DEVELOPMENT OF A HEURISTIC ALGORITHM TO OBTAIN A CONTROL MEASURE TO COST FUNCTION IN FIVE MANUFACTURING COMPANIES

Anyanwu, Felix Tochukwu
Department of Mechanical Engineering Technology
Imo State Polytechnic, Umuagwo, P.M.B 1472 Owerri, Imo State, Nigeria.
Email: felixanyanwu.t@gmail.com

Dr. Igbokwe,Onyechege Johnson
Department of Mechanical Engineering
Federal University of Technology Owerri, Imo State, Nigeria
Email: Johnkwe678@yahoo.com

Dr. Okoronkwo,Chukwunenye Anthony
Department of Mechanical Engineering
Federal University of Technology, Owerri, Imo State, Nigeria
Email: Chukwunenye-jireh@yahoo.com

Professor Onyenwuchi, N. Oguoma
Department of Mechanical Engineering
Federal University of Technology, Owerri, Imo State, Nigeria
Phone no: +2348037097135

***Corresponding Author: Email: felixanyanwu.t@gmail.com**

DOI: 10.31364/SCIRJ/v10.i1.2022.P0122902
http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

Abstract: Development of a heuristic algorithm where there is a control measure to cost is presented. The study developed a flow chart of heuristic algorithm and dynamic programming was noted as optimization tool to obtain the cost function. The results obtained moved towards the left which showcased reduction in the cost function (Z). A control measure to cost function was obtain in order to check the cost function in terms of trend, this is denoted as Zcheck.

Keywords: Heuristic algorithm, control measure, cost function, dynamic programming, optimization.

1. INTRODUCTION

The need for significant increase in productivity of several industries calls for the use of queuing system to reduce waitingtime or down time [1].The waiting time could be reduced or even eliminated by providing additional service facilities [2]. The study of queuing models has been of considerable active interest ever since the birth of queuing theory at the beginning of last century. Queuing theory continues to be one of the most extensive theories of stochastic models. It has attained a progressive movement both in methodology and application. In terms of innovative analytic treatments as it concerns its theoretical development, a tremendous advancement has been recorded. Also, queuing theory provides an efficient mathematical framework for the study of several congestion phenomena arising in diverse application areas which include, production lines of manufacturing industries, banks, telecommunications, marking of papers, etc.

In traffic jams queues also occur, other areas where queues occurs include tool booths, supermarkets, and airport. Queues also occur based on internet and telephone system. In hospitals, doctors operate using queuing system, as well as jobs on a machine. All these waiting are disliked by the customers and the servers, and as a result lead to customers' dissatisfactions. Invariable, owing to customer's dissatisfactions, both productivity and profit are negatively affected. Queues are predominate in manufacturing companies such as First aluminum Port Harcourt, Vinal aluminum Irete, Eagles cement Port Harcourt, Seven up bottling company Aba, and Coca cola bottling company Aba. As such, this calls for improvement so as to increase the productivities of these company. This study emphasizes the need to reduce queues so as to increase the profit margins made by these companies. Considering the level of queuing problems, it is obvious that queuing studies need persistent effort aimed at eliminating or reducing queues.

The research on optimization of queuing system based on computer simulation is discussed. The study showcased that each consumer hoping to complete a transaction must pass through the road queuing system to a prominent position. A new design of metaheuristic search called improved monkey algorithm based on random perturbation for optimization was critically examined [1, 2]. The study aimed at presenting a design of a metaheuristic search that provides a solution for optimization issues [2].

A multi-level (m - level) mechanism and evolution strategies (ESs) was introduced in order to address a class of global optimization problems that could benefit from fine discretization of their decision variables [3].

Heuristic algorithms which involve the decision tree method and the greedy search algorithm help solutions with less time and improved solution's quality [4] infinite monkey theorem and heuristicity were introduced such that heuristicity can be analysed using infinite metaheursistics, are a class of approximate methods, which are designed to attack hard combinational optimization problems [5,6]. Future of metaheuristic algorithm was examined so as to ensure its application especially in engineering and sciences [7].

The Locus mutation method is a gene-dependent local mutation operator that involves genes with different multation rates [8].

