International Journal of Industrial Engineering and Management (IJIEM), Vol. 5 No 2, 2014, pp. 77-84
Available online at www.iim.ftn.uns.ac.rs/ijiem_journal.php
ISSN 2217-2661

UDK: 005.6:658.5.018.2

Priority Analysis on the Reliability Parameters of an Existing Model

Seyed Hossein Khodaei
Master Graduate, Department of Material, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Skudai, Malaysia, Hossein_edu@yahoo.com

Adnan Hassan
Associate Professor, Department of Material, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Skudai, Malaysia, Adnan@utm.my

Masoud Rahiminezhad Galankashi
PhD Candidate, Department of Material, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Skudai, Malaysia, masoud.rahiminejad@yahoo.com

Received (23.03.2014.); Revised (19.06.2014.); Accepted (28.06.2014.)

Abstract

The basic goal of this paper is to create an alternative based analysis in a reliability model. Despite the vast amount of studies on reliability analysis and related techniques, the evaluation of the importance of different alternatives is less investigated. In order to fill this gap, this research was carried out to systematically investigate the result of setting three different scenarios on a reliability model. A model of reliability system was proposed based on redundancy allocation problems. There are certain limitations (Weight and Cost)of proposed model. In particular, three different scenarios (the results of Failure Rate preference, Weight preference and Cost Preference) was presented. This investigation operated based on the assumption of allocating only one redundant component for the subsystems, and the main goal of this investigation is to determine what would be the results when lowest possible Weight, lowest possible Cost and lowest possible failure rate is needed.

Key words: *Redundancy Allocation, k-out-of-n, Failure rate, Cost, Weight, Preferences*

1. INTRODUCTION

In today's competitive markets, managers have understood that there is a vital need to improve the reliability of the entire process. With the advent of statistical models, reliability can be considered as a winning strategy for all functions within the process from the first to the last component to provide a more reliable system. Although the concept of reliability have been discussed by many authors, only a very few attempts have been made to discuss the importance of additional factors, especially when considering important constraints and parameters such as budget(cost), weight, failure rate, etc. In this context, identifying, analysing, comparing, and discussing the existing parameters in current models to provide more clarification is a challenge for many managers, practitioners and researchers. While parameters are mostly considered in some researches, their combined scenarios are less investigated in the literature. This is partly due to the innate complexities inherent to statistical models. Furthermore, parameters in the models have been analyzed one by one (lonely), assuming that the final model contains all of them. However, considering different scenarios of these different parameters can be beneficial due to the following reasons:

1. In real life, these parameters affect reliability which makes them significant events.

2. Parameters sometimes must be considered simultaneously in order to compare their importance

3. Determining the parameters' importance can be useful for managers to determine their priorities.

Hence, developing different scenarios to evaluate the importance level of different parameters is the main objective of this study. To do so, it aims to address the following questions:

1. How do these parameters affect the reliability of the entire system?

2. How do the preferences within one of the parameters influence the other parameters and also the total reliability?

3. How can the importance of parameters be evaluated?

The scope of this study is limited to a popular reliability model available in literature developed by [1]. However, the research framework, methodology, and results can be useful to researchers and practitioners who are going to determine other additional criteria which may be significant in other reliability models. This study contributes to determining, analyzing and rating the reliability of system when the priority is with both total reliability and parameters.

2. LITERATURE REVIEW

Reliability has been defined from different aspects by diverse researchers in various areas such as service, manufacturing, human resource, supply chain etc. Nevertheless, there is no consensus on a reliability definition among researchers because it can be defined from different perspectives. The reliability characteristics of an item are influenced by different factors such as the operational environment, maintenance policy, operator skill, etc [2]. Emphasis has been placed on the reliability of an entire system, as opposed to the reliability of its components. System reliability is defined by the reliability of the components as well as the way the components are arranged reliability-wise. By emphasizing the optimization concept, [3] described reliability optimization problem as a nonlinear integer programming problem, of combinatorial nature and NP-hard. It is a classical problem that has been thoroughly studied and discussed in literature with both enumerative-based methods and heuristic.

