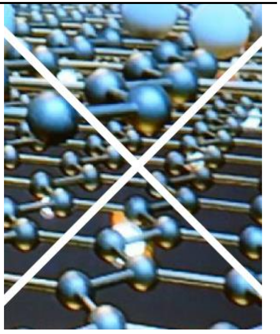
TIJMET, Vol. 0004 (2021) 157-167

The International Journal of

Materials and Engineering Technology

ISSN: 2667-4033
TIJMET ID: 210402008 (11 pages)
Type of the Paper: Research Article
Received: 06.10.2021 Revised: 27.12.2021 Accepted: 27.12.2021 Published (Online): 30.12.2021
Journal homepage: http://dergipark.gov.tr/tijmet



OPTIMUM DESIGN OF OVERHEAD CRANE CONSTRUCTION USING THE BEES ALGORITHM

SAMİ YEŞİLBEL[*1a], **MAHMUT ÇİMEN** [2b], **METE KALYONCU**[3c]

[1, 2]Sekizli Makina ve Vinç San. Tic. A. Ş., 42050 Konya / TURKEY
[3]Konya Technical U., Engineering and Nature Science Faculty, Department of Mechanical Engineering, 42250 Konya / TURKEY
[*]sami@sekizli.com.tr

Abstract

In this study, the optimum design of an overhead crane construction was carried out using The Bees Algorithm in order to have minimum weight while fulfilling the desired technical and functional features. The sheet materials, which are the girders of overhead cranes, are produced by forming boxes and welding to each other, the largest item is the amount of material used. In addition, the major factor affecting the movements and operating costs during their operations is the mechanical construction. For these reasons, it is very important that the weight of the crane that will do the lifting work with the same characteristics is low and the construction work is also outside the operation. Therefore, the purpose of the design of the crane is to provide maximum performance with minimum cost from the system. In the construction design of the overhead crane, it is necessary to make the most appropriate choices according to the important parameter, such as weight, overhead span, variable parameters of the working class, as well as minimized fire. In this type of displaying The Bees Algorithm, a sample overhead crane construction design, necessary and constraints were defined and the most appropriate parameters were provided. An overhead crane was compared numerically before and after optimization for the design parameters determined according to the FEM (Federation Europenne de la Manutetion) standard. Obtained results are given in the form of tables.

Keywords: Optimization, The Bees Algorithm, mechanical construction design, overhead crane, manufacturing cost, structural analysis.

1. Introduction

Overhead cranes are important tools used in some modern industrial sectors such as construction, manufacturing, mining and transportation. These are extremely basic equipment that requires good knowledge of

How to cite this article:
Yeşilbel, S., Çimen, M., Kalyoncu M., Optimum Design of Overhead Crane Construction Using the Bees Algorithm, The International Journal of Materials and Engineering Technology, 2021, 4(2): 157-167.

ORCID ID:
[a]0000-0002-2052-5766, [b]0000-0002-3761-3295, [c]0000-0002-2214-7631

safety practices and operating competencies. They are used to transport heavy loads from one place to another. Due to industrialization and high productivity, modern industries have adopted the use of overhead cranes to speed up project deliveries. Safety is very important when using overhead cranes because any slip could result in serious injury or untimely death. However, if used carefully, you can reach all your goals quickly. While overhead cranes are highly adaptable to many environments, they must be extremely reliable. It is very important to design a minimum weight of overhead crane for safety, a minimum cost and maximum performance [1]. Electric overhead traveling cranes (EOT crane) are very popular due to their ease of use and free floor space. Since the main beams are the basic structure that carries most of the load, great care should be taken in their design. There are various types of beams such as tube beam, plate beam, truss beam and typical box beam with many advantages such as reduced overall weight, high torsional rigidity and low production time [2].

Various studies have been carried out on the numerical optimization of the crane beam. Many researchers have formulated the crane beam problem as a minimum weight design problem with restrictions on the maximum allowable deflection, stress, overall stability and stiffness, as well as the shock absorption capacity during accidental collision. Some researchers used combinatorial discrete backtracking programming method to solve the crane beam optimization problem. It showed that the use of higher strength steel could produce lighter beams. In addition to weight minimization, some researchers add other criteria to be optimized such as manufacturing cost, welding and painting costs. The resulting multi-objective problem is solved with a decision support system that includes various optimization algorithms such as the min-max method [3].

2. Mathematical Modelling of the Overhead Cranes

From time to time, manpower is naturally insufficient to lift heavy loads and move them to another area. In such cases, the most important tool that can be assisted in moving tons of weight from one point to another is crane types such as overhead cranes. The most important part of overhead cranes, which are often used in medium-sized workshops, is the girder. Strong and solid girders between two walls can affect the crane's mobility [4, 5].

