

# A Comparative Analysis of Heuristics Applied to Collecting Used Lubricant Oils Generated in the City of Pereira, Colombia

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**Abstract**—Currently, in Colombia is arising a problem related to collecting used lubricant oils which are generated by the increment of the vehicle fleet. This situation does not allow a proper disposal of this type of waste, which in turn results in a negative impact on the environment. Therefore, through the comparative analysis of various heuristics, the best solution to the VRP (Vehicle Routing Problem) was selected by comparing costs and times for the collection of used lubricant oils in the city of Pereira, Colombia; since there is no presence of management companies engaged in the direct administration of the collection of this pollutant. To achieve this aim, six proposals of through methods of solution of two phases were discussed. First, the assignment of the group of generator points of the residue was made (previously identified). Proposals one and four of through methods are based on the closeness of points. The proposals two and five are using the scanning method and the proposals three and six are considering the restriction of the capacity of collection vehicle. Subsequently, the routes were developed - in the first three proposals by the Clarke and Wright's savings algorithm and in the following proposals by the Traveling Salesman optimization mathematical model. After applying techniques, a comparative analysis of the results was performed and it was determined which of the proposals presented the most optimal values in terms of the distance, cost and travel time.

**Keywords**—Heuristics, optimization model, savings algorithm used vehicular oil, VRP.

## I. INTRODUCTION

MANUFACTURING companies have begun to consider the importance of making a proper collection, storage, and disposal of products that have completed their lifecycle, in order to reintegrate them into the production chain with other functions or mitigate or reverse the environmental damage caused by their improper disposition. In respect to the collection, it is essential to have a proper design of their transport systems. This allows for minimizing the time and costs in the delivery and collection of these products, and also effectively manages the activities of the supply chains. The logistics network design allows you to carry out the process with the least economic impact for companies [1]. Taking into account the above, in Colombia different studies have been developed that are based on the use of techniques and methods

to find a feasible solution to the problem of routing. Among these studies, one can be highlighted, such as that proposed in [2], where a model of optimization of transport routes was designed in a transport company. The company operates in the urban area of the city of Cali and its neighboring municipalities. This company is responsible for 45 routes, for this study only seven routes was selected (from the route 2 to 5 and from the route 7 to 9). The routes are located in the town center zone of Cali and are group the largest number of customers and represent the greater difficulties. The problem was the absence of a quantitative criterion for the allocation of routes. To solve the problem VRP Solver 1.3 software was used. This software implements the Clarke and Wright's savings algorithm method, in order to reduce the distances that used vehicles must travel and to minimize the required number of them to serve the customers. The most significant results were evident on Route 2 and Route 8 where the distance was reduced by 8% (from 11.93 km to 10.98 km) and 19% (from 17.56 km to 14.34 km), respectively.

The study [3] proposed a heuristic algorithm for establishing the scholar routes of the Secretariat of Education of Bogota for the locality of Kennedy. Due to the availability of the information from a total of 64 routes (that relate to the 20 schools in the locality), 48 routes were chosen. The algorithm used was adapted to the COVRP (capacitated open vehicle routing problem), on the basis of the CVRP (VRP with restriction of capacity) general algorithm. As a result of the algorithm application, the distance traveled decreased by approximately 225 km from the total distance, and for the routes that are using more than one bus, the decrease was 25%. On the other hand, [4] has generated and applied a mathematical model which takes as a reference theoretical central the VRP, whose aim was to improve the supply routes of each storage center in the collection process of milk at the Sugamuxi Province. For this, eight collection centers located in the municipalities of Firavitoba, Iza, Sogamoso and Tibabosa (who concentrated 597 producers) were studied. The times and levels of production were defined, also the provisioning costs, the means of transport used and their capacity. The study population was represented by 102 producers, eight collection centers, and two processors,

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