High-reliability systems play crucial roles in modern industry. System reliability may be enhanced by: (a) raising component reliability, (b) providing redundant components in parallel, (c) using a combination of enhanced component reliability and redundant components provisioned in parallel, and (d) reassigning interchangeable components. The second and third options are called redundancy allocation problem (RAP) and reliability–redundancy allocation problem (RRAP), respectively. In RAPs, there are discrete component choices with known characteristics such as reliability, cost, and weight, where the aim is to find the optimal/near optimal number of redundancies in each subsystem in order to maximize the overall system reliability subject to some constraints. The reliability–redundancy allocation problem (RRAP) is the problem of maximizing system reliability through component reliability choices and component redundancy, which forms a difficult but realistic optimization problem in which component reliability is not given but treated as a design variable while component cost, weight, volume, etc. are defined in advance as increasing non-linear functions of component reliability . In reliability studies, either of two different strategies, called active and standby, may be considered for determining how the redundant components must be used. In the active strategy, all redundant components simultaneously start to operate from time zero although only one is required at any particular time. Standby redundancy may take one of three variant forms, cold, warm, or hot. In the cold variant, the redundant components are protected from operational stresses associated with system operation so that no component fails before it starts. The components in the warm-standby redundancy are affected by operational stresses more than those in the cold variant. Finally, in the hot-standby redundancy, component failure does not depend on whether the component is idle or in operation. The mathematical formulation for the hot-standby strategy is the same as that with the active redundancy case. In the standby redundancy strategy, the redundant components are sequentially used in the system at failure times of operating components by switching to one of the redundant components in order to continue system operation [4-8].

Reliability, like other issues in today's competitive market, is an extensive journey in the pursuit of excellence with no ending, and nonstop and slow increase of the system capabilities ends in improved performance. To attain a high degree of performance, systems must deploy a combination of reliability techniques and managerial factors in the whole system to rapidly plan novel designed operation. To provide a clearer insight on the related literature, following are some of the most important previous researchers in the field of reliability redundancy allocation.

A study on System Reliability allocation introduced a computational algorithm and were the researchers involved in the subject of reliability. In this paper they designed a method to select the optimal solution in the context of trade- of analysis. It is noted that it may be structured as an n-stage sequential decision problem. A computational algorithm is enabled by the use of dynamic programming. The author introduced the maximization of the reliability function and its constraints known as weight and cost. It has shown that dynamic programming can yield an exact solution for the function. But the problem is the inability of the algorithm to solve large scale problems [9].

A research on Surrogate Constraints Algorithm for Reliability Optimization Problems with Two Constraints, presented a new efficient solution algorithm (N&M) which uses surrogate constraints obtained by combining multiple constraints into one constraint. He mentioned that is it difficult to solve integer separable nonlinear programming problems with the application of the surrogate method. It is also difficult to solve surrogate problems with Dynamic programming (conventional way). The author tested the algorithm in 33 problems with modifications of the [10] model. In the gap are existing areas where Dynamic Programming cannot yield solution even in easy problems but N&M can do it [10].

An investigation was carried out on the optimal allocation of redundant components for large systems. This paper discussed allocating redundant components subject to resource constraints. Two new algorithms are introduced. The first one, BLE1, can solve problems with 100 stages and 10 constraints in just a few seconds of CPU time. The other is BLE2 which exploits a multiple choice knapsack structure. Another method which is a heuristic method for solving large problems known as BLH is also introduced [11].

Optimization approaches to the redundancy allocation problems for series-parallel systems is the topic of a research performed by [12]. This paper did optimization with past methods including Integer Programming(IP), Dynamic Programming(DP) and MINLP(mix integer nonlinear programming) and also introduced the Meta-Heuristics stochastic method called GA. MINLP had 2 problems: 1) For many designs components must be selected from a discrete list which have known reliability and cost and weight so in this case MINLP cannot select which component to use. 2)It is not always practical to determine a differentiable function for component cost as it relates to reliability.GA is very flexible and can accommodate both discrete and continuous function and can investigate a larger search space than corresponding DP and IP.

