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OPTIMIZATION OF MATERIAL UTILIZATION IN CUTTING STOCK PROBLEM (CSP) UNDER FUZZY TECHNIQUE

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Abstract: The cutting stock problem of two dimensional shapes is a Nesting System (NS) based on Fuzzy optimization Technique (FOT) is established. This approach gives the optimum sequence of the parts with their coordinates. It deals with how the parts can be effectively utilized in the sheet metal to have the best arrangement of the parts in the sheet. The orientation of two-dimensional shapes in press tool which is design is a general optimization problem known as Cutting Stock Problem (CSP). The method to implement optimization of material utilization is needed for every organization. The objective is to minimize the material wastage also the maximum use of work piece within the constraint imposed by stock size and materials is analysis mainly depends on the cutting process, size and shape of the sheet for different combinations of the parts and the subsequent operations required on the part.

Key words: Cutting Stock, Nesting, Fuzzy logic, Modeling, Shape, utilization, optimization.

1. Introduction : Most of the modern industries has developed the sheet working operation from the manual method to semi automatic with the help of computer user interface[1] to reduce time and increase the cost saving .Different industries work with the different constraints with different objectives. Each industries have implemented to develop its own approach with limited constraints

In order to develop the constraints the researchers are concentrated towards their methodology used, like CAD modeling (2), Computer Geometry(3) ,Computer Graphics(4) etc. Dowsland[5] has proposed a solution approach for the above said constraints.Further the above said constraints were proposed by Ibolya[6].He proposed the semi–definite optimization for determining the final shapes and T.C.Martine [7] et al expressed a crystallization heuristic to improve the number of accepted solution.Baldacci[8]et al proposed an iterative algorithm with legrangeen relexation approach .The algorithm is producing one master piece ,which satisfies all the requirement by means of minimizing total wastage. Edmund[9] proposed automatic heuristic design process where computer takes some design by intelligently combining all the polygon. The solution approach has been proposed by uady et al[10]with help of Parallel Genetic Algorithm (PGA) for clustering, ordering and sequencing .Hiroshi Murate[11] proposed a module based on rectangular packing by the sequence pair.

The Heuristic process is mixed with specific algorithm [12] and meta heuristic algorithm for the best sequence of the shapes to handle sheets[13] ,but these process involved more number of variables. So this type of problem will fall on the non-traditional techniques. The similar type of problems are proposed by different techniques like GA[14],SAA[15],Neural Network(NN) [16][17].

The computer procedure considers all possible combinations of the parts sequence and their orientation to give the optimum nested pattern, but it takes considerably longer time to achieve the final solution. Such complexity can be overcome with the help of non traditional techniques like GA, SAA, NN, Ant Colony Algorithm (ACO), Particle Swarm Optimization (PSO) etc.

2. Overview: The point of fuzzy logic is to map an input space to an output space, and the primary mechanism for doing this is a list of if-then statements called rules. All rules are evaluated in parallel, and the order of the rules is unimportant. The rules themselves are useful because they refer to variables and the adjectives that describe those variables. Before you can build a system that interprets rules, you must define all the terms you plan on using and the adjectives that describe them. To say that the water is hot, you need to define the range that the water's temperature can be expected to vary as well as what we mean by the word hot. The following diagram provides a roadmap for the fuzzy inference process. It shows the general description of a fuzzy system on the left and a specific fuzzy system on the right.

3. Fuzzy Technique : Fuzzy logic starts with the concept of a fuzzy set. A fuzzy set is a set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership. To understand what a fuzzy set is, first consider the definition of a classical set. A classical set is a container that wholly includes or wholly excludes any given element. For example, the set of days of the week unquestionably includes Monday, Thursday, and Saturday. It just as unquestionably excludes butter, liberty, and dorsal fins, and so on. Monday Thursday Liberty Shoe Polish Dorsal Butter Fins Saturday Days of the week This type of set is called a classical set because it has been around for a long time. It was Aristotle who first formulated the Law of the Excluded Middle, which says X must either be in set A or in set not-A. Another version of this law is: Of any subject, one thing must be either asserted or denied. To restate this law with annotations: “Of any subject (say Monday), one thing (a day of the week) must be either asserted or denied (I assert that Monday is a day of the week).” This law demands that opposites, the two categories A and not-A, should between them contain the entire universe. Everything falls into either one group or the other. There is no thing that is both a day of the week and not a day of the week.

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4. Membership Functions : A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the universe of discourse, a fancy name for a simple concept. One of the most commonly used examples of a fuzzy set is the set of tall people. In this case, the universe of discourse is all potential heights, say from 3 feet to 9 feet, and the Foundations of Fuzzy Logic 2-7 word tall would correspond to a curve that defines the degree to which any person is tall. If the set of tall people is given the well-defined (crisp) boundary of a classical set, you might say all people taller than 6 feet are officially considered tall. However, such a distinction is clearly absurd. It may make sense to consider the set of all real numbers greater than 6 because numbers belong on an abstract plane, but when we want to talk about real people, it is unreasonable to call one person short and another one tall when they differ in height by the width of a hair.