Heuristic algorithm for combined heat and power system was studied. In the research, residential buildings were taken into account based on components interactions. the idea is to obtain a process that decomposes the three energy vectors needs which are electrical, thermal and hot water. Interconnection and operational constraints were taken into account. Series of simulations were used on residential pilot with a nano-cogenerator unit of about 25-30% energy saving when compared with a meta heuristic genetic algorithm method [9]. Algorithms and flowcharts are two important tools that explain process of a program [10].

Generally, optimization has been applied in many fields in order to transform the performance of products, processes, and interventions [11]. The application of dynamic programming to the identification of optimal parameters of tree-structure energy pipeline networks was determined. They study presented unified conceptual and mathematical statement. A single stage manufacturing system with setups that give rise to a single part type in order to satisfy demand was examined. In the study dynamic programming was employed which is in form of Markov Decision process in order to minimize backorder, lost sales and set up costs, [12, 13]. An iterative algorithm for the max-min knapsack problem with multiple scenarios was determined. The method was evaluated using vet bench mark from recent literatures. Results obtained were compared and it provided a better bounds than already published literature [14].

An approach was made to a selection hyper-heuristic algorithm for multiobjective dynamic economic and environmental load dispatch. The study established the amountof electricity generated from plants during the planning period to meet load demand as energy consumption costs is minimized. Unit

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

commitment problem using an evolutionary algorithm and a plurality of priority list was determined base on energy management.

A heuristic algorithm for optimal service composition in complex manufacturing networks handled service composition in a cloud manufacturing environment that involves adaptive and optimal assembly of manufacturing service [15, 16, 17]. A heuristic algorithm based on line-up competition and granulized pattern searchforsolving integer and mixed integer non-liner optimization problems was examined. The algorithm treats multi-model problems as well as concurring with existing literature [18]. Various publications exist on queuing systems model. Majority approached the solutions separately. This work was aimed at studying a heuristic algorithm to obtain a control measure to cost function based on dynamic programming.

II. MATERIAL AND METHODS

2.1 Development of a heuristic algorithm

The heuristic algorithm was developed in line with the methods obtainable in mathematics and computer science [9]. These steps include problem definition, model development, specification of the algorithm, program testing and documentation.

In this study, the procedure for the flowchart of a heuristic algorithm is shown in Fig. 1. The processes include identification of the queuing problem, feasibility studies of the optimization method, decision, resort to optimization, choosing dynamic programming, obtain the cost function, obtain the control to cost function.

2.2 Determination of dynamic programming

In order to achieve a **Maintenance constraint**

This takes care of repair and upkeep of machines as described in equation.

Policy on queuing constraints

In this study the queuing policy ensures that the two constraints above are equal.

Objective function of the queuing model

The objective function in this study is to minimize the total production cost.

Minimize $\sum_{i=1}^{n}\sum_{k=1}^{m} C_{ik}X_{ik} + \sum_{k=1}^{n}\sum_{j=1}^{m} C_{kj}X_{kj}$

Summaryof the model

$$\sum_{i=1}^{n}\sum_{k=1}^{m} C_{ik}X_{ik} \quad \sum_{k=1}^{n}\sum_{j=1}^{m} C_{kj}X_{kj}$$

Subject to the constraints

Time $\sum_{j=1}^{n} X_{ik} \leq T_i$ i=1, 2, 3 ---m

Maintenance $\sum_{i=1}^{m} X_{kj} \leq R_i$ j=1,2=…n

Policy $\sum_{j=1}^{n} X_{ik} - \sum_{i=1}^{m} X_{jk} = 0$

$X_{ik}, X_{kj} \geq 0$

Step one

Formulate the optimization equation

Minimize Z = f(x)

Subject to the constraints

Time $\sum_{j=1}^{n} X_{ik} \leq T_i$ (1)

Maintenance $\sum_{i=1}^{m} X_{ik} \leq R_j$ j=1, 2, ---n

(2) $\sum_{j=1}^{n}\sum_{i=1}^{m}$

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

Policy X_{ik}- X_{kj} =0

Step two

Develop the necessary models and make necessary assumptions

Time is in minutes

Cost is in Naira

$$Z = \sum \{ C_1 Lq (S_i) + C2 [\sum (S_i - n). P_{si} \} \quad (3)$$

$$\sum P_{si} = P_{si} + P_{S2} + P_{S3} + P_{S4} + P_{S5} + P_{S6} \quad (4)$$

n = 10, number of customers

C_1 = 0.3, cost per customer

C_2 = 3, cost per idle server

K =6

Where Z = cost function in Naira (₦)

S= number of servers

Step six

Determine the Z_{check} using equation (5)

Step seven

Perform the analysis with excel software. The dynamic programming was applied so as to obtain the optimization cost function called "Z". In this process, necessary basic assumptions were made to enable the functionality of the method. Data from five companies were handled.

$$Z_{check} = \sum [C_1 .L_q (S_i) + C_2 [\sum (n - S_i). Psi] \quad (5)$$

Considerations should be made for twenty four hours a day, this implies that the system is twenty four.