Coit and Liu (2000) did a study on system reliability optimization with *k-out-of-n* subsystems. In this paper the goal was to optimize reliability in *k –out- of- n* systems. Individual subsystems may use either active or cold standby redundancy or they may require no redundancy. It is a difficult combinational problem which has been shown to be NP-hard [13].

Cold standby redundancy optimization for non-repairable systems is a research performend by [14]. In this paper a solution methodology is described and demonstrated to determine optimal design configurations for non-repairable series-parallel systems with cold-standby redundancy. This paper introduced the idea that cold standby components be distributed according to an Erlang distribution. Integer programming is used in this paper. The cold standby systems are more difficult to deal with because the ability to detect the failed components is also compulsory.

Coit (2003) assumed that both active redundancy components and cold-standby components can alternatively be chosen for each subsystem. Optimal solution to the problem is found by an equivalent problem formulation and integer programming [5].

A study on cost benefit analysis of availability systems with warm standby units and imperfect coverage concerns the availability analysis of three different series system configurations with warm standby components and general repair times. A standby component is called a warm standby if its failure rate is nonzero and is less than the failure rate of a primary component [15].

Tavakkoli Moghaddam et al. (2008) did a study on reliability optimization of series parallel systems with a choice of redundancy strategies using Genetic Algorithm. The optimizing of redundancy allocation is proposed using GA algorithm and it is assumed that both active mode and standby mode can be chosen for each subsystem while in the past papers most of the consideration was on the active mode. Due to its complexity it is difficult to optimally solve such problems by using traditional optimization tools [16].

Sharifi et al. (2009) did a research on real time study of a k-out-of-n systems. This paper discussed the k-out-of-n:g system with n parallel and identical elements with increasing failure rates. It means that if a component fails other component failure rates increase and it follows Weibul distribution. A numerical example was solved to demonstrate the procedure [17].

A research conducyed by [18] proposed a variant of non-dominated sorting Genetic Algorithm (NSGA-II) to solve a novel mathematical model for multi objective redundancy allocation problems. The proposed algorithm demonstrates the ability to identify a set of optimal solutions, which provides the decision maker a complete picture of the optimal solution space. The past researches were based on SORAP model(single objective redundancy allocation problems).

Najafi et al. (2012) provided two meta-Heuristics for solving the reliability redundancy allocation problem to maximize mean time to failure of a series-parallel system [19]. In this paper a case of 30 problems with the examination of a number of subsystem components is produced using two meta-heuristic algorithms called GA and SA. After comparison it was found that GA is better than SA. But the problem is that they should have used the case study of the [1] in order to be more illustrative with their result.

A new multi-objective particle swarm optimization method for solving reliability allocation aroblems proposed by [20]. In this research, a Meta-Heuristic algorithm called MOPSO is used to solve a simple problem of redundancy allocation.

As can be seen from the above researches, available literature tried to solve the Reliability Redundancy Allocation in different ways. Models have been produced and researchers have tried to solve them in various ways from traditional ways of optimization to the most intelligent ones which are called Meta-Heuristic Algorithms. It is clear that few researches have been done on the matter of reliability parameters which is the focus of this article. There should be comparison and analysis also on the reliability parameters in order to provide clarity for managers, companies and the others who deal with manufacturing and the markets these days.

In summary, an effective method to compare and analyze the reliability parameters of the system has not been developed, especially when considering applicable managerial variables which are more realistic in the real world. In addition, some of the aforementioned methods are inefficient when managers aim to change the system parameters based on their desires. A practical method is needed to combine the various aspects of reliability into integrated and sensible outputs.

