RESEARCH ARTICLE

OPTIMIZATION OF PRODUCTION PROCESS OF SOYA OIL.

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Abstract

Modern processing plants extract soya beans oil by solvent liquid transfer. Soya beans are cleaned, cracked, de hulled and conditioned into a thin flake before they enter the extractor. Extraction is by successive, counter current washes with hexane solvent. The extracted flakes are then carried by a sealed conveyor to be de solvent in enclosed vessels by application of jacket and spurge steam. Hexane is removed from the oil in rising film evaporators and with final vacuum distillation. Hexane is recovered from the meal and the oil in atmospheric condensers. Parameters of the process in the plant are no. of part of seed, thickness of flake and weight of solvent per ton of soya beans. Oil quality is measured in terms of free fatty acids, absence of residual hexane and crude oil.

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Keywords:-
Soya beans , solvent, flake, Taguchi, Orthogonal Array, S/N Ratio.

Introduction:-

Taguchi is a methodology which gives the optimum combination of independent parameter which has a significant role to change the value of dependent parameter. The prime objective of the method is to design best quality product at least cost of manufacturer. This method was generated by Dr. Genichi Taguchi of Japan .This method has designed to investigate how various parameters significantly affect the mean and variance of parameter pertaining to main characteristic and quality of process .The orthogonal arrays is the prime tool which arrays to organize the parameters affecting the process and the levels at which they should be varies. Taguchi method tests pairs of combinations in place of all possible combinations .This provide the necessary data to identify the significance of factors affecting product quality with a minimum recourses and time. The arrays are selected on the basis of degree of freedom of parameter which depends on the no of parameter and their level. The data from the arrays can be analyzed by visual analysis.

Taguchi Technique:-

This technique is completely based on statistical concepts and. Many renowned firms have achieved great success by applying this methods. Taguchi method adopted experimentally to investigate influence of parameters such as no of pieces of soya seeds , thickness of flake , and weight of solvent per ton of soya seeds.The Taguchi process helps to select or to determine the optimum combination of these parameters on production of oil . Many researchers developed many mathematical models to optimize these parameters to get maximum production of oil.

Philosophy of the Taguchi Method:-

Quality of product depends on the process by which it has been produced. One can improve the quality by optimising the parameter which affects the process.

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1. Best quality can be achieved by minimizing uncontrollable environmental factor which leads to deviation from a target.
2. The cost of quality should be measured as a function of deviation from the standard and the losses should be measured system wide.

Procedure and Steps:-

Step-1:: Selection of the quality characteristic
There are three types of quality characteristics in the Taguchi methodology, such as smaller-the-better, larger the-better, and nominal-the-best. For example, smaller-the-better is considered when measuring fuel consumption of fuel in automobile or roughness in surface finish. The goal of this research was to find the effect of parameters and achieve maximum production of soya oil

Step–2:: Selection of noise factors and control factors
Selected controllable factors are no of pieces (N), Thickness of flake (T) and Weight of solvent (W). Since these factors are controllable so they are considered as controllable factors in the study. Uncontrollable factor may be the ambiance temperature and Humidity

Step–3:: Selection of Orthogonal Array
There are 9 basic types of standard Orthogonal Arrays (OA) in the Taguchi parameter design. Selection of arrays depends on the degree of freedom of selected parameter. Degree of freedom of all three parameter is 6. An L9 Orthogonal Array is selected for this work. The layout of this L9 OA is as mentioned in Table 1

| Experiment | P1 | P2 | P3 |
|------------|----|----|----|
| 1          | 1  | 1  | 1  |
| 2          | 1  | 2  | 2  |
| 3          | 1  | 3  | 3  |
| 4          | 2  | 1  | 2  |
| 5          | 2  | 2  | 3  |
| 6          | 2  | 3  | 1  |
| 7          | 3  | 1  | 3  |
| 8          | 3  | 2  | 1  |
| 9          | 3  | 3  | 2  |

Table 1::L9 Orthogonal Array

Step–4:: Conducting the experiments
Table illustrates the experimental settings in this study for maximum production of oil. The parameters used in this experiment are no of pieces, Thickness of flake, and Weight of solvent.

Step–5:: Predicting Optimum Performance
Using the mentioned data, one could predict the optimum combination of parameter. With this prediction, one could conclude that which combination will creates the better result.

Step–6:: Establishing the design by using a confirmation experiment
The confirmation experiment help to verify our prediction particularly when small fractional factorial experiments are utilized.

