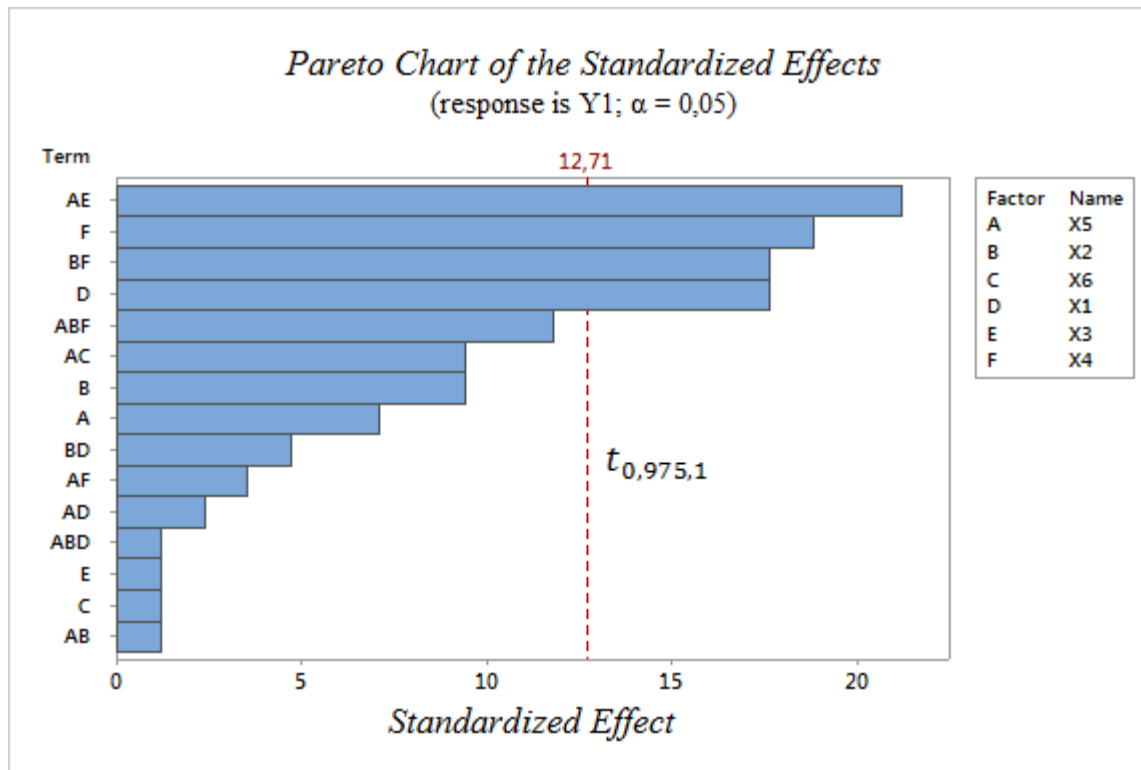


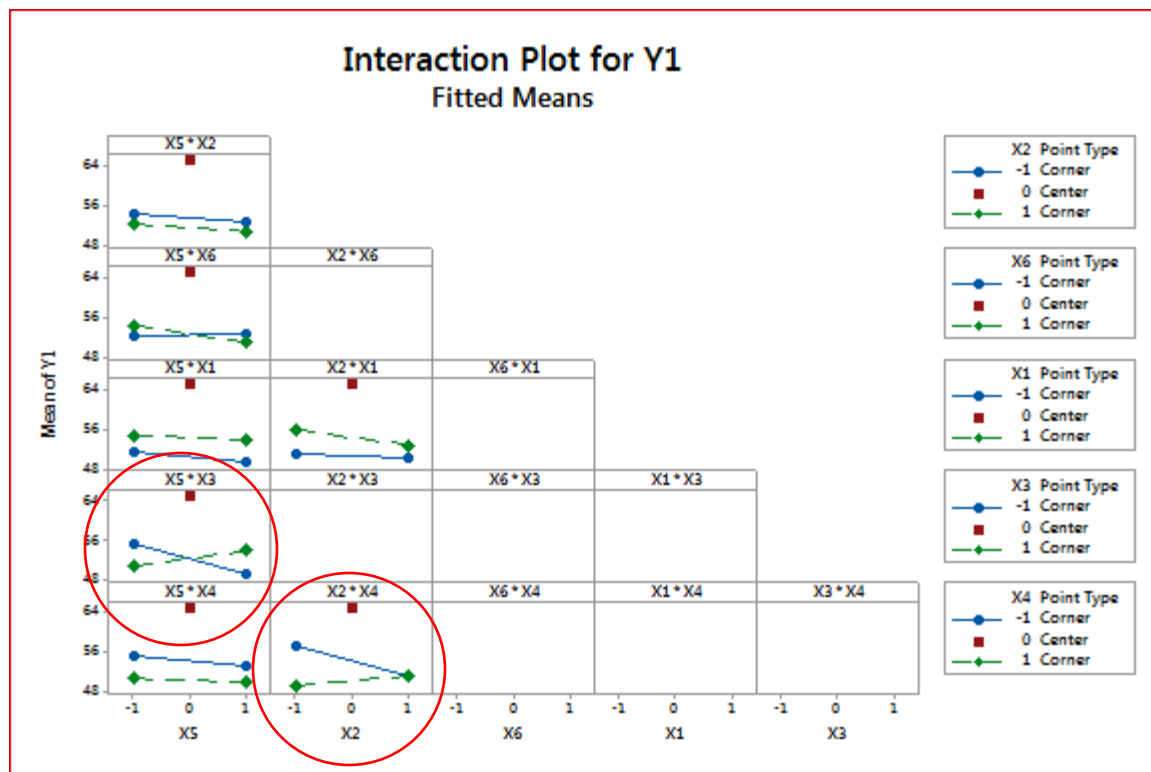
THE FOLLOWING CONSIDERATIONS ARE LIMITED,  
NOW, FOR TIME REASONS, ON THE FIRST  