3. RESEARCH METHODOLOGY

The need for an analysis between common parameters in the reliability models could be essential for managers, manufacturers and investors. The fact is that a high degree of total reliability is not the only thing which can satisfy top managements, meaning that they may want some other factors simultaneously. There are some activities to be done in order to have high total reliability. If all considerations are allocated to reliability alone, it may result in some problems like extra cost,

extra weight, extra volume etc. Thus, in this article the struggle is to determine in what ways we could have a balanced and reasonable set between them.
As mentioned earlier, a comparison between important parameters in the reliability models is somehow essential in order to demonstrate which parameters have more power in decisions about reliability engineering.
To do the analysis, the parameters must first be known. Therefore, the model must be first be introduced and the parameters will be extracted from that. As this article wants to provide deeper insight into reliability models, there is no need to introduce a new model. Thus, the model of [1] has been chosen. The model is designed for solving redundancy allocation problems with k-out-of-n systems under Cold standby strategy.
Once the model has been chosen, the case study has to be introduced in order to help us illustrate the steps and findings properly. Like the model, the case study is also from [5] as this case study is famous in the literature and most researchers have gone through it to demonstrate their findings. The only difference is in this article the first four subsystems out of total fourteen subsystem of the case study of Coit(2003) will be used. The reason is that it helps to make it easier to understand; however an analysis of the whole subsystem is also possible.
Once familiar with the model and case study, it is time to extract the factors we need. The factors are weight (w), cost (c) and failure rate (□). The comparison is based on priority which means that each of the parameters individually will be the preferences in three separated scenarios. At the final point these three scenarios will be compared.
As mentioned the system is k-out-of-n meaning that if k components out of all n components work, the system will work properly. It is clear from the definition that n-k is the number of redundant components which have to be added to each subsystem. In this project the n-k is always equal to one. It means only one component is added to each subsystem. This assumption is essential for two reasons: 1) the aim is not to optimize 2) the condition for all the experiments should be the same for comparison reasons.
In the first point we assume the failure rate as our priority and we call it failure rate preferences and select the components which are going to enter the model based on that. To do that MATLAB software was used. The algorithm first goes through the components with lowest possible Failure rate for our subsystems and then with the data of selected components, the other variables (Reliability, Weight and Cost) will be calculated. This scenario also has to be done for the other two parameters which are weight preferences and cost preferences. All these theories will be discussed fully in the next chapter.
When all three steps have been done, there will be three total Reliability, three total cost, and three total weight which are the keys to start comparison and find which preference is the best. Note that there is no need to report the failure rate in comparison because the failure rate is shown in the degree of Reliability.

4. DISCUSSION AND RESULTS

This chapter is going to first introduce the model and case study and then apply the methodology which has been mentioned in the previous chapter.
Before introducing the model and case study, the essential notations are shown in (Table1.)

Table 1. Notations

Symbols	Notation
$R_1(t)$	Reliability of each subsystem in cold standby
λ_{iz_i}	The amount of failure rate depends on type z component in subsystem 'i'
k_i	Minimum possible number of Components in subsystem i which is required for system working in k-out-of-n system
n_i	number of component in subsystem 'i'
W w_{iz_i}	Maximum allowed weight weight of each type z component in subsystem 'i '
c_{iz_i} C	Cost of purchase and installation component in subsystem 'i' from type z Maximum allowed cost
i z_i	Counter of subsystems Type of component in subsystem 'i'
t	Time

4.1 Assumptions

There are some assumptions in this article and corresponding model:

i. System has series of different subsystems.
ii. The first four subsystems of all the subsystems in the case study of [5] have been chosen

iii. All of the subsystems are k-out-of-n system and in each subsystem the number of redundant components is one only.

iv. Policy of subsystems is cold standby.

v. Failure rate of components in each subsystem is constant.

vi. Components are not repairable, they are changeable only.

vii. The ((t)) parameter is equal to 1 in all calculation processes as a fixed parameter which means Reliability in the first unit of time.