Step three

Determine the server utilization P_{si}, for the values of i ranging from 1 to K where K is 6.

$$Psi = \frac{\lambda}{s\mu} \quad (6)$$

Summation of the above : $\sum_{I=1}^{k}$ Psi (7)

Step four

Calculate the queue length L_q

$$L_q = \sum_{I=1}^{k} (n - S_i). P_{si} \quad (8)$$

Step five

Evaluate the cost function Z in equation (3)

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

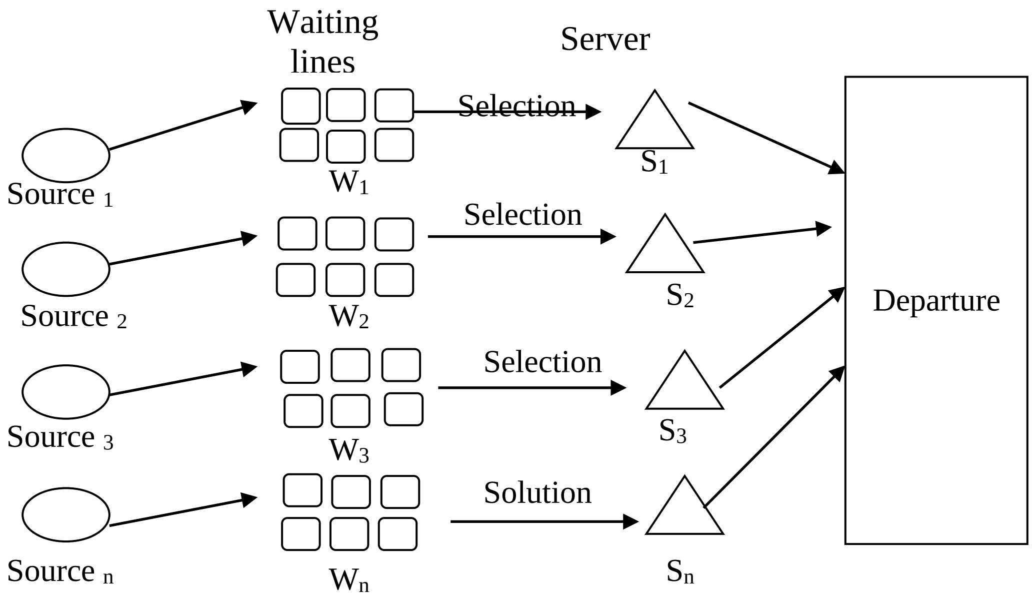


Figure 1: Diagram showing connection of a queuing system of several sources and one departure.

III **RESULTS AND DISCUSSION**

Determination of a control measure to cost function

The evaluation of the control measure to cost function was achieved by dynamic programming. Twenty four systems with eight shifts were determined.

Table 1 Dynamic Programming Result

FOR FIRST ALUMINIUM						
S/N	**ʎ**	**µ**	**P**	**Lq**	**Z**	**Zcheck**
1	1.3	4	0.79625	94.75375	-1108.62	2302.516
2	2.3	4	1.40875	167.6413	-1961.4	4073.682
3	2.5	4	1.53125	182.2188	-2131.96	4427.916
4	1.7	4	1.04125	123.9088	-1449.73	3010.983
5	4.4	4	2.695	320.705	-3752.25	7793.132
6	1.8	4	1.1025	320.705	-1535.01	3188.099
7	2.4	4	1.025	131.1975	-2046.68	4250.799
8	2.9	4	1.77625	211.3738	-2473.07	5136.382
9	3.7	4	2.26625	269.6838	-3155.3	6553.315
10	5.2	2	3.185	379.015	4434.48	9210.065
11	1.3	4	0.79625	94.75375	-1108.62	2302.516
12	2.3	4	1.40875	167.6413	-1961.4	4073.682
13	2.5	4	1.53125	182.2188	-2131.96	4427.916