RESPONSE, LEAVING TO A FINAL SUMMARY THE  
COMBINATION WITH OTHER TWO.

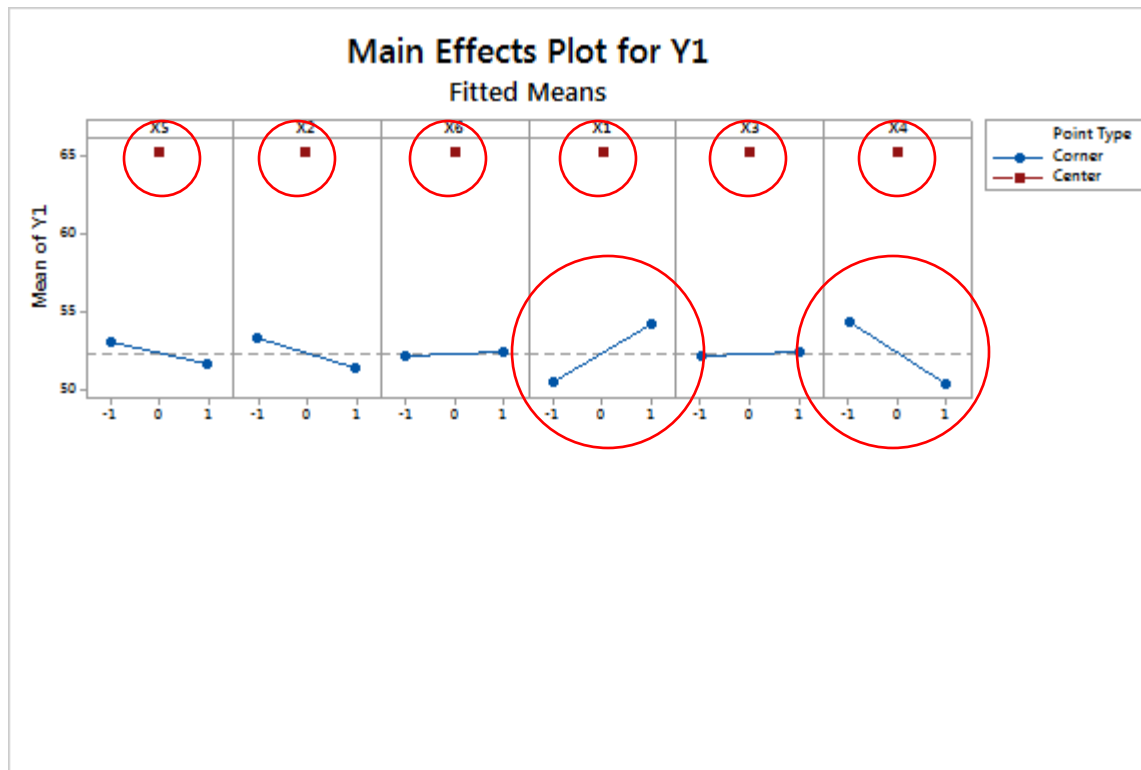
THE ANALYSIS OF PREVIOUS DATA INDICATE THE  
SIGNIFICANT EFFECT S.