4.2 **Model and Case study**

Based on Fyffe (1968) and Coit (2001), we have(1):

$$MaxR(t) = \prod_{i \in A} R_1(t) \qquad (1)$$

$$s.t:$$

$$\sum_{i=1}^{s} c_{iz_i} n_i \le C$$

$$\sum_{i=1}^{s} w_{iz_i} n_i \le W$$

$$n_i = k_i + 1; i \in (1,2,3,4)$$
$$z_i \in (1,2,3,4)$$

Which R_1 is:

$$R_1(t) = \sum_{j=0}^{n_i - k_i} \frac{e^{-k_i \lambda_i t}.(k_i \lambda_i t)^j}{j!}$$

As can be seen from the model, *C* and *W* are our constraintns (Cost and Weight respectively). n is equal to k_i +1 which means the essential working components plus one redundant one and i∈ (1,2,3,4) represented the number of subsystems. z_i∈ (1,2,3,4) because there are four types of components in the case study of [5] which will be introduced below.
As discussed above, the first four subsystems of all fourteen subsystems of the case study are used in this article. The data of the case study is shown in (Fig 1.).

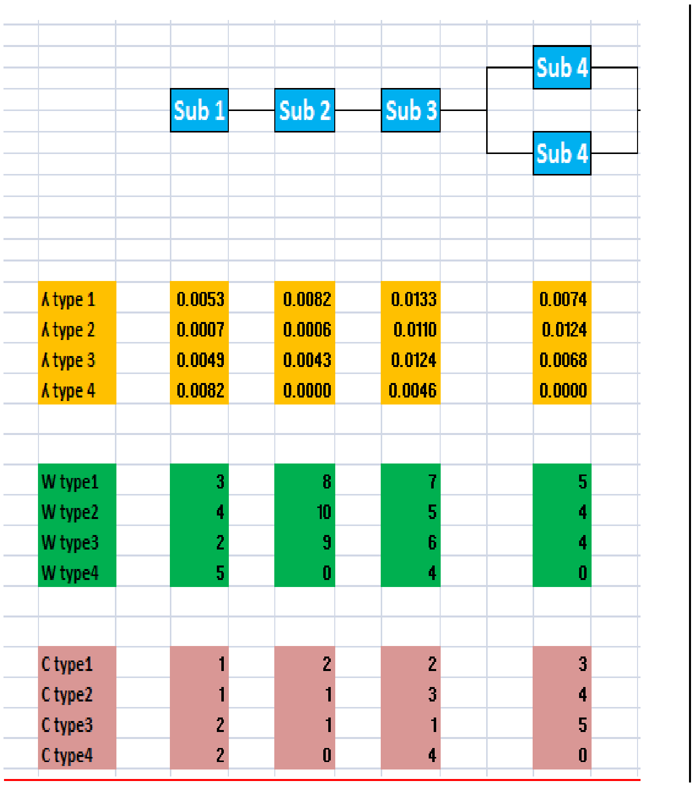

Figure 1. Configuration of case study

The figure represents the data of case study. Above the figure is the configuration of main and raw system, for example it shows that in the fourth subsystem there are two (k=2) working components. The lower part of the figure shows the data of redundant components (failure rate, weight and cost). It is notable that this figure only shows graphically the information of case study as introduced by Coit(2003). Now is the time to begin the analysis.

4.3 **Cost preferences**

As mentioned before, in some cases, regardless of what the amount of Reliability is, our preference is to provide the cheapest components for our system. So the algorithm must go through the case study and find the cheapest components and then calculate the total Reliability, total Cost and total Weight by the selected components. (Fig 2.) shows the configuration of the selected components and (Table 2.) reperesents corresponding results:

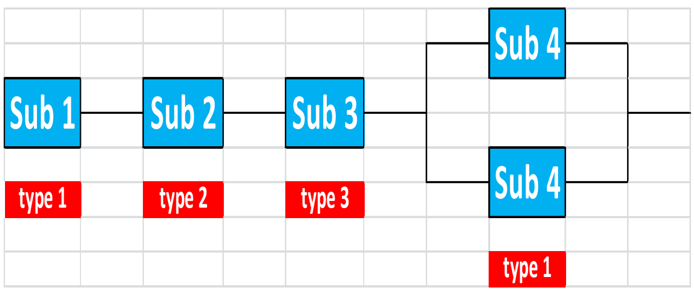

Figure 2. Configuration of Cost preferences

Table 2. Result of Cost preferences design

Total Reliability	Total Cost	Total Weight
0.9998	15	53

These approaches are the same for the next two preferences (Weight preferences and Failure rate preferences), so we only report the results of the other two preferences.