2.1. Construction and Calculation Principles of Overhead Cranes

In the construction of lifting machines and parts, it is the most important feature to consider that the system performs its task in the desired performance during these. For this purpose, the working group and duration of the lifting machine and parts to be designed first should be determined according to the FEM (Federation Europenne de la Manutention) standard [6]. Classification of lifting machines according to FEM standard was made according to 3 groups.

- Lifting machine as a whole,
- Special equipment and mechanisms as a whole,
- Structural and mechanical parts.

When making this classification, 2 criteria are based. These are;

- Total usage time of the parts taken into account,
- Hook load, loading or voltage distribution in any part

2.2. Classification of Installation Types

An overhead crane construction installs according to DIN 15018 standard [7]. These are;

- H (main load) version of the installation
- Hz (main and additional loads) version of the installation
- HS (main and special loads) version of the installation

Table 1. Upgrade coefficient linked by lifting group

Lifting group	A1	A2	A3	A4	A5	A6	A7	A8
Upgrade coefficient	1.00	1.02	1.05	1.08	1.11	1.14	1.17	1.20

2.3. Selecting the upgrade coefficient, "γ_c"

Various tables have been created in accordance with FEM and DIN standards according to the working type of the trolley hoist. The selection of the upgrade coefficient by removal group is seen in Table 1

2.4. Selecting the lifting load coefficient, "ψ"

The lifting load coefficient is a designated coefficient of the lifting speed of the lifting machine. The lifting load coefficient cannot be selected less than 1.15. Figure 1 shows the change of the lifting load coefficient according to the lifting speed, v_K.

2.5. Construction Principles of Double Girder Overhead Crane

In this study, box girder construction was given as double girder overhead crane girder construction. A standard box girder construction is shown in Figure 2.

2.6. Moment of inertia and strength bending in box girders

A cross-section of bending inertia and strength moment in box girders are shown in Figure 3. When calculating the moment of bending inertia in the box girders, the neutral axis or section center of gravity is first located. After the neutral axis of the system is found, the girders inertia moment is calculated.

Moment of inertia, I_x;

$$I(x) = 2.\left(\frac{t_2 \cdot h_2^3}{12} + \frac{b_1 \cdot t_1^3}{12}\right) + \frac{b_R \cdot h_R^3}{12} + (y_1^2 + y_3^2)A_1 + 2.y_2^2 \cdot A_2 + y_5^2 \cdot A_R \qquad (1)$$

Moment of inertia, I_y;

$$I(y) = 2.\left(\frac{h_2 \cdot t_2^3}{12} + \frac{t_1 \cdot b_1^3}{12}\right) + \frac{h_R \cdot b_R^3}{12} + (x_2^2 + x_4^2)A_2 + 2.x_3^2 \cdot A_1 + x_4^2 \cdot A_R \qquad (2)$$

Strength moment, W_x, according to X-Axis

Since maximum stress is used in accounts, it is necessary to calculate the minimum strength moment. The minimum strength is calculated with moments e_{max} and u_{max} as follows.