Selection Of Ranges & Levels Of Process Variables:-
As the literature suggested, the quality and quantity of oil product depends upon various factors and their levels are chosen, which are following:
1. Quality of seeds
2. Size of pieces
3. Thickness of flake
4. Quantity of solvent
The factor that considerably contributes to
The quality and quantity of soya oil are selected.
No. of pieces (N)

L = Lower Level = 4
M = Medium Level = 6
H = High Level = 8

Thickness of flake (T)
L = 0.28 mm
M = 0.3 mm
H = 0.32 mm

Solvent Per ton of soya seed (W)
L = 1.5 ton
M = 2.0 ton
H = 2.5 ton

Experimental Results:

| S.N | N  | T (mm) | W (ton) | Oil production (Liter/ton) | Product (Liter) |
|-----|----|-------|--------|--------------------------|----------------|
|     |    |       |        | I | II | III |                  |
| 1   | 4  | 0.28  | 1.5    | 16.5 | 16.8 | 16.7 | 16.70 |
| 2   | 4  | 0.30  | 2.0    | 18.5 | 18.7 | 18.9 | 18.70 |
| 3   | 4  | 0.32  | 2.5    | 17.6 | 17.5 | 17.8 | 17.63 |
| 4   | 6  | 0.28  | 2.0    | 15.7 | 16.3 | 16.0 | 16.00 |
| 5   | 6  | 0.30  | 2.5    | 16.7 | 17.3 | 17.0 | 17.00 |
| 6   | 6  | 0.32  | 1.5    | 15.7 | 15.8 | 15.9 | 15.80 |
| 7   | 8  | 0.28  | 2.5    | 14.4 | 14.5 | 14.7 | 14.53 |
| 8   | 8  | 0.30  | 1.5    | 15.2 | 15.4 | 15.3 | 15.33 |
| 9   | 8  | 0.32  | 2.0    | 15.4 | 15.4 | 15.5 | 15.45 |

Table 2: Experimental Result

Signal to Noise Ratio or S/N Ratio:
The response variable considered in this study is Production, which is of larger the better kind. Therefore, signal to noise ratio is defined by

\[
S/N RATIO (H) = -10 \log_{10} \left( \frac{1}{n} \cdot \frac{1}{\sum Y_i^2} \right)
\]

Where, \( Y_i \) are the individual measurement production in liter per ton of soya seeds

| S.N0 | Exp1 | Exp2  | Exp3  | MSD | S/N Ratio |
|------|------|-------|-------|-----|-----------|
| 1    | 16.5 | 16.8  | 16.7  | 0.0036 | 2.4436 |
| 2    | 18.5 | 18.7  | 18.9  | 0.0028 | 2.5528 |
| 3    | 17.63| 17.5  | 17.8  | 0.0032 | 2.4948 |
| 4    | 15.7 | 16.3  | 16.0  | 0.0039 | 2.4089 |
| 5    | 16.7 | 17.3  | 17.0  | 0.0034 | 2.4685 |
| 6    | 15.7 | 15.8  | 15.9  | 0.0040 | 2.3972 |
| 7    | 14.4 | 14.5  | 14.7  | 0.0047 | 2.3279 |
| 8    | 15.2 | 15.4  | 15.3  | 0.0042 | 2.3767 |
| 9    | 15.4 | 15.45 | 15.5  | 0.0041 | 2.3872 |

Table 3: Signal to noise ratio

Mean Production & S/N Ratio Summary Sheet:

| Symbol | Controllable Factors | Level I | Level II | Level III |
|--------|----------------------|---------|----------|-----------|
| N      | No of Soya Pieces    | 2.49    | 2.41     | 2.35      |
| T      | Flake Thickness      | 2.38    | 2.46     | 2.42      |
Analysis Of Mean:
The mean effect of No. of pieces at various level is calculated as follows:
\[ N_1 = \frac{(16.66+18.70+17.63)}{3} = 17.66 \text{ lit} \]
Similarly,
\[ N_2 = \frac{(16.0+17.0+15.80)}{3} = 16.26 \text{ Lit} \]
\[ N_3 = \frac{(14.53+15.33+15.45)}{3} = 15.10 \text{ Lit} \]

The main effect of thickness of flake at various levels are calculated as:
\[ T_1 = \frac{(16.66+16.0+14.53)}{3} = 15.73 \text{ Lit} \]
Similarly,
\[ T_2 = \frac{(18.70+17.0+15.33)}{3} = 17.01 \text{ Lit} \]
\[ T_3 = \frac{(17.63+15.8+15.45)}{3} = 16.29 \text{ Lit} \]