Y1

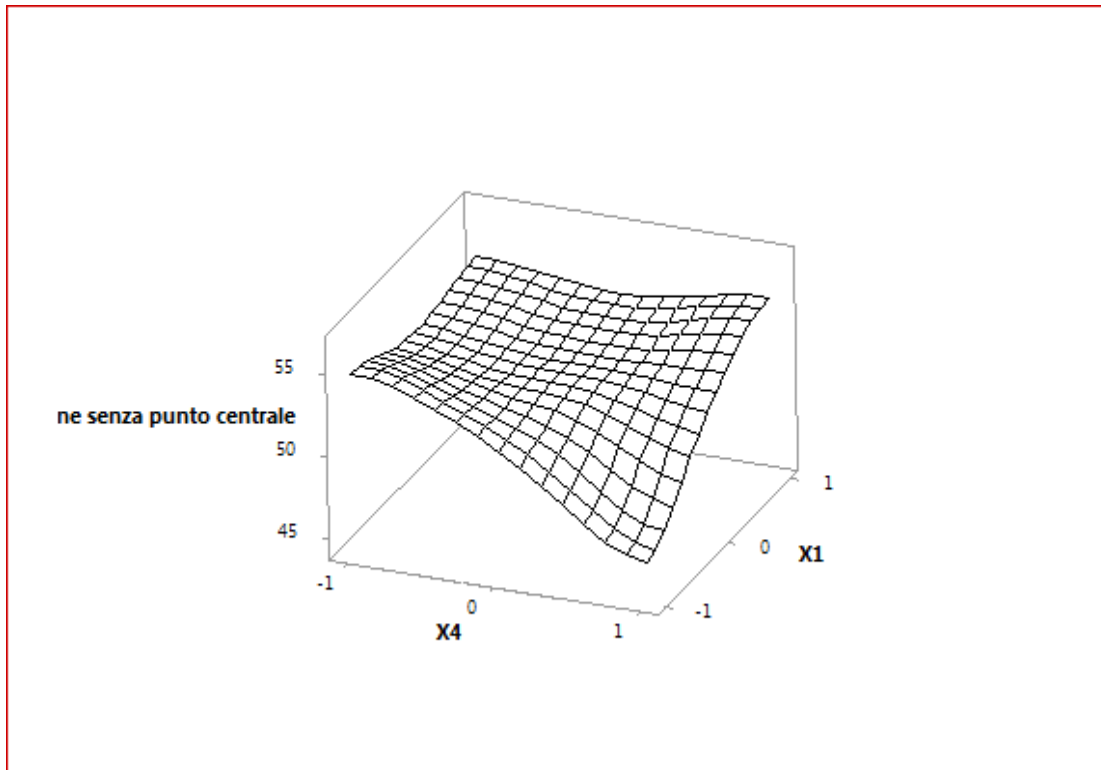




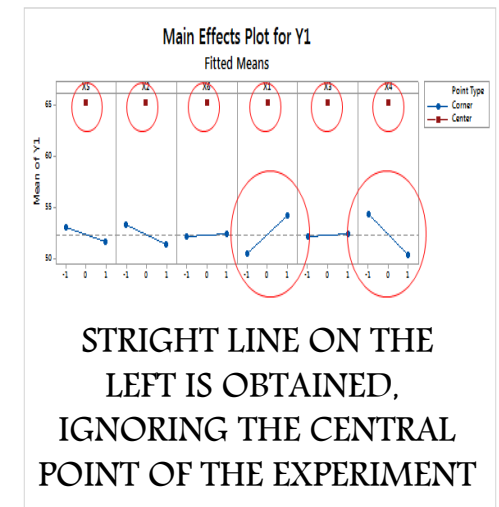
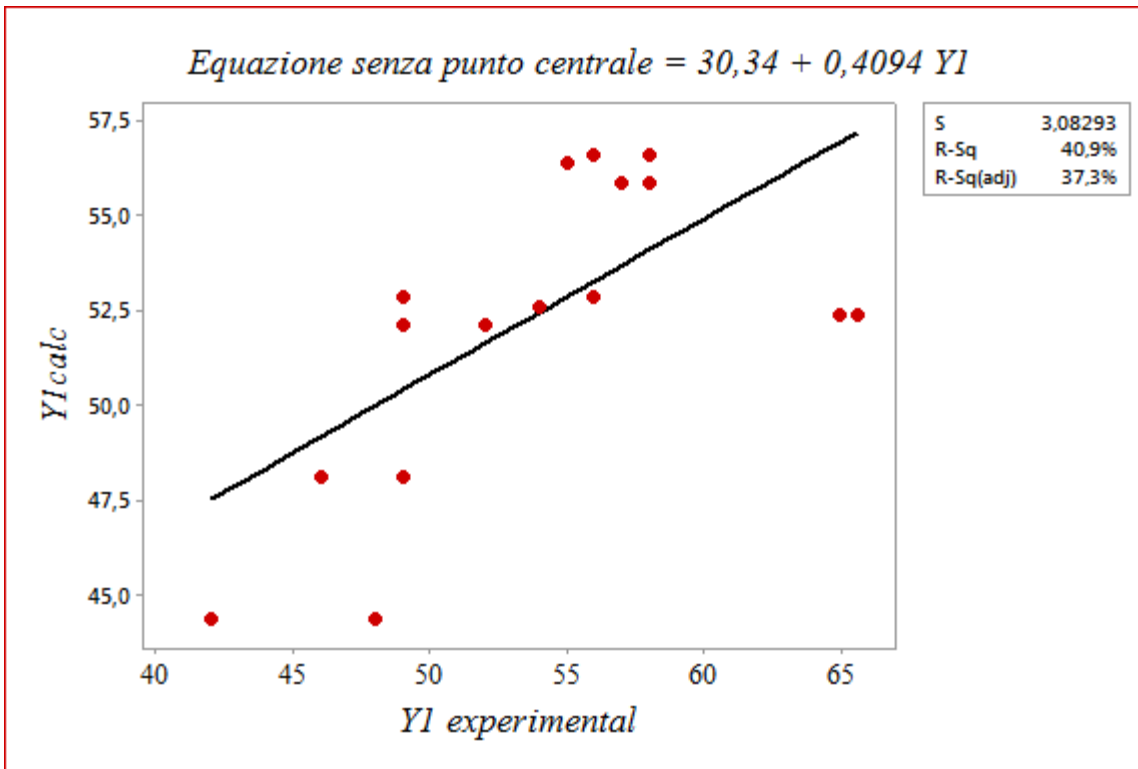


## LA FUNZIONE RICAVABILE DA QUESTI RISULTATI E' LA SEGUENTE:

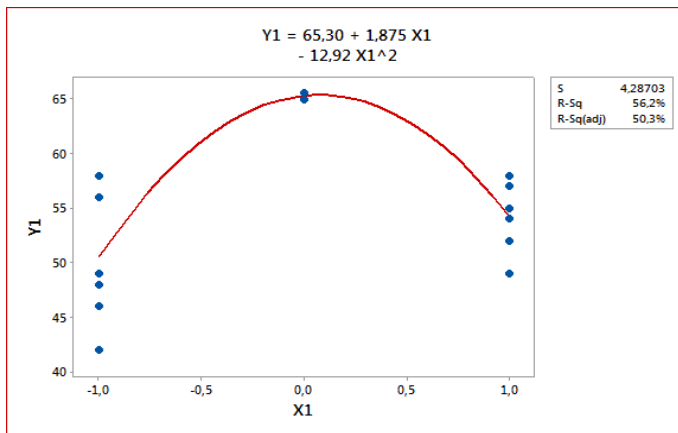
$$Y_1 = 52,375 + 1,875X_1 - 2X_4 + 2,25X_3X_5 + 1,875X_2X_4$$