4.4 **Weight Preferences**

(Fig 3.) shows the configuration of Weight preferences and (Table 3.) illustrates the corresponding results.

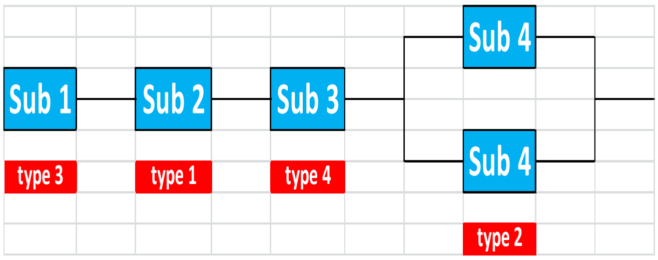

Figure 3. Configuration of Weight preferences

Table 3. Result of Weight preferences design

Total Reliability	Total Cost	Total Weight
0.9996	28	40

4.5 **Failure Rate Preferences**

(Fig 4.) shows the configuration of Weight preferences and (Table 4.) illustrates the corresponding results.

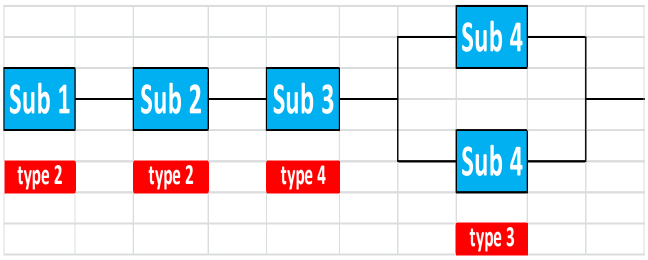

Figure 4. Configuration ofFailure rate preferences

Table 4. Result of Failure rate preferences design

Total Reliability	Total Cost	Total Weight
0.99999	27	48

4.6 **Comparison of Preferences**

In the three previous parts, the results of Cost preference, Weight preference and Failure rate preference have been presented. The main goal of this investigation is to determine what would be the results when lowest possible Weight, lowest possible Cost and lowest possible failure rate is needed and also to compare them. As reported before, for each preference we calculated three parameters, Total Reliability value, Total Cost value and Total Weight value. In order to compare the three preferences we have to consider each individual value by the three preferences. For instance the (Fig 5.) shows the Reliability values which are reflected in the three preferences.

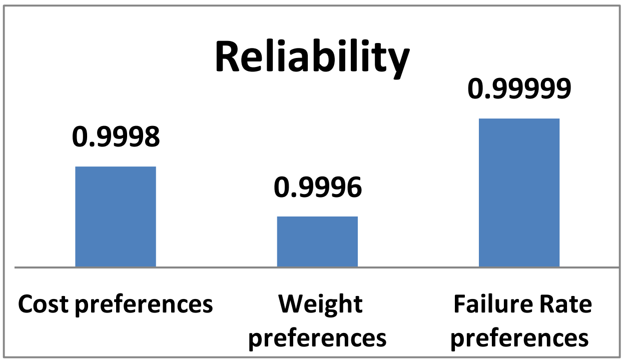

Figure 5. Comparison of three Preference based on Reliability

As the (Fig 5.) shows, the Failure rate preferences emerged the best when it comes to Reliability. Cost preferences and Weight preferences are ranked second and third respectively.

Another case is to compare the preferences based on Weight value which is provided graphically in (Fig 6.).