$$w_x = \frac{I_x}{e_{max}} \; ve \; w_y = \frac{I_y}{u_{max}} \qquad (3)$$

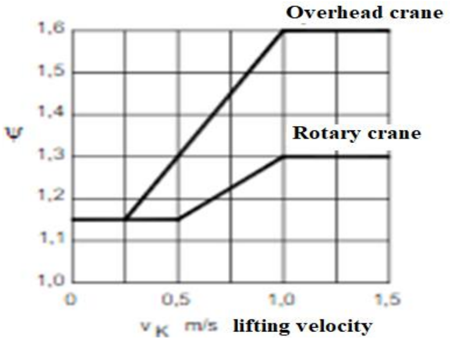


Figure 1 Lifting load coefficient

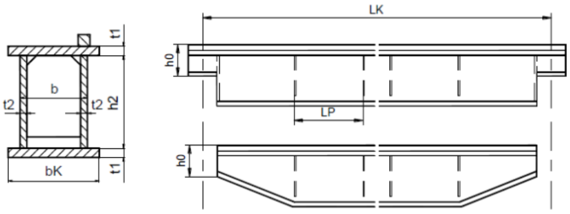


Figure 2 Box girder construction

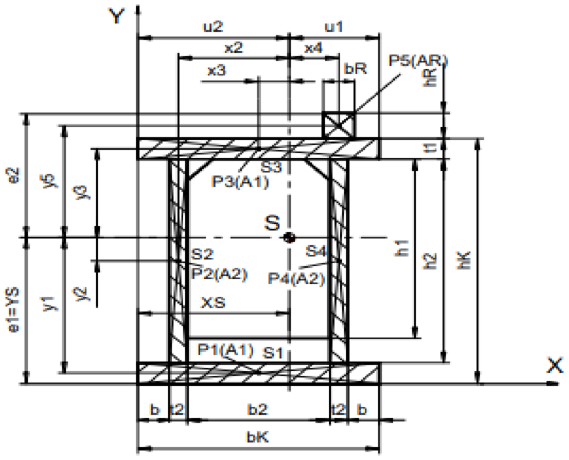


Figure 3 Section of bending inertia and strength moment in box girders

2.7. Normal Stresses and Calculations in Crane Girder

Normal stresses occurring on the crane girder are calculated taking into account the H situation. Additional stresses for HS and HZ state are calculated by adding the equation (4).

$$\sigma_{\max} = y_c(\sigma_1 + \sigma_2 + \psi\sigma_3 + \sigma_4 + \sigma_5) \quad (4)$$

$$\sigma_{\min} = (\sigma_1 + \sigma_2) \quad (5)$$

A pair of wheels and symbolized trolley (crane) are seen on the overhead crane girder and rail in Figure 4. Where;

F_{TD} = The force that influences the wheels of the trolley hoist,

F_{TH} = Horizontal force from trolley contraction and effect on the trolley wheel,

K_{r1} = Horizontal force Kr_1 (friction force) in the direction of movement from acceleration and braking on the crane wheel.

2.8. Stress of crane's subjectivity, "σ₁"

The stress consisting of the self-weight of the crane girder is the bending tension created by the moment when the crane girder is emitted. The stress consisting of the self-weight of the crane girder, σ1, is obtained with the following expression (Figure 5).

$$\sigma_1 = \frac{(q_k+q_p)\cdot gL_k^2}{8w_{x_k}} \quad (6)$$

2.9. Stress of the trolley hoist self-indivity, "σ₂"

The stress of the self-weight of the trolley is the bending tension created by the moment caused by the self-weight of the trolley hoist (Figure 6).

$$\sigma_2 = \frac{F_{AA}}{32\cdot L_k\cdot w_{x_k}}\cdot\left(2\cdot L_{k-L_A}\right)^2 \quad (7)$$

2.10. Stress consisting of lifting load, "σ₃"

It is the stress that comes from the weight strength of the lifting load (Figure 7).

$$\sigma_3 = \frac{F_y}{32\cdot L_k\cdot W_{x,i}}(2\cdot L_k - L_A)^2 \quad (8)$$

2.11. Strain of inertial forces, "σ₄"

The stretching consisting of the crane girder and the force of inertia caused by the mass of the trolley is calculated by horizontal forces calculated according to DIN 15018 (Figure 8).

$$\sigma_4 = \frac{0.075\cdot L_k}{w_{yk}}\cdot\left[\varphi\cdot\left(q_k+q_\rho\right)\cdot g\cdot L_k + \frac{F_{AA}}{2}\right] \quad (9)$$

