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CROSS SECTION DESIGN OF AN AUTO CRANE ARTICULATED BOOM USING METAHEURISTIC OPTIMIZATION ALGORITHM FOR SET DEFLECTION

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ABSTRACT

Picking the right geometric parameters for the cross section of an auto crane articulated boom is a complex and tedious iterative process. These geometric parameters, such as type, width, height, and plate thickness of the cross section influence the behavior of the articulated boom, especially deflection. Metaheuristic optimization algorithms can be employed to accelerate this process. The optimization algorithm was used for picking geometric characteristics of the members of a three-segment articulated boom (Figure 1), where each segment is consisted of a box cross section with different parameters (Figure 2). Constraints were defined in such way the height of the cross section cannot exceed the triple width of the cross section, and the whole structure should not exceed the set value of deflection. The mathematical model for calculating the deflection was derived using the second Castigliano's theorem in function of the weight of the payload. The position of the structure in which the deflection takes the highest value was detected (Figure 3), and for that position the optimization was conducted. The goal of the optimization process was to find geometric characteristics of the cross sections of minimal total mass for the set maximal deflection value. Two optimization algorithms were used: Differential Evolution algorithm (DE)[1], and Search and Rescue optimization algorithm (SAR)[2]. The value of set maximal deflection was 5 cm, the payload was set to be 2 kN, the material was set to be structural steel for all three segments. The results of the optimization are shown in Table 1. The verification of the results was completed using finite element method.

Table 1. Results of the optimization

	k	B_1	δ_1	B_2	δ_2	B_3	δ_3	Max. deflection	Total mass
	-	mm	mm	mm	mm	mm	mm	mm	kg
DE	2,958	174,6	3	167,4	3	150	3	≈ 50	565,6141
SAR	2,986	173,5	3	165,7	3	150	3	≈ 50	565,4616

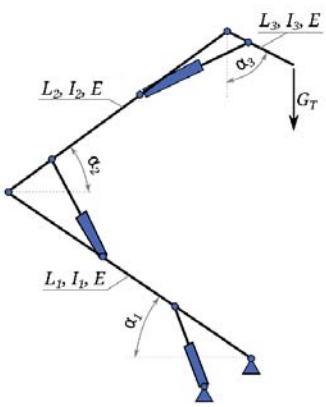

Figure 1. Auto crane articulated boom model

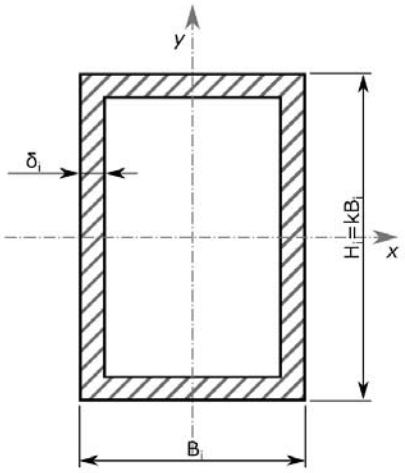

Figure 2. Cross section with important geometric characteristics

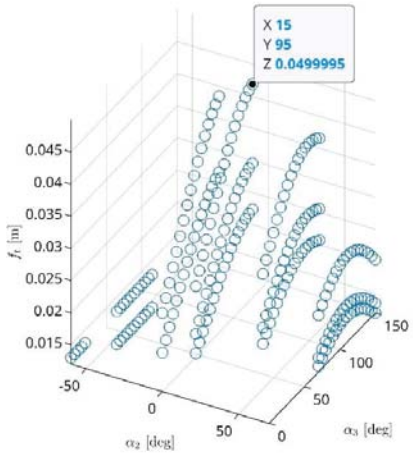

Figure 3. Deflection of the auto crane articulated boom for the optimized cross section

REFERENCES

[1] Storn, R., Price, K., "Differential evolution – a simple and efficient heuristic for global optimization over continuous spaces", *Journal of Global Optimization* 1997; 11(4); 341-359, doi: 10.1023/A:1008202821328

[2] Shabani, A., Asgarian, B., Gharebaghi, S.A., Salido, M., Giret, A., "A New Optimization Algorithm Based on Search and Rescue Operations", *Mathematical problems in Engineering* 2019; doi: 10.1155/2019/2482543