The main effect of weight of solvent at various levels are calculated as:
\[ W_1 = \frac{(16.66+15.8+15.33)}{3} = 15.93 \text{ Lit} \]
Similarly,
\[ W_2 = \frac{(18.70+16.0+15.45)}{3} = 16.716 \text{ Lit} \]
\[ W_3 = \frac{(17.63+17.00+14.53)}{3} = 16.386 \text{ Lit} \]

| Symbol | Controllable Factors | Level I  | Level II | Level III |
|--------|----------------------|----------|----------|-----------|
| N      | No of Soya Pieces    | 17.66    | 16.26    | 15.10     |
| T      | Flex Thickness       | 15.73    | 17.01    | 16.29     |
| W      | Solvent Weight       | 15.93    | 16.71    | 16.38     |

Mathematical Modeling:
\[ X = \begin{bmatrix} 1 & 1.3863 & -1.2792 & 0.4054 & 1 & 1.3863 & -1.2039 & 0.6931 & 1 & 1.3863 & -1.1394 & 0.9162 & 1 & 1.7917 & -1.2729 & 0.6931 & 1 & 1.7917 & -1.2039 & 0.9162 & 1 & 1.7917 & -1.1394 & 0.4054 \end{bmatrix} \]

\[ X = \begin{bmatrix} 1.0000 & 1.3863 & -1.2729 & 0.4054 \1.0000 & 1.3863 & -1.2039 & 0.6931 \1.0000 & 1.3863 & -1.1394 & 0.9162 \1.0000 & 1.7917 & -1.2729 & 0.6931 \1.0000 & 1.7917 & -1.2039 & 0.9162 \1.0000 & 1.7917 & -1.1394 & 0.4054 \end{bmatrix} \]
\[
Y = \begin{bmatrix}
2.8154 \\
2.9285 \\
2.8696 \\
2.7725 \\
2.8332 \\
2.7600 \\
2.6762 \\
2.7298 \\
2.7376
\end{bmatrix}
\]

\[
X' = \begin{bmatrix}
1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\
1.38 & 1.38 & 1.38 & 1.79 & 1.79 & 1.79 & 2.07 & 2.07 & 2.07 \\
-1.27 & -1.20 & -1.13 & -1.27 & -1.20 & -1.13 & -1.27 & -1.20 & -1.13 \\
0.40 & 0.69 & 0.91 & 0.69 & 0.91 & 0.40 & 0.91 & 0.40 & 0.69
\end{bmatrix}
\]

\[
X'X
\]

\[
\text{ans} =
\begin{bmatrix}
9.0000 & 15.7725 & -10.8486 & 6.0441 \\
15.7725 & 28.3690 & -19.0122 & 10.5923 \\
-10.8486 & -19.0122 & 13.1036 & -7.2856 \\
6.0441 & 10.5923 & -7.2856 & 4.4525
\end{bmatrix}
\]

\[
\text{inv}(X'X)
\]

\[
\text{ans} =
\begin{bmatrix}
59.8084 & -2.4083 & 45.0726 & -1.7068 \\
-2.4083 & 1.3742 & 0.0000 & -0.0000 \\
45.0726 & 0.0000 & 37.3923 & 0.0000 \\
-1.7068 & -0.0000 & 0.0000 & 2.5415
\end{bmatrix}
\]

\[
A = \text{ans}
\]

\[
A =
\begin{bmatrix}
59.8084 & -2.4083 & 45.0726 & -1.7068 \\
-2.4083 & 1.3742 & 0.0000 & -0.0000 \\
45.0726 & 0.0000 & 37.3923 & 0.0000 \\
-1.7068 & -0.0000 & 0.0000 & 2.5415
\end{bmatrix}
\]

\[
B = X'Y
\]

\[
B =
\begin{bmatrix}
25.1228 \\
43.8643 \\
-30.2759 \\
16.8926
\end{bmatrix}
\]

\[
A*B
\]
ans =

3.4712
-0.2245
0.2672
0.0532

C₀ = Antilog 3.4712
= 32.1753
C₁ = -0.2245
C₂ = 0.2672
C₃ = 0.0532

Production = 32.1753*(N)^-0.2245 *(T)^0.2672 *(H)^0.0532

**Conclusion:**
The research article an application of Taguchi method for optimizing the parameters and indicates that the Taguchi design of experiment is an effective way of determining the optimal combination of parameter for maximum production of oil in liter per ton of soya seeds. The outcome of the calculation and formulation for the optimization by Taguchi method, is that With 4 no of pieces of soya seeds having 0.3mm thickness of flake give the maximum production if the solvent is just double in weight of soya seeds.

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