Optimization of Steel Composition Using Genetic Algorithm.

[1]Mosin khan , R.Tarun raja , Nilanjan Nath ,Kunal Rathod,

[2]Sonali Appasaheb P

[1]*Student ,Computer Engineering ,Savitribai Phule Pune University ,Pune, India*

[2]*Prof.,Computer Engineering ,Savitribai Phule Pune University ,Pune, India*

ABSTRACT

Many engineering processes currently being used, depends on the experience of the operating engineers overseeing the execution. This causes a lot of oversights and inaccuracies in the process. These inconveniences can be reduced or eliminated by computational optimization, but many of these problems are complicated and deal with multiple factors affecting the final product. Even more so, many of these problems also suffer from the unavoidable drawback of having sub-optimal solutions. All of these problems can be overcomed by process simulation and using robust optimizing techniques such as genetic algorithm. The process of selecting an alloying composition for steel requires computation of many variables and also includes multiple compositions that can provide the desired hardness and also provide the ideal "depth of hardness".

Keywords: *Hadrenability of Steel, Optimization, Genetic Algorithm, Steel Composition.*

1.INTRODUCTION

The process of steel making is done by alloying iron with other alloying elements like carbon, nickel, manganese, molybdenum etc. Each of these elements have different effects on the hardenability of steel. There may be several combinations of these element which may produce the required "depth of hardness", but this requirement alone is not sufficient enough to gauge the quality of the steel. The combination of the problem faced being a multi-variable problem as well as the presence of several "pseudo-optimum" solutions is why genetic algorithms are being used for this project. Genetic algorithm is an evolutionary algorithm which uses the process of recombination and mutation to randomly induce changes in the dependent variables. We will go about the optimization of the composition of steel through the following steps:

1. Generate an initial population of strings that define the composition of steel.
2. Compute the population using a fitness function, and find the "strongest" among them.
3. Carry out crossovers among the strongest members of the population to create the next generation
4. Go back to step 1 and repeat until the specified benchmarks are satisfied.

1.1 LITERATURE REVIEW

Uncertainty inadvertently exists in most real-world applications. In the optimization process, uncertainty poses a very important issue and it directly affects the optimization performance. In order to efficiently and effectively solve Robust Multi-objective Optimization Problems (RMOPs) [1], a novel Robust Multi-objective Optimization Evolutionary Algorithm (RMOEA) is developed. Traditionally genetic algorithms work by providing hurdles to successive genrations. The ability to overcome these hurdles defines the strength of the individual. Through the use of schema, these hurdles are scaled with respect to the generations, thus forcing each individual to ”work harder” to be able to survive onto the next genration [2,3]. A schema describes a set of individuals, the strength individuals decide the strength of the entire schema. To further improve the odds of survival of the fittest the concept of elite count or eliteism is implemented [4]. It selects the cream of the crop ,so to speak, and guarantees it is carried forward into the next generation. This has been mathematically shown in .The best individual of the generation is selected and crossover is gauranteed. While the continuous casting and heat treatment process has not been implemented in our system the application of genetic algorithm in optimization of steel composition provides usefull in sight into steel manufactuaring processesand varibles involved such as the jominy hardenability process.

1.2PROBLEM STATEMENT

Generating an alloy compostion for steel using genetic algorithm whose characteristics allign with the propsed requirements given by the onsite engineer.

A. Problem Analysis

We are considering 8 elements used in the production of steel, and all optimization processes will be carried out with regards to their properties. The alloying elements will be given a binary string sequence, whose length will depend on the required accuracy of the optimization. Assuming each element is allotted 5 bits, and 8 elements are being considered, we get a binary string of 40 bits, which encompasses the composition of the steel. A randomized population of N such strings are generated, this is generation 1. Out of these two will be randomly chosen and compared. The better fit is chosen for recombination to create the next generation. A random chance of mutation is also introduced in which a random bit is flipped (0 changed to 1 and vice versa). The randomized mutation prevents the algorithm from sticking to a local optima. Recombination examples -

1101000100 x 0010111010 = 1100100100 and 0010111100

Mutation examples -

10100(1)0110 () indicates bit chosen for mutation after

mutation is greater than 1010000110

As for the selection process of suitable pairs for the recombination process, the fitness of the “gene” will contribute to its percentage chance of being selected for recombination. The fitness will be factored to produce a percentage factor, the higher the percentage the better the chance of it being selected multiple times for recombination.