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

14	1.7	4	1.04125	123.9088	-1449.73	3010.983
15	4.4	4	2.695	320.705	-3752.25	7793.132
16	1.8	4	1.1025	320.705	-1535.01	3188.099
17	2.4	4	1.025	131.1975	-2046.68	4250.799
18	2.9	4	1.77625	211.3738	-2473.07	5136.382
19	3.7	4	2.26625	269.6838	-3155.3	6553.315
20	5.2	2	3.185	379.015	4434.48	9210.065
21	1.3	4	0.79625	94.75375	-1108.62	2302.516
22	2.3	4	1.40875	167.6413	-1961.4	4073.682
23	2.5	4	1.53125	182.2188	-2131.96	4427.916
24	1.7	4	1.04125	123.9088	-1449.73	3010.983

Table 2 Dynamic Programming Result

FOR VINAL ALUMINIUM						
S/N	**ʎ**	**µ**	**P**	**Lq**	**Z**	**Zcheck**
1	3.5	4	2.14375	255.1063	-298.74	6199.082
2	3.9	4	2.38875	284.2613	-3325.86	6907.548
3	6.3	4	3.85875	459.1913	-5372.54	11158.35
4	3.9	4	2.38875	284.2613	-3325.86	6907.548
5	3.2	4	1.96	233.24	-2728.91	5667.732
6	6.1	4	3.73625	444.6138	-5201.98	10804.11
7	3.1	4	1.89875	225.9513	-2643.63	5490.615
8	1.9	4	1.16375	138.4863	-1620.29	3365.216
9	2.3	4	1.40875	167.6413	-1961.4	4073.682
10	4.0	4	2.45	291.55	-3411.14	7084.665
11	3.5	4	2.14375	255.1063	-298.74	6199.082
12	3.9	4	2.38875	284.2613	-3325.86	6907.548
13	6.3	4	3.85875	459.1913	-5372.54	11158.35
14	3.9	4	2.38875	284.2613	-3325.86	6907.548
15	3.2	4	1.96	233.24	-2728.91	5667.732
16	6.1	4	3.73625	444.6138	-5201.98	10804.11
17	3.1	4	1.89875	225.9513	-2643.63	5490.615
18	1.9	4	1.16375	138.4863	-1620.29	3365.216
19	2.3	4	1.40875	167.6413	-1961.4	4073.682
20	4.0	4	2.45	291.55	-3411.14	7084.665
21	3.5	4	2.14375	255.1063	-298.74	6199.082
22	3.9	4	2.38875	284.2613	-3325.86	6907.548
23	6.3	4	3.85875	459.1913	-5372.54	11158.35
24	3.9	4	2.38875	284.2613	-3325.86	6907.548

Table 3 Dynamic Programming Result

EAGLE CEMENT						
S/N	**ʎ**	**µ**	**P**	**Lq**	**Z**	**Zcheck**
1	3.6	4	2.205	262.395	-3070.02	6376.199
2	3.8	4	2.3275	276.9725	-3240.58	6730.432
3	6.4	4	3.92	466.48	-5457.82	11335.46

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

4	3.9	4	2.38875	284.2613	-3325.86	6907.548
5	6.1	4	3.73625	444.6138	-5201.98	10804.11
6	4.3	4	2.63375	313.4163	-3666.97	7616.015
7	3	4	1.8375	218.6625	-2558.35	5313.499
8	3.2	4	1.96	233.24	-2728.91	5667.732
9	5.9	4	3.61375	430.0363	-5031.42	10449.88
10	6.3	4	3.85875	459.1913	-5372.54	11158.35
11	3.6	4	2.205	262.395	-3070.02	6376.199
12	3.8	4	2.3275	276.9725	-3240.58	6730.432
13	6.4	4	3.92	466.48	-5457.82	11335.46
14	3.9	4	2.38875	284.2613	-3325.86	6907.548
15	6.1	4	3.73625	444.6138	-5201.98	10804.11
16	4.3	4	2.63375	313.4163	-3666.97	7616.015
17	3	4	1.8375	218.6625	-2558.35	5313.499
18	3.2	4	1.96	233.24	-2728.91	5667.732
19	5.9	4	3.61375	430.0363	-5031.42	10449.88
20	6.3	4	3.85875	459.1913	-5372.54	11158.35
21	3.6	4	2.205	262.395	-3070.02	6376.199
22	3.8	4	2.3275	276.9725	-3240.58	6730.432
23	6.4	4	3.92	466.48	-5457.82	11335.46
24	3.9	4	2.38875	284.2613	-3325.86	6907.548