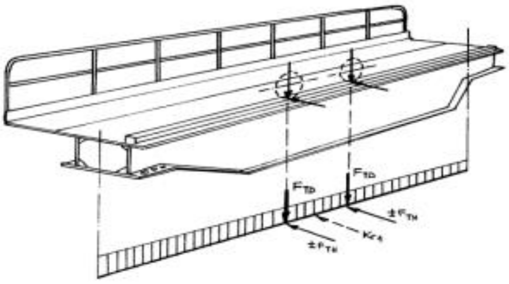


Figure 4 Overhead crane girder and girder-effect forces

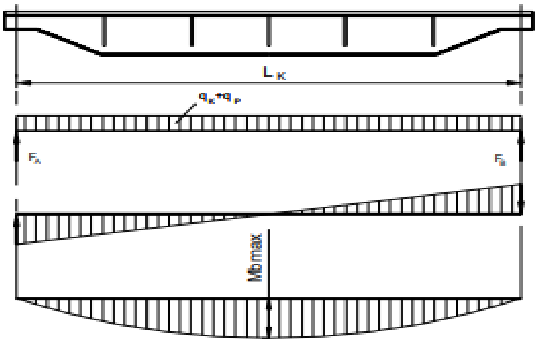


Figure 5 Distribution of the girders self-depreciation moment

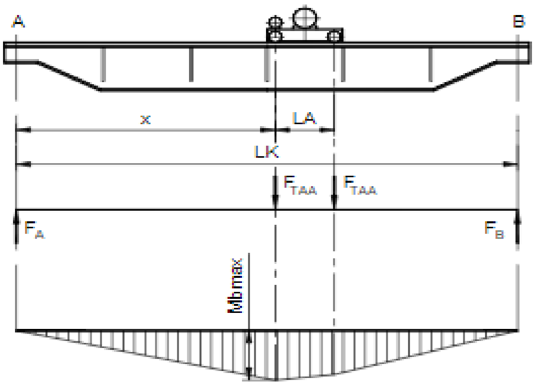


Figure 6 Distribution of the trolley hoist self-weight moment on the girder

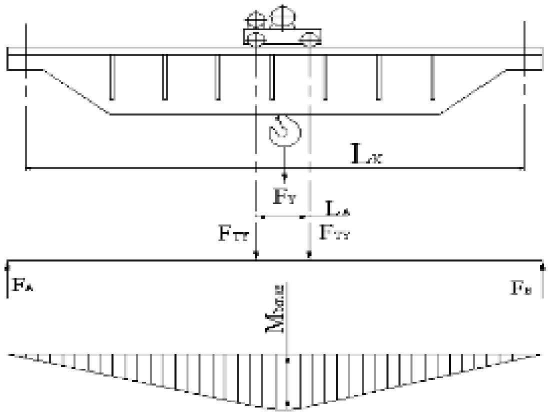


Figure 7 Distribution of the self-weight moment of the lifting load on the girder

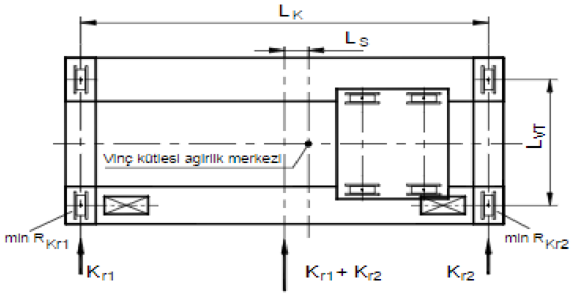


Figure 8 Forces of inertia on the girder

2.12. Stress caused by trolley contraction, "σ_5"

It is the stress caused by the bending moment caused by the horizontal force "F_{ATH}" caused by the trolley contraction on the crane girder (Figure 9).

$$\sigma_5 = \frac{0{,}05 L_A}{w_{yk}} \cdot \left(F_{AA} + F_y\right) \qquad (10)$$

2.13. Slip Stretching on Crane Girder, "τ_{ball}"

Total slip stretching, τ(ball), on the crane girder consists of two different types of slip stretching (torsion and cutting) superposition. In both cases of stress, there is a hyperstatic condition. Hyperstatic moments of slip currents and the slip center point must be present in order to precisely determine the slip stresses leading from both the torsional moment and the cutting force. However, there is little difference between the stresses found with this type of calculation and the strains found by a simpler approximate calculation method that we will use, and these differences are important for the safety of the account.

$$\tau_{top} = \tau_t + \tau_k \qquad (11)$$

where;

τ_t = Torsion stress from wheel forces,

τ_k= Cutting stress from wheel forces.

2.14. Torsion stress from wheel forces, "τt"

Asymmetrical torsion (torsion) caused by the moment of torsion caused by the steep and horizontal forces on the trolley wheels is stretched (Figure 10).

$$\tau_t = \frac{(x_4 + 0{,}2 \cdot y_5)(F_{AA} + F_y)}{4 \cdot t_2 \cdot (x_2 + x_4)(y_1 + y_3)^-} \qquad (12)$$

2.15. Cutting stretching from wheel forces, "τ_k"

Cutting stretching or cutting load is the stress of the trolley hoist own weight lifting load, which is caused by the weight and the girders own weight forces (Figure 11).

$$\tau_k = \frac{\psi \cdot F_y + \gamma \cdot F_{AA}}{4 \cdot t_2 \cdot h_2} \qquad (13)$$