1.3EXISTENT SYSTEM

While there are optimization tools for the process of steel casting the task of selecting a suitable composition of steel is dependent on a mixture of the experience of the onsite engineer, and trial and error. The composition of steel is set by the engineer using a method of exprinence and trial and error. the method for testing steel is physical process that requires time and effort. If the composition does not provide the required quality, the entire batch is scraped, and new composition is tried.

1.4. Drawbacks of Existent System

1.time consuming.

2.wastage of resources.

1.5 PROPOSED SYSTEM

System depends heavily on randomly generated variables that are used to create next genrations that finally result in the final answer. Therefore the input provided is just used as a comparision point.It provides the ideal jominy graph whos composition needs to be found.

The Jominy method is descrbed as an exprimental method that describes hardenabillity (the ability of the steel to harden) with respect to the depth of the steel smaple. There are several steps involved in finding the Jominy graph: 1.A solid steel cylinder of 2 inch diameter and 32 inches in lenght is heated above 850_C. 2.A spray of water is applied to one end and the entire sample is allowed to cool down to room temperature. 3. some material is shaved of the sample lenght wise to avoid tainted results due to oxidation and impurities. 4.The hardness of the sample is determined using Rockwell Hardness tesing machine in 0.25 inch interval. 5.this provides a jominy graph as shown in fig2.

Fig.1 shows the proposed flowchart for the design of the optimizaion process.

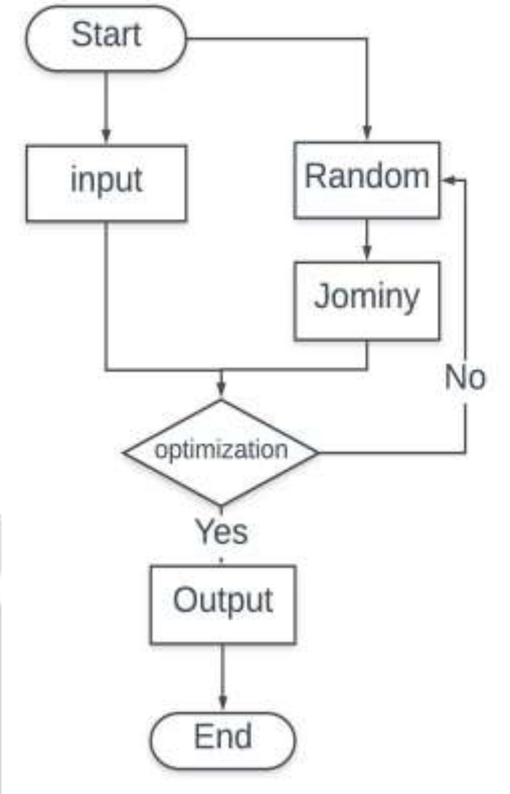

Fig. 1. Proposed System Flowchart.

Fig. 2. Jominy graph and test apparatus .

1.6 Algorithm

Fig.3 shows the flow chart for genetic algorithms. It first initializes 'n' binary sequences that constitues the first generation. The objective function of each binary sequence is computed and compared to the ideal value. If it matches then the algorithm is stoped,otherwise the next genration is created through the process of crossovers and mutations. We have also included the concept of schema that allows a level of implicit prallelism[7].This allow multiple individuals to be described by one schema,allowing us to compute quality of a large group in a single run.