5. Fuzzy membership function : Fuzzy consistent will inevitably lead to the fuzzy objective based on the ideology and symmetric model. Thus, for the objective function, $\mathbf{Z}(x)$ those is a fuzzy set $\bar{z} = \{(z, u_{z(\tau)}) / Z \in R\}$ .let $X_i = \dfrac{xR}{\sum_{j=1}^{n} a_{i,j} x_j} \geq b_i - d_i$ for all $i = 1, \ldots\ldots\ldots m_i$ and $a_{i,1}x_1 + \ldots\ldots. a_{in}x \geq, b_i$, for all $\{i = m_i + 1, \ldots\ldots, m\}$, $X_u = \left\{ \dfrac{x \in R}{a_{i,1}x_1 + a_{i,2}x_2 + \ldots.. a_{i,n}x_n} \geq b_i \right\}$ for all $i = 1, 2, \ldots\ldots, m$, $\bar{z} = \min Z(x)$ and $\bar{z} = \min Z_{(x)}$

So the membership function of $u_z(\tau)$ of $\bar{z}$ is given by $u_z(\tau) = \begin{cases} 0, \bar{z} \leq z \\ 1 - \dfrac{z - \underline{z}}{\bar{z} - \underline{z}}, \underline{z} < z \leq \bar{z} \\ 1, z \leq \underline{z} \end{cases}$

For the type of nesting problem of rectangle parts, the optimizing model is established from the subject of mathematics. In order to facilitate the analysis, the variables are firstly described as follows

Number of all pieces to be nested and all pieces constitute pieces set R_I,I $\in \{1,2,\ldots.n\}$

L, W – the length and width of the sheet

L_{min}- the height of sheet required

ℓ_i, W_i – the length and width of the rectangle pieces R_i

x_1^i ,y_1^i- the coordinates of lower left corner point of the rectangle pieces R_i

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Rectangle pieces of nesting problem can be expressed as follows

$Ca_{i,j}$=tolerance of $a_{i,j}$,,

$Ct_{i,j}$=tolerance of $t_{i,j}$,

$C\tau_j^f$ = tolerance of τ_j^f ,

λ_i=Decision variable for the fuzzy number

S^0=Objective variable for the fuzzy number

S^1=Objective variable for the fuzzy number

$$\text{Min } L=\theta \sum_{i=0}^{n} C_i \sum_{j=0}^{n} d_{i,j} + (1-\theta)\, C_i \sum_{i=0}^{n} b_{i,} \leq S^1 + (1-\tau)(S^0-S^1),$$

$$\lambda = C_i \sum_{i=0}^{n} w_{i,}\, \lambda^i$$

The fuzzy variables nest meets these conditions as follows

$$y_{i,j+1}-x_{i,j} \geq a_{i,j} + (\lambda_1 - 1)\, Ca_{ij}$$

$$x_{i,j} \geq x_{i,j}^1 ,\ h_{i,j}=1$$

In order to determine a compromise solution, it is usually assumed that the total satisfied of a decision maker may be defined by

$$y_{i.i+1} - x_{i,j} \geq a_{ij} + (\tau_1 - a_{ij})$$

$$x_{i.j} \geq x_{i,j}, h_{i.j} = 1$$

$$x_{i,j} - x_{i,j} = d_{i,j}$$

$$x_{i,j} - y_{i,j} \geq \tau_{i,j} + (\tau_2 - 1)\, c.\tau_{i,j}$$

$$xu^i = x_1^i + (1-\Upsilon_i) w_i + \Upsilon_i l_i, iFI$$

$$yu^i = y_1^i + (1-\Upsilon_i)\, \mathrm{I}_i + \Upsilon_i u_i, iFI$$

$$xu^c \leq x_1^i + w(1-I_{ii}) iFjEI$$

$$yu^c \leq y_1^i + I(1-b_{ii}) iFjEI$$

$$u_j + I_{ji} + b_{ij} + b_{ji} \geq 1, \text{ijEi}$$

$$l_{\min}, xu^i, yu^i, \mathrm{x}_i{}^i, yi^i \geq 0$$

$b_{ij} = 0, \mathrm{R}_i$ is placed upper fuzzy function

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$= 1, R_i$ is placed lower fuzzy number

$l_{ij} = 0, R_i$ is placed on $Rlts$ of members

$= 1, R$ is placed on $lIts$ of members.

Conclusion: The computer procedure considers all possible combinations of the parts sequence and their orientation to give the optimum nested pattern, but it takes considerably longer time to achieve the final solution. Such complexity can be overcome with the help of non traditional techniques like GA, SAA, NN, Ant Colony Algorithm (ACO), Particle Swarm Optimization (PSO) etc.

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