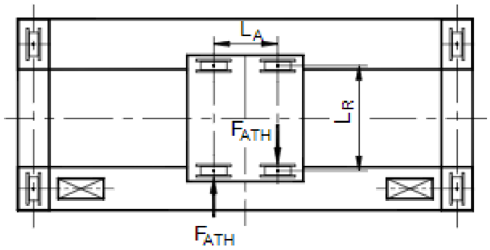


Figure 9 Forces caused by trolley contraction

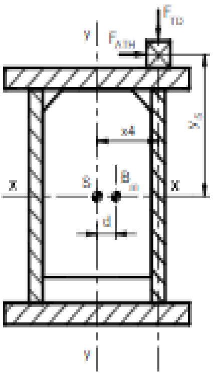


Figure 10 Girder section

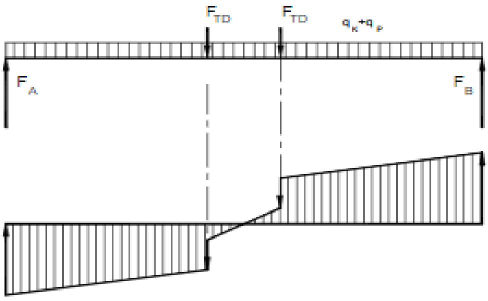


Figure 11 Distribution of cutting forces on the girder

2.16. Safe Strength Value for Static Control, "σ_{EM}"

The safety strength value, σ_{EM}, for static control is seen in Table 2.

The box girder is made of St 37 material. The safety strength value for St 37 is σ_{EM}=160 N / mm$^{2.}$ This value is for tensile stress. It has been seen in a box girder that the damage and deformations caused by the tensile forces are greater than the damage caused by the pressing forces. Therefore, the stress that is usually based on static control in calculations is safe tensile stress. However, it is important for the accuracy of the account to take into account the compression tension in terms of control of the accounts made. The safe compression strength value from Table 2 is σ_{EM}= 140 N / mm$^{2.}$

2.17. Safe Strength Value for Dynamic Control

The continuous dynamic safe strength value of the material depends more on the notch effect with the ratio of limit values [8]. The limit values ratio (close) is as follows;κ

$$\kappa = \frac{\sigma_{min}}{\sigma_{max}} = \frac{F_{min}}{F_{max}} \qquad (14)$$

Since the stresses are directly proportional to the force, there is no harm in writing the force ratio instead of the rate of stresses. The value and direction of the force should be taken into account in the calculation of the limit values ratio. Safe strength values of material for κ= -1 is shown in Table 3.

Table 2 Safe strength values for girder material

Type of equipment		Loading Status	Safe comparison strength value	Safe tensile strength value	Safe compression strength value	Safe shear strength value
St37	DIN 17100	H	160 N/mm^2		140 N/mm^2	92 N/mm^2
		HZ	180 N/mm^2		160 N/mm^2	104 N/mm^2
St52-3	DIN 17100	H	240 N/mm^2		210 N/mm^2	138 N/mm^2
		HZ	270 N/mm^2		240 N/mm^2	156 N/mm^2

Table 3 Safe strength values of material for κ = -1

Type of material	St37			St52-3		
Strength values	R_m = 340 N/mm^2 R_e = 240 N/mm^2			R_m = 490 N/mm^2 R_e = 350 N/mm^2		
Notch group	K2	K3	K4	K2	K3	K4
Loading group	Safe strength value (N/mm$^{2)}$ of the material for κ = -1					
U1, U2	180	180	152	270	254	152
U3	180	180	108	252	180	108
U4, U5	178	127	76	178	127	76
U6	126	90	54	126	90	54
U7	89	63	38	89	63	38
U8, U9	63	45	27	63	45	27

3. The Bees Algorithm

In this study, the optimum design of a crane construction with a roaming overhead was carried out using The Bees Algorithm [9-13] in order to have a minimum weight while fulfilling the desired technical and functional characteristics. When determining the girder section, the lightest construction must meet the required strength values. In this, our aim will be to obtain the minimum girder section area.

The Bees Algorithm (AA) was first proposed by Pham et al. and is a population-based search algorithm that mimics the resource-seeking behavior of honey bees [14]. Training of artificial neural networks for AA image recognition Pham et al. [15-19], forming production cells Pham et al. [20], scheduling jobs on a production machine [21], finding multiple suitable solutions to a design problem [22], data setting [23], optimization of mechanical component design [24], multipurpose optimization [25] have been successfully applied in recent years. Designed for the control of a robot arm with flexible limbs; In the optimization of PID controller gain coefficients [26] and in the optimization of pre-designed Fuzzy Logic Controller parameters [27], they have successfully applied The Bees Algorithm optimization method. In order to measure the effectiveness of The Bees Algorithm in solving complex optimization problems, they optimized the hierarchical PID controller gains with The Bees Algorithm for the control of an articulated robot arm obtained by the artificial neural network of the reverse kinematic model. According to the results of the optimization, they stated that the optimization method with The Bees Algorithm works better than the methods of adjusting standard PID gains. In his study, Fahmy selected the optimum speed parameters of wind turbine generators by optimizing them with The Bees Algorithm [28]. In the studies of Mr. Yuce, he introduced the optimization method in detail with the basic Bee Algorithm developed by Pham and compared their functional performance by applying their advanced versions with the basic Bee Algorithm for the solution of various functions. They stated that the Basic Bee Algorithm is advantageous compared to other optimization methods. The work of Pham and his colleagues in the year is a study comparing the performance of The Bees Algorithm and metaheuristic optimization methods inspired by other nature [29-32].