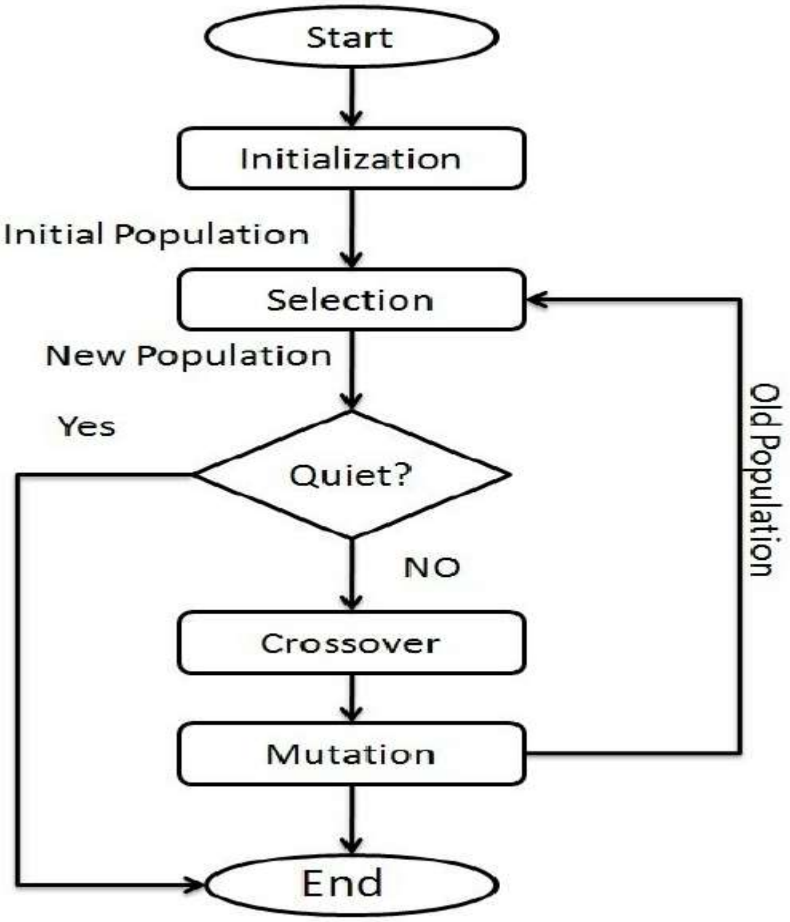

Fig. 3. Genetic Algorithm Flowchart.

1.7 UML diagram

1) Class diagram:: fig.4 shows the classes and this respective functions that are used to generate the ideal compostion

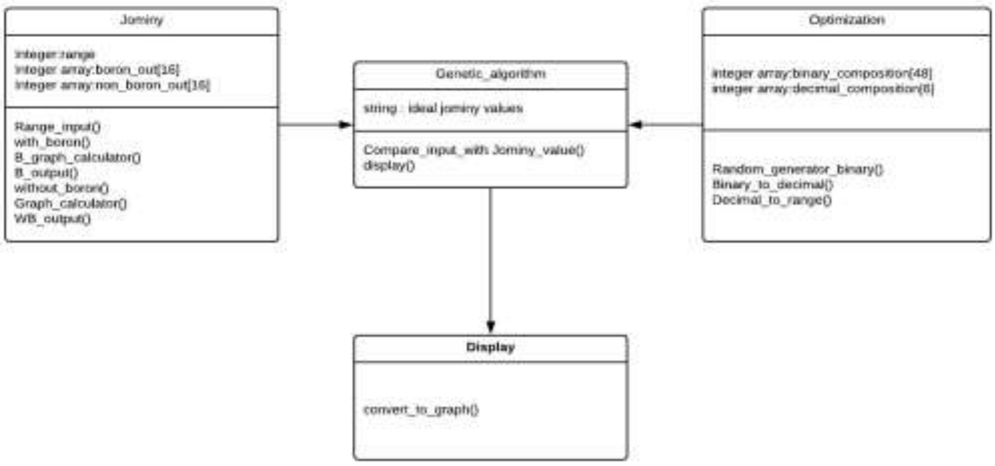

Fig. 4. UML Class Diagram

1.The jominy class is used to determine the effect of each element on the final hardness of the steel. 2.Gentic algorithm uses the randomly generated compostion to create new generations through crossover and mutation. 3.Optimization class generates the random compositions that are fed to the genetic algorithm .