Table 5 Dynamic Programming Result

				Coca-Cola		
S/N	**λ**	**μ**	**P**	**Lq**	**Z**	**Zcheck**
1	3.9	4	2.38875	284.2613	-3325.86	6907.548
2	4.1	4	2.51125	298.8388	-3496.41	7261.782
3	1.4	4	0.8575	102.0425	-1193.9	2479.633
4	2.8	4	1.715	204.085	-2387.79	4959.266
5	3.4	4	2.0825	247.8175	-2899.46	6021.965
6	7.3	4	4.47125	532.0788	-6225.32	12929.51
7	1.3	4	0.79625	94.75375	-1108.62	2302.516
8	6	4	3.675	437.325	-5116.7	10627
9	2.9	4	1.77625	211.3738	-2473.07	5136.382
10	3.1	4	1.89875	225.9513	-2643.63	5490.615
11	3.9	4	2.38875	284.2613	-3325.86	6907.548
12	4.1	4	2.51125	298.8388	-3496.41	7261.782
13	1.4	4	0.8575	102.0425	-1193.9	2479.633
14	2.8	4	1.715	204.085	-2387.79	4959.266
15	3.4	4	2.0825	247.8175	-2899.46	6021.965
16	7.3	4	4.47125	532.0788	-6225.32	12929.51
17	1.3	4	0.79625	94.75375	-1108.62	2302.516
18	6	4	3.675	437.325	-5116.7	10627
19	2.9	4	1.77625	211.3738	-2473.07	5136.382
20	3.1	4	1.89875	225.9513	-2643.63	5490.615
21	3.9	4	2.38875	284.2613	-3325.86	6907.548

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

22	4.1	4	2.51125	298.8388	-3496.41	7261.782
23	1.4	4	0.8575	102.0425	-1193.9	2479.633
24	2.8	4	1.715	204.085	-2387.79	4959.266

Table 5 Dynamic Programming Result

				7 Up		
S/N	**λ**	**μ**	**P**	**Lq**	**Z**	**Zcheck**
1	3.1	4	1.89875	225.9513	-2643.63	5490.615
2	3.3	4	2.02125	240.5288	-2814.19	5844.849
3	1.7	4	1.04125	123.9088	-144.73	3010.983
4	3	4	1.8375	218.6625	-2558.35	5313.499
5	4.3	4	2.63375	313.4163	-3666.97	7616.015
6	2.4	4	1.47	174.93	-2046.68	4250.799
7	6	4	3.675	437.325	-5116.7	10627
8	8.3	4	5.08375	604.9663	-7078.11	14700.68
9	4.5	4	2.75625	327.9938	-3837.53	7970.248
10	5.6	4	3.43	408.17	-4775.59	9918.531
11	3.1	4	1.89875	225.9513	-2643.63	5490.615
12	3.3	4	2.02125	240.5288	-2814.19	5844.849
13	1.7	4	1.04125	123.9088	-144.73	3010.983
14	3	4	1.8375	218.6625	-2558.35	5313.499
15	4.3	4	2.63375	313.4163	-3666.97	7616.015
16	2.4	4	1.47	174.93	-2046.68	4250.799
17	6	4	3.675	437.325	-5116.7	10627
18	8.3	4	5.08375	604.9663	-7078.11	14700.68
19	4.5	4	2.75625	327.9938	-3837.53	7970.248
20	5.6	4	3.43	408.17	-4775.59	9918.531
21	3.1	4	1.89875	225.9513	-2643.63	5490.615
22	3.3	4	2.02125	240.5288	-2814.19	5844.849
23	1.7	4	1.04125	123.9088	-144.73	3010.983
24	3	4	1.8375	218.6625	-2558.35	5313.499

Tables 1 - 5 show the dynamic programming of data from First Aluminium and four other companies. Twenty four hourly systems are involved with three shifts per day. The service rate are kept constant at a value of four (4). The values of P, Lq, Z and Zcheck were obtained. The numerical values are used to show the relationship between the system and other parameters. The Z values moved downward, while Zcheck moved upwards to show control of trend.