This section summarizes the main steps of the Bees Algorithm. Figure 12 shows the pseudo code for the algorithm in its simplest form. As detailed in [14, 15], the algorithm requires a number of parameters to be set, namely: number of scout bees (n), number of sites selected for exploitation out of n visited sites (m), number of top-rated (elite) sites among the m selected sites (e), number of bees recruited for the best e sites (nep), number of bees recruited for the other (m-e) selected sites (nsp), initial size of each patch (a patch is a region in search space that includes a visited site and its neighbourhood) and stopping criterion. The parameters of the Bees Algorithm were set as shown in Table 4.

Table 4 The Bees Algorithm Parameters

n	m	e	nep	nsp	ngh
10	4	3	8	5	0.01

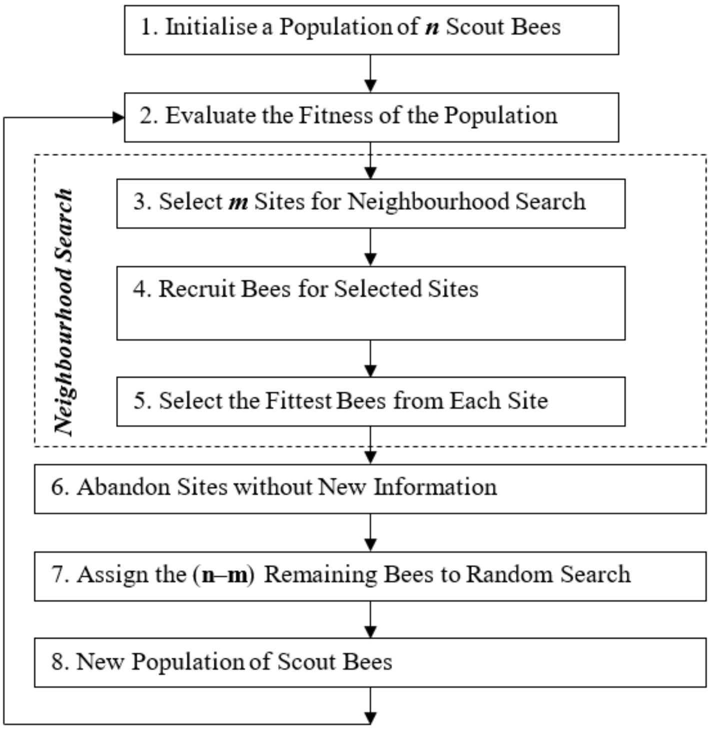


Figure 12. Flowchart of the basic Bees Algorithm

4. Numerical Results and Discussion

In Figure 13, an overhead crane manufactured by Sekizli Makina ve Vinç Sanayi Ticaret A. Ş., is shown to have used for optimization. The girder section values found as a result of the classical calculations are given in Table 5. The calculated girder section unit weight is 238.10 kg/m. According to this value, the total weight for an overhead girder of 30 meters is 7.143,00 kg. The results found using The Bees Algorithm in the Matlab software are given in Table 6. Table 6 contains the 10 different results obtained by The Bees Algorithm.

The best girder section unit weight found is 198.4 kg/m. According to this value, the total weight for an overhead girder of 30 meters is 5.953,00 kg. After comparing these two results, it is seen that approximately 16.5% material savings are achieved. The mean objective value for 10 different runs of the Bees Algorithm was found to be 5.953,00 kg and (see Table 6). Also, the standard deviation of all runs was calculated as 665.74 which proves the reliability of the algorithm.

Figure 13. An overhead crane manufactured by Sekizli Makina ve Vinç Sanayi Ticaret A. Ş.

Table 5. Girder section values calculated by classical calculation method

Measurement of parts					
b1	500	mm	t1	8,0	mm
b3	500	mm	t3	8,0	mm
h2	1200	mm	t2	8,0	mm
h4	1200	mm	t4	8,0	mm
bR	40	mm	hR	40,0	mm
bB	20	mm	hP	50,0	mm
Lk	30	m			
q_{PL}	50	kg/m			
Lper	2	m			
Moment of inertia of girder					
$I_{X\text{-}X}$	581874,20	cm^4	$I_{Y\text{-}Y}$	122482,30	cm^4
Moment of strength of the girder					
$W_{X\text{-}X}$	9050,90	mm^3	$W_{Y\text{-}Y}$	4665,00	mm^3
Weight of quipment					
Unit weight of girder	238,1	kg/m			