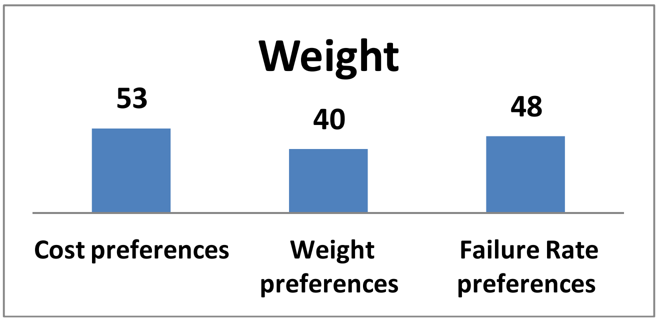

Figure 6. Comparison of three Preference based on Weight

Finally at the last step, there is comparison of the three preferences based on Cost shown in (Fig 7.).

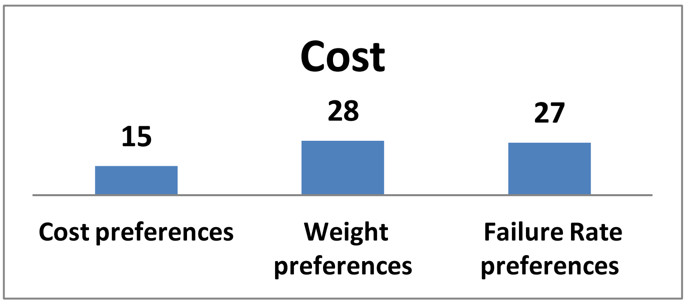

Figure 7. Comparison of three Preference based on Cost

Before going through the final results it should be noted that the lower values in Cost and Weight have to be preferred because they are constraints while in the case of reliability the highest has to be preferred.
Therefore, the diagrams of comparisons have been shown and the final resulted ranking is as follows:

1. Failure rate preference is the ranked first by one first grade (0.99999 in Reliability) and two second grade (27 in Cost and 48 in Weight)
2. Cost preference is rated second with one first grade (15 in Cost) , one second grade (0.9998 in Reliability) and one third grade (53 in Weight)
3. The last ranks allocates to Weight preference by one first grade (40 in Weight) and two third grades (0.9996 in Reliability and 28 in Cost)

Although the failure preference had been selected as the best preference, there may be some cases in which the managers want to know the values of parameters in a variety of cases. Thus the results of this article could be a useful reference for them to finally choose which type of component to use.

5. CONCLUSION

This article tried to consider the importance of parameters (Weight, Cost and Failure rate) in the reliability model simultaneously with total Reliability. To do this three preferences were set based on the parameters. Meaning that in each time, one of the parameters was our priority in calculations. After getting the results, it was proved that Failure rate preferences resulted in the best and there were Cost preferences and Weight preferences at second and third ranks.

6. REFERENCES

[1] Coit, D. W. *(2001).* Cold-standby redundancy optimization for nonrepairable systems. *IIE Transaction **33**: 471-478.*

[2] Barabadi, A., Barabady, J., & Markeset, T. (2014). Application of reliability models with covariates in spare part prediction and optimization–A case study.*Reliability Engineering & System Safety*, *123*, 1-7**.**

[3] Garg, H., Rani, M., Sharma, S. P., & Vishwakarma, Y. (2014). Intuitionistic fuzzy optimization technique for solving multi-objective reliability optimization problems in interval environment. *Expert Systems with Applications*, *41*(7), 3157-3167.

[4] Kuo, W., & Prasad, V. R. (2000). An annotated overview of system-reliability optimization. *Reliability, IEEE Transactions on*, *49*(2), 176-187.

[5] Coit, D. W. (2003). Maximization of system reliability with a choice of redundancy strategies. *IIE transactions*, *35*(6), 535-543.

[6] Ebeling, C. E. An introduction to reliability and maintainability engineering, 1997.

[7] Tavakkoli-Moghaddam, R., Safari, J., & Sassani, F. (2008). Reliability optimization of series-parallel systems with a choice of redundancy strategies using a genetic algorithm. *Reliability Engineering & System Safety*, *93*(4), 550-556.

[8] Abouei Ardakan, M., & Zeinal Hamadani, A. (2014). Reliability–redundancy allocation problem with cold-standby redundancy strategy. *Simulation Modelling Practice and Theory*, *42*, 107-118.

