

**DEVELOPMENT OF MODELS AND META-HEURISTICS
FOR STOCHASTIC DYNAMIC FACILITY LAYOUT**

by

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CERTIFICATE

This is to certify that the thesis entitled “**Development of Models and Meta-Heuristics for Stochastic Dynamic Facility Layout**” being submitted by **Akash Tayal** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** is a bonafide record of original research work carried out by him. He has worked under my supervision and has fulfilled the requirements for the submission of the thesis, which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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(Akash Tayal)

ABSTRACT

A facility can be a workstation in a manufacturing system or a department in an organization, which is used to produce goods or provide services. The classical Facility Layout Problem (FLP) is a well explored and studied combinatorial optimization problem (COP). In FLP, the key objective is to efficiently arrange ' N ' indivisible facilities to ' M ' locations such that the distance of material travel is minimized. Reduced material movement lowers work-in-process levels and throughput times, less product damage, simplified material control and scheduling, and less overall congestion. Hence, while minimizing material handling cost (through minimizing material movement), other objectives are achieved simultaneously. In practical scenarios, facility layout design is dependent on demand which could be static, deterministic or random, and time planning horizon which could be single period or multiple periods. Thus, it can be classified as static, dynamic and stochastic. Considering uncertainty in the product demands in single period and multi-period leads to two stochastic FLPs called Stochastic Static Facility Layout Problem and Stochastic Dynamic Facility Layout Problem (SDFLP), respectively. This research focuses on Equal Area SDFLP. SDFLP is known to be NP-hard, which is modelled as QAP. Thus, it poses challenges when solved using exact algorithms and heuristic techniques.

The objective of SDFLP is to find an optimum layout for each time period so as to minimize the total material handling and rearrangement costs. In this research, three well-known meta-heuristics, namely, Simulated Annealing (SA), Chaotic SA (CSA) and Firefly Algorithm (FA) were evaluated to solve SDFLP and the best cooling schedule and chaotic map were identified. Then, a new hybrid meta-heuristic 'Hybrid FA/CSA' was designed for

solving SDFLP. It was benchmark with the results available in the literature and it showed that Hybrid FA/CSA outperformed the other meta-heuristics.

Further, the research proposes two models of Multi-Objective Stochastic Dynamic Facility Layout Problem (MO-SDFLP), referred as MO-SDFLP Type I and MO-SDFLP Type II, as and their solution methodology. To solve the MO-SDFLP Type I model, a new integrated technique of SA, Data Envelopment Analysis (DEA) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was developed. Beside formulating MO-SDFLP the aim of the research was to deal with the practical situations - economic, social, environmental aspects of the manufacturing unit. Keeping in light of this Sustainable MO-SDFLP (Type II) was proposed. It was solved using a new technique of combining meta-heuristic, Multi Attribute Decision Making (MADM) and integrated ranking, considering the expert's opinion and at the same time reducing the subjectivity and bias of the expert.

The research then, explores the applicability of Big Data Analytics in the domain of facility layout. The 3 V's of Big Data are mapped to FLP, then using Factor Reduction and MADM techniques a MO-SDFLP model was formulated, which was solved using hybrid meta-heuristic.

Finally, the application of the proposed SDFLP model to design layout for real industry was studied. A Shirt manufacturing unit was taken, where product demand for each season is uncertain. The data used was collected from various reports available in the industry and some of the data that was not readily available was gathered after discussion with the management. After analysis, the case was modeled as SDFLP and solved using hybrid meta-heuristic. Finally, the results and suggestions for improving the plants layout were shared with the management.