Table 6. Optimization solutions

	b	**h**	**t1**	**t4**	**fitness (mm^2)**	**weight (kg)**
1	610	1135	10	5	25150	5953.005
2	680	985	7	8	26880	6362.496
3	735	1265	9	6	30010	7103.367
4	840	950	7	9	30460	7209.882
5	640	850	9	11	31820	7531.794
6	645	780	14	8	32140	7607.538
7	1110	1240	5	8	32540	7702.218
8	1080	1440	4	8	33280	7877.376
9	530	985	23	4	33860	8014.662
10	605	1190	13	7	33990	8045.433

5. Conclusions

The optimum design of an overhead crane construction was carried out using The Bees Algorithm in order to have minimum weight while fulfilling the desired technical and functional features in this paper. A methodology is presented for the optimization of the main girder of an overhead travelling crane with double box-girder, based on The Bees Algorithm. The crane-girder problem is formulated with the area of box-section as the objective function of minimum weight. Constraints have been imposed on FEM standard. Results show that the proposed algorithm can achieve better results to those exist on the literature. The resulted The Bees algorithm was tested on an overhead crane calculated classical methods and compared with the existing crane dimensions. The results show that the optimized dimension can surpass the classical approach according to FEM standard. By varying the area of box-section of girders, a much lighter crane girder is obtained, which can reduce the cost of manufacturing and operation. Numerical results show that the optimized design obtained by using The Bees Algorithm have the minimum weight and approximately 16.5% material savings.

References

1. Michalewicz, Z., A survey of constraint handling techniques in evolutionary computation methods, Proceedings of the 4th Annual Conference on Evolutionary Programming, **1995**, 135-155.
2. Cho, S.W., Kwak, B.M., Optimal Design of Electric Overhead Crane Girders, Journal of Mechanisms, Transmissions, and Automation in Design, **1984**, 106: 203-208.
3. Chakri, A., Khelif, R., Benouaret, M., Optimization of the box-girder of overhead crane with constrained new bat algorithm, Rev. Sci. Technol., Synthèse, **2017**, 35: 187-203.
4. Sun, C., Zeng, J., Pan, J., “A Modified Particle Swarm Optimization with Feasibility-based Rules for mixed-variable Optimization Problems”, International Journal of Innovative Computing, Information and Control, June **2011**, 7: 3081–3096.
5. Coello, C.A., Theoretical and numerical constraint-handling techniques used with evolutionary algorithms: A survey of the state of the art, Computer Methods in Applied Mechanics and Engineering, **2002**, 191: 1245-1287.
6. F.E.M., Rules for the Design of Hoisting Appliances, Booklet 1 Federation europeenne de la Manutention, **1998**.
7. DIN-15018 T1, Krane grundsåtze für stahltragwerke berechnung, Deutche Norm, Germany, **1993**.
8. Kutay, M.G., Gezerköprü Vinç Dolu Kiriş Hesapları, Almanya, **1993**.
9. Bilgic, H.H., Sen, M.A., Kalyoncu, M., Tuning of LQR controller for an experimental inverted pendulum system based on the Bees Algorithm. Journal of Vibroengineering, **2016**, 18(6): 3684-3694.
10. Şen, M.A., Bilgiç, H.H., Kalyoncu, M., Çift Ters Sarkaç Sisteminin Denge Ve Konum Kontrolü için Arı Algoritması ile LQR Kontrolcü Parametrelerinin Tayini, Mühendis ve Makina, **2016**, 57, 53-62.
11. Sen, M. A., & Kalyoncu, M., Grey Wolf Optimizer Based Tuning of a Hybrid LQR-PID Controller for Foot Trajectory Control of a Quadruped Robot. Gazi University Journal of Science, **2019**, 32(2): 674-684.
12. Sen, M. A., & Kalyoncu, M., Optimal tuning of a LQR controller for an inverted pendulum using The Bees Algorithm, J. Autom. Control Eng., **2016**, 4(5): 384-387.
13. Fahmy, A.A., Kalyoncu, M., Castellani, M., Automatic design of control systems for robot manipulators using The Bees Algorithm. Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, **2012**, 226(4): 497-508.
14. Pham, D.T., Koç, E., Ghanbarzadeh, A., Otri, S., Rahim,S., Zaidi, M., The Bees Algorithm A Novel Tool for Complex Optimisation Problems, 2nd International Virtual Conference on Intelligent Production Machines and Systems, **2006**, 454-461.
15. Pham, D.T., Otri, S., Ghanbarzadeh, A., Koç, E., Application of The Bees Algorithm to the Training of Learning Vector Quantisation Networks for Control Chart Pattern Recognition, International Conference on Information and Communication Technologies, Damascus, Syria, **2006**, 1624-1629.
16. Pham, D.T., Koç, E., Ghanbarzadeh, A., Otri, S., Optimisation of the Weights of Multi-Layered Perceptrons Using The Bees Algorithm, 5th International Symposium on Intelligent Manufacturing Systems, Sakarya, Turkey, **2006**, 38-46.
17. Pham, D.T., Soroka, A.J., Ghanbarzadeh, A., Koç, E., Otri, S., Packianather, M., Optimising Neural Networks for Identification of Wood Defects Using The Bees Algorithm,