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

Figure 2 Dynamic Programming Result For First Aluminium

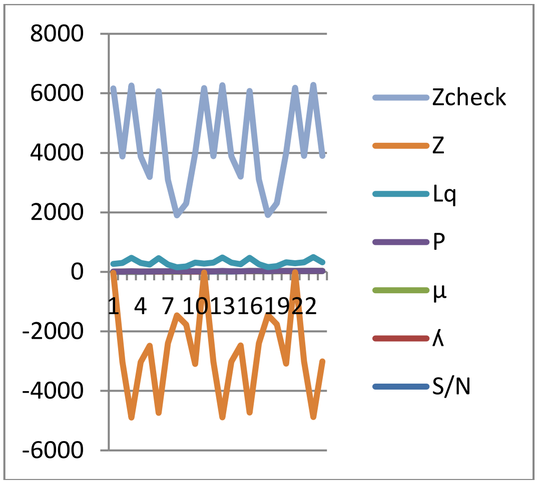


Figure 3 Dynamic Programming Result For Vinal Aluminium

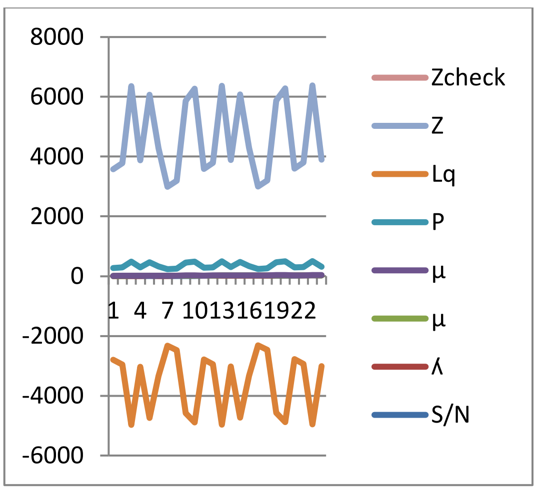
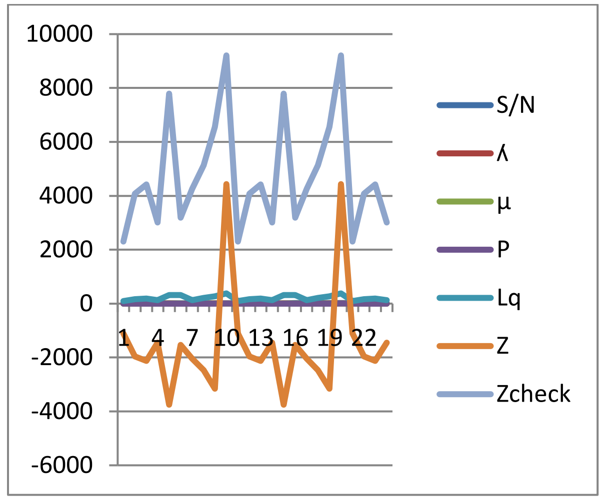


Figure 4 Dynamic Programming Result for Eagle Cement



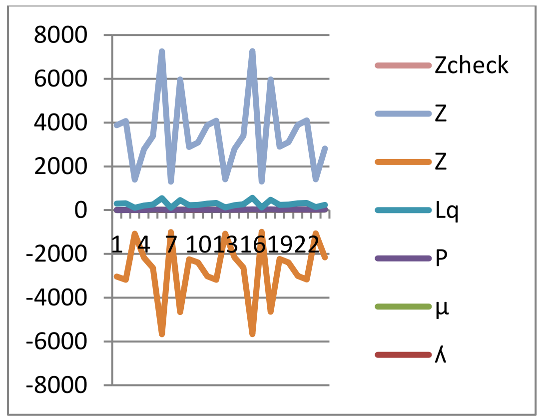
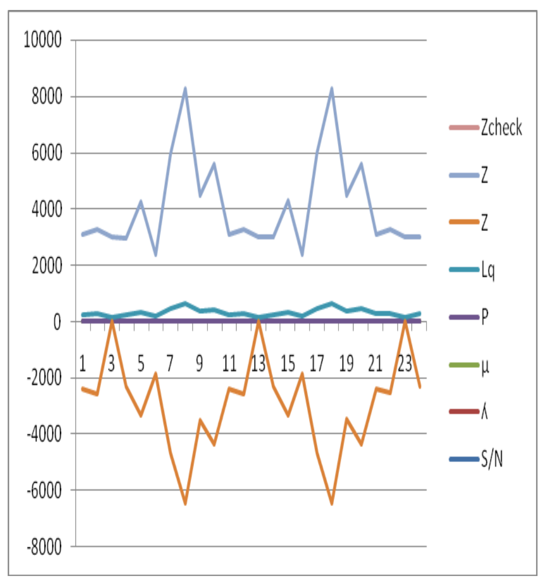