सार

एक सुविधा एक विनिर्माण प्रणाली में एक कार्य केंद्र या एक संगठन में एक विभाग हो सकता है, जो माल का उत्पादन करने या सेवाएं प्रदान करने के लिए उपयोग किया जाता है। शास्त्रीय सुविधा लेआउट समस्या (एफएलपी) एक अच्छी तरह से पता लगाया और संयोजन किया गया संयोजन संयोजन अनुकूलन समस्या (सीओपी) है। एफएलपी में, मुख्य उद्देश्य 'एम' स्थानों पर कुशलतापूर्वक 'एन' अविभाज्य सुविधाओं की व्यवस्था करना है, जैसे भौतिक यात्रा की दूरी को कम किया जाता है। कम हुई सामग्री आंदोलन कार्य-इन-प्रोसेस स्तर और थूपुट बार, कम उत्पाद क्षति, सरलीकृत सामग्री नियंत्रण और शेड्यूलिंग और कम समग्र भीड़ को कम करता है। इसलिए, सामग्री से निपटने की लागत को कम करते समय (सामग्री आंदोलन को कम करके), अन्य उद्देश्यों को एक साथ हासिल किया जाता है व्यावहारिक परिस्थितियों में, सुविधा लेआउट डिज़ाइन मांग पर निर्भर है जो स्थिर, नियतात्मक या यादृच्छिक हो सकता है, और समय नियोजन क्षितिज हो सकता है जो एकल अवधि या कई अवधि हो सकता है। इस प्रकार, इसे स्थिर, गतिशील और स्टोकेस्टिक के रूप में वर्गीकृत किया जा सकता है एकल अवधि और बहु-अवधि में उत्पाद की मांगों में अनिश्चितता को देखते हुए क्रमशः स्टोकेस्टिक स्टैटिक सुविधा लेआउट समस्या और स्टोचस्टिक डायनेमिक सुविधा लेआउट समस्या (एसडीएफएलपी) नामक दो स्टोकेस्टिक एफएलपी होते हैं। यह शोध समान क्षेत्र SDFLP पर केंद्रित है एसडीएफएलपी को एनपी-हार्ड कहा जाता है, जिसे क्यूएपी के रूप में तैयार किया गया है। इस प्रकार, यह चुनौतियों का सामना करता है जब सटीक एल्गोरिदम और अनुमानी तकनीकों का उपयोग करके हल किया जाता है।

एसडीएफएलपी का उद्देश्य प्रत्येक समय अवधि के लिए इष्टतम लेआउट ढूंढना है ताकि कुल सामग्री प्रबंधन और पुनर्व्यवस्था लागत को कम किया जा सके। इस शोध में, तीन प्रसिद्ध मेटा-ह्युरिस्टिक्स, अर्थात्, सिमुलेट एनेलिंग (एसए), अराजक एसए (सीएसए) और फायर फ्लाइ एल्गोरिथम (एफए) का मूल्यांकन एसडीएफएलपी को हल करने के लिए किया गया था और सबसे अच्छा शीतलन कार्यक्रम और अराजक नक्शा की पहचान की गई थी। इसके बाद, एसडीएफएलपी को सुलझाने के लिए एक नया हाइब्रिड मेटा-हीरिस्टिक 'हाइब्रिड एफए / सीएसए' तैयार किया गया

था। साहित्य में उपलब्ध परिणामों के साथ यह बेंचमार्क था और यह दर्शाता है कि हाइब्रिड एफए / सीएसए ने अन्य मेटा-हयूरिस्टिक्स को बेहतर किया

इसके अलावा, शोध में मल्टी-ऑब्जेक्टिव स्टेचस्टिक डायनेमिक फेवेलिव लेवेज प्रॉब्लम (एमओ-एसडीएफएलपी) के दो मॉडलों का प्रस्ताव है, जिसे एमओ-एसडीएफएलपी टाइप आई और एमओ-एसडीएफएलपी टाइप II, और उनके समाधान पद्धति के रूप में संदर्भित किया गया है। एमओ-एसडीएफएलपी टाइप आई मॉडल को हल करने के लिए, एसए, डेटा एनोप्लामेंट एनालिसिस (डीईए) की एक नई एकीकृत तकनीक और आदर्श समाधान (टॉपीस) के लिए समानता द्वारा क्रम वरीयता के लिए तकनीक विकसित की गई थी। अनुसंधान के उद्देश्य एमओ-एसडीएफएलपी तैयार करने के अलावा व्यावहारिक परिस्थितियों से निपटना था - विनिर्माण इकाई के आर्थिक, सामाजिक, पर्यावरण पहलुओं। इस सस्टेनेबल एमओ-एसडीएफएलपी (टाइप II) के प्रकाश में रखा गया था। विशेषज्ञों की राय पर विचार करते हुए और विशेषज्ञ की आत्मीयता और पूर्वाग्रह को कम करने के साथ-साथ मेटा-उत्परिवर्ती, मल्टी आटिटरिटी डिसिसन मेकिंग (एमएडीएम) और एकीकृत रैंकिंग के संयोजन की एक नई तकनीक का उपयोग करके हल किया गया।