IEEE International Conference on Industrial Informatics, Singapore, **2006**.

18. Pham, D.T., Ghanbarzadeh, A., Koç, E., Otri, S., Application of The Bees Algorithm to the Training of Radial Basis Function Networks for Control Chart Pattern Recognition, 5th CIRP International Seminar on Intelligent Computation in Manufacturing Engineering, Ischia, Italy, **2006**, 711-716.
19. Pham, D.T., Muhamad, Z., Mahmuddin, M., Ghanbarzadeh,A., Koç, E., Otri, S., Using The Bees Algorithm to Optimise a Support Vector Machine for Wood Defect Classification, Innovative Production Machines and Syst. Virtual Conference, Cardiff, UK, **2007**.
20. Pham, D.T., Afify, A., Koç, E., Manufacturing Cell Formation Using The Bees Algorithm, Innovative Production Machines and Systems Virtual Conference, Cardiff, UK, **2007**.
21. Pham, D.T., Koç, E., Lee, J.Y., Phrueksanant, J., Using The Bees Algorithm to Schedule Jobs for a Machine, 8th International Conference on Laser Metrology, CMM and Machine Tool Performance, Euspen, UK, **2007**, 430-439.
22. Pham, D.T., Castellani, M., Ghanbarzadeh, A., Preliminary Design Using The Bees Algorithm, 8th International Conference on Laser Metrology, CMM and Machine Tool Performance, Euspen, UK, **2007**, 420-429.
23. Pham, D.T., Otri, S., Afify, A., Mahmuddin, M., Al-Jabbouli, H., Data Clustering Using The Bees Algorithm, 40th CIRP International Manufacturing Syst. Seminar, UK, **2007**.
24. Pham, D.T., Soroka, A.J., Koç, E., Ghanbarzadeh, A., Otri, S., Some Applications of the Bees Algorithm in Engineering Design and Manufacture, International Conference on Manufacturing Automation, Singapore, **2007**.
25. Pham, D.T., Ghanbarzadeh, A., Multi-Objective Optimisation Using The Bees Algorithm, Innovative Production Machines and Systems Virtual Conference, Cardiff, UK, **2007**.
26. Pham, D.T., Koç, E., Kalyoncu, M., Tınkır, M., Hierarchical PID Controller Design for a Flexible Link Robot Manipulator Using The Bees Algorithm, Proceedings of 6th International Symposium on Intelligent Manufacturing Systems, Sakarya, Turkey, Ekim 14-16, **2008**, 757-765.
27. Pham, D.T., Kalyoncu, M., Optimisation of a Fuzzy Logic Controller for a Flexible Single-Link Robot Arm Using the Bees Algorithm, Cardiff CF24 3AA, Cardiff University, UK, **2009**.
28. Fahmy, A.A., Kalyoncu, M., Castellani, M., Automatic design of control systems for robot manipulators using the Bees Algorithm, Proceedings of the Institution of Mechanical Engineers-Journal of Systems and Control Engineering, **2012**, 226(4): 497-508.
29. Pham, D.T., Castellani, M., Le-Thi, H.A., Nature-Inspired Intelligent Optimisation using The Bees Algorithm, Transactions on Computational Intelligence XIII, 8342, **2014**, 38-69.
30. Şen, M.A., İki tekerlekli robot için bulanık mantık tabanlı kontrolcü tasarımı ve Arı Algoritması kullanılarak optimizasyonu, Yüksek Lisans Tezi, Danışman: Doç. Dr. Mete KALYONCU, Selçuk Üniversitesi, **2014**.
31. Baronti, L., Castellani, M., Pham, D.T., An analysis of the search mechanisms of The Bees Algorithm, Swarm and Evolutionary Computation, **2020**, 59.
32. Massoudi, M.S., Sarjamei, S. & Esfandi Sarafraz, M., Smell Bees Optimization algorithm for continuous engineering problem. Asian J Civ Eng 21, **2020**, 925–946,