[9] Fyffe, D. E., Hines, W. W., & Lee, N. K. (1968). System reliability allocation and a computational algorithm. *Reliability, IEEE Transactions on*, *17*(2), 64-69.

[10] Nakagawa, Y., & Miyazaki, S. (1981). Surrogate constraints algorithm for reliability optimization problems with two constraints. *Reliability, IEEE Transactions on*, *30*(2), 175-180.

[11] Bulfin, R. L., & Liu, C. Y. (1985). Optimal allocation of redundant components for large systems. *Reliability, IEEE Transactions on*, *34*(3), 241-247.

[12] Coit, D. W., & Smith, A. E. (1996). Reliability optimization of series-parallel systems using a genetic algorithm. *Reliability, IEEE Transactions on*, *45*(2), 254-260.

[13] Coit, D. W., & LIU, J. C. (2000). System reliability optimization with k-out-of-n subsystems. *International Journal of Reliability, Quality and Safety Engineering*,*7*(02), 129-142.

[14] Coit, D. W. (2001). Cold-standby redundancy optimization for nonrepairable systems. *IIE Transactions*, *33*(6), 471-478.

[15] Wang, K. H., & Chiu, L. W. (2006). Cost benefit analysis of availability systems with warm standby units and imperfect coverage. *Applied mathematics and computation*, *172*(2), 1239-1256.

[16] Tavakkoli-Moghaddam, R., Safari, J., & Sassani, F. (2008). Reliability optimization of series-parallel systems with a choice of redundancy strategies using a genetic algorithm. *Reliability Engineering & System Safety*, *93*(4), 550-556.

[17] Sharifi, M., Memariani, A., & Noorossanah, R. (2009). Real Time Study of a k-out-of-n System: n Identical Elements with Increasing Failure Rates. *Iranian Journal of Operations Research*, *1*(2), 56-67.

[18] Safari, J. (2012). Multi-objective reliability optimization of series-parallel systems with a choice of redundancy strategies. *Reliability Engineering & System Safety*, *108*, 10-20.

[19] Najafi, A. A., Karimi, H., Chambari, A., & Azimi, F. (2013). Two metaheuristics for solving the reliability redundancy allocation problem to maximize mean time to failure of a series–parallel system. *Scientia Iranica*, *20*(3), 832-838.

[20] Khalili-Damghani, K., Abtahi, A. R., & Tavana, M. (2013). A new multi-objective particle swarm optimization method for solving reliability redundancy allocation problems. *Reliability Engineering & System Safety*, *111*, 58-75.

Analiza prioriteta na osnovu parametara pouzdanosti postojećeg modela

Seyed Hossein Khodaei, Masoud Rahiminezhad Galankashi, Adnan Hassan

Primljen (23.03.2014.); Recenziran (19.06.2014.); Prihvaćen (28.06.2014.)

Rezime

Osnovni cilj ovog rada je izrada alternativne analize modela pouzdanosti. Uprkos velikom broju studija o analizi pouzdanosti i povezanim tehnikama, evaluacija značaja različitih alternativa je manje istraživana. Kako bi se taj nedostatak popunio, ovo istraživanje je sprovedeno da bi se sistematski istražio rezultat postavljanja tri različita scenarija na osnovu modela pouzdanosti. Model sistema pouzdanosti je predložen na osnovu problema obilja raspodela (RAP). Postoje određena ograničenja (težina i cena) predloženog modela. Posebno su predložena tri različita scenarija (rezultati prema Stopi neuspeha, prema Težini i prema Ceni). Ovo istraživanje je sprovedeno na osnovu pretpostavke o distribuciji samo jedne redundantne komponente za podsisteme, i glavni cilj ovog istraživanja je da se odredi koji bi bili rezultati kada su potrebni najmanja moguća Težina, najniža moguća Cena i najniža moguća Stopa neuspeha.

Ključne reči: *RAP, k-od-n, Stopa neuspeha, Cena, Težina, Prioritet*