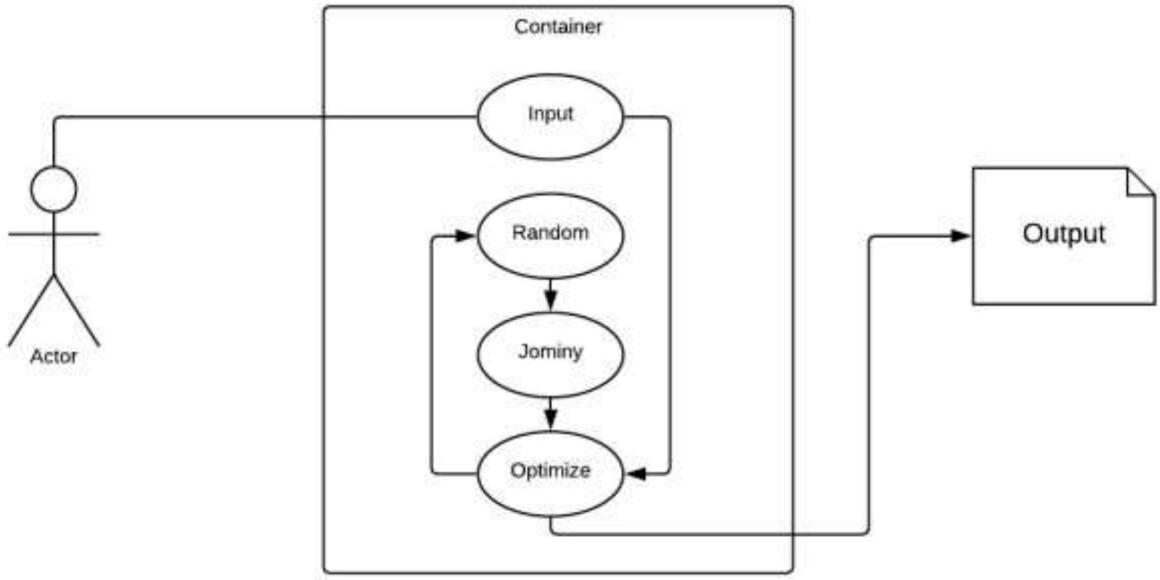

Fig. 5. UML User Case Diagram

2) Use Case Diagram.: In fig.5 the actor refferes to the systems engineer who decides the range and the grade of steel to be used. The input isn't used for initiallization,rather, it is the ideal characteristics of the steel.All the generated compositions will be compared with respect to the input. The randomly generated sequences are appropriately converted and fed to the jominy model that will calcualte the jominy graph used to define the characteristics of steel. the produced values are compared and sent for crossover and mutation and the steps are repeated till the desired output is created or the termination point is reached.

1.8 PROS AND CONS

A. Pros

1. The production and testing time will be reduced.
2. Results will be accurate .
3. The probability of sub optimal solutions will be reduced.

B. Cons

1. This model does not account for heat treatment.
2. The optimization process has high time complexity.

1.9. Applications

1. This process allows efficient manufacturing and testing saving factories crucial time and resources.
2. This model provides a further use for optimization and design of other processes such as casting and carburization.
3. It will simplify the process of steel manufacturing allowing higher accuracy and better quality.

2.0 Future scope

The hardeness, toughness and other properties of steel effectively depends on the cooling rate of the steel. This project does not yet include that aspect of steel manufacturing, it only focuses on providing the ideal composition required to provide the optimum hardenability. Optimizing the cooling process for the steel is the next step in completely optimizing steel manufacturing, however increasing cooling rates are limited by sample size and the composition of the alloy.

2.1. CONCLUSION

Using the algorithms and methodology listed in this paper we will be able to design and implement an optimization technique based on genetic algorithm that will allow us to reduce the shortcomings of the current testing processes of the steel industries.

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