THE LINE CONNECTS THE ACTUAL EXPERIMENTAL POINTS WITH THOSE DETERMINED BY EQUATION OF THE PREVIOUS SLIDE

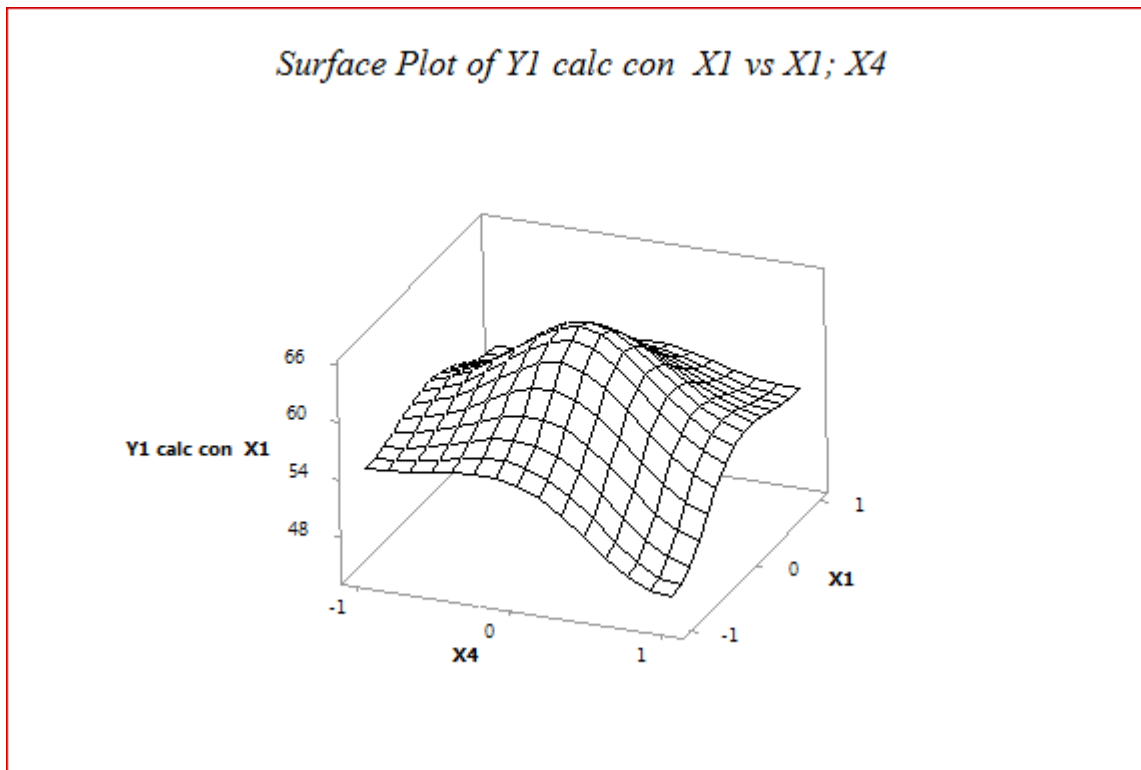


TO TAKE INTO ACCOUNT THE CENTRAL POINT, A CENTRAL COMPOSITE DESIGN WOULD BE NECESSARY. BUT THE EXPERIMENTAL SIZE WOULD RESULT OF 54 TRIALS. WE HAD NO RESOURCES FOR THIS, BUT JUST TWO MORE BATCHES IN ADDITION TO THE 18 ALREADY MANUFACTURED IN THE PREVIOUS FRACTIONAL DESIGN. THEN, IT HAS BEEN DEVISED AN ALTERNATIVE, CONSISTING IN THE INCLUSION INTO THE DESIGN MATRIX OF THE CENTRAL POINT RESULTS, BELONGING TO ONE OF THE TWO VARIABLE RESULTED SIGNIFICANT IN THE FIRST EXPERIMENT.