Table 5 Dynamic Programming Result for Coca-Cola



http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

Figure 6 Dynamic Programming Result for 7 Up

Figure 2-6show the dynamic programming of data from First Aluminium and four other companies. Twenty four hourly systems are involved with three shifts per day. The service rate are kept constant at a value of four (4). The values of P, Lq, Z and Zcheck were obtained. The numerical values are used to show the relationship between the system and other parameters. The Z values moved downward, while Zcheck moved upwards to show control of trend.

iv. **CONCLUSION**

The observation of a heuristic algorithm where there is a control measure to cost function was successfully conducted. The results obtained showed that the higher the control measure to cost function, the lower the cost function. This was possible by the application of the working tool note as dynamic programming. The result obtained for the cost function moved towards the left which showcased reduction. A control measure to cost function was obtained in order to check the cost function in terms of trend, this is denoted as Zcheck.

REFERENCES

[1] Z. Xiaosong, "Research on optimization of Quening System Based on Computer Simulation IEEE, 2017.

[2] T. Mustafa, "A New Design of Metaheuristic Search called Improved Monkey Algorithm Based on Random Perturbation for Optimization Problems" Scientific Programming, 2021.

[3] M. S. Ofer, X. Xi, R. Herschel, |Multi-level evolution strategies for high resolution balck-bot control "Journal of Heuristic, Pringer link, 2021.

[4] S. Ping, Z. Y. Zi, "Developing two heuristic algorithms with metaheuristic algorithms to improve solutions of optimization problem with soft and hard constraints". An application to nurse rostering problems, Applied soft computing, volume 93, 2020.

[5] Y. Xin-She, Titiew on "Bio- inspried computation in Telecommunication", 2015.

[6] K. Taichi, "a probabilistic analysis of neighbourhoods for combinatorial optimization problems and its application, Journal of Heuristics, Springer links.

[7] Bryar, "The Future of Meta- heuristic algorithm, 2021.

[8] Algorithms, "Journal Agorthms" volume 14 issue 2, 2021.

[9] M. F. Shehzad, et al., "Heuristic Algorthm for combined Heat and Power System Operation Management", Energies, 14, 1588, 2021.

[10] www.edrawsoft.com, 04-13-2021

[11] W. Luke, B. Katarzyna, L. Y. Sze, "Optimization defining and exploring a concept to enhance the impact of public health initiatives", Health Research Policy and Systems.

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902

[12] D. Sokolov, E. Barakhteneke, "An application of Dynamic Programming to the determination of optimal parameters of tree-structure energy pipeline networks", International conference on Industrial Engineering, 2020.

[13] L. Stratos, S. ALexandors, S. Loanms, "Joint Production, Inventory rationing, and Order admission control of Stochastic Manufacturing System with Operational Research Springer, Vol. 21(2), pp. 827- 855., 2021.

[14] A. Thekra, H. Mhand, Z. Vassils, "An iterative algorthm for the Max-Min Knapsack Problem with Multiplied Scenasios", Operational Research, Springer, Vol. 21 (2) pp. 1355 -1392, 2021.

[15] L. Yang, D. He, "A Selection of Hyper-Heuristic Algorithm for Multi Objective Dynamic Economic and Environmental Load Dispatch," Research Article, 2020.

[16] Y. Wu et al., "A Heuristic Algorithm for Optimal Service Composition in Complex Manufacturing Networks," Research Article, 2019.

[17] A. T. Vasilious, G. V. Constantinos, I. t. Athanasios, "Optimizing a unit commitment problem using an evolutionary algorithm a plurality of priority lists" Operational Research, Springer, Volume 21 (1), pp 1- 54, 2021.

[18] B. Sharal et al, "A Heursitic Algorithm Based on line-up competition and generalized pattern search for solving integar and mixed inter Non-liner Optimization Problems, Latin American Journal of Solids and Structures, Volume 13 Number 2, pp. 1679 - 7825, 2016.

http://dx.doi.org/10.31364/SCIRJ/v10.i1.2022.P0122902