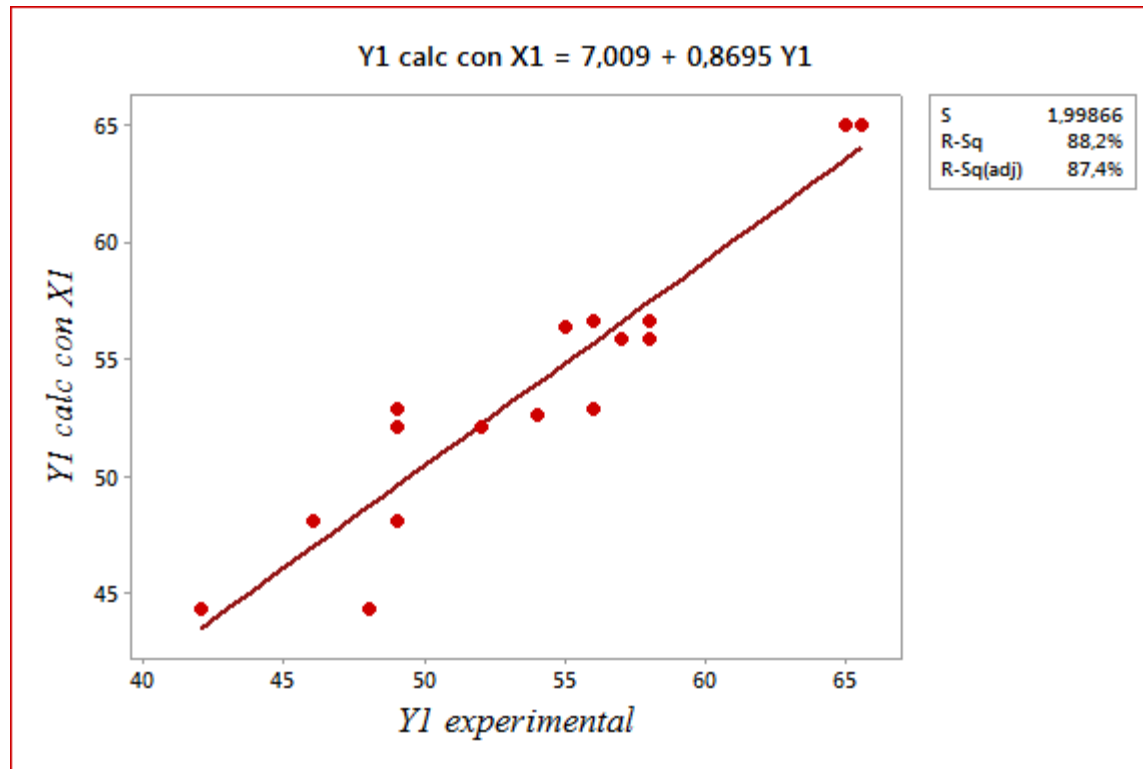
A MULTIPLE REGRESSION HAS GIVEN IN THIS CASE:

$$Y_1 = 65 + 1,87X_1 - 2X_4 + 1,875X_2X_4 + 2,25X_3X_5 - 12,6X_1^2$$



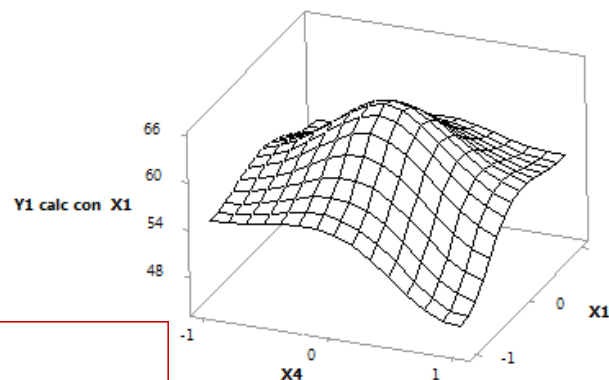


THE LINE CONNECTS THE ACTUAL EXPERIMENTAL POINTS WITH THOSE DETERMINED BY EQUATION OF THE PREVIOUS SLIDE

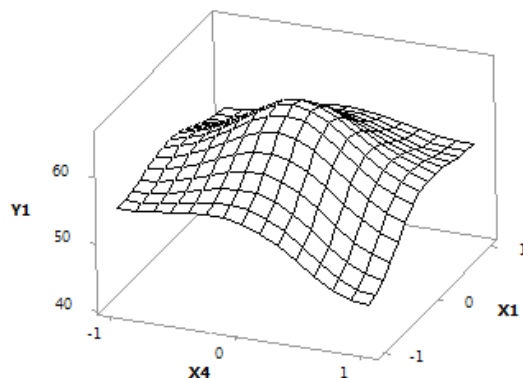


## CONFRONTATION BETWEEN EXPERIMENTAL RESULTS AND INTERPRETING MODEL

*Surface Plot of Y1 calc con X1 vs X1; X4*



*Experimental results*



**MAXIMUM IS 71,2**

X1	X2	X3	X4	X5	X6
0,074	-1	1	-1	1	0

## CONCLUSIONS

OTHER RESPONSES GAVE ALMOST THE SAME RESULTS. CONSIDERING Y1, WITH LEVELS SUGGESTED BY RESULTS OF HISTORICAL ANALYSIS, THE RESULTS ARE IN LINE WITH PRODUCTION RESULTS, I.E. AROUND 50.

	X1	X2	X3	X4	X5	X6	
OPTIMAL LEVELS	0,074	-1	1	-1	1	0	71,2
LEVELS BY HISTORICAL ANALYSIS	1	0	0	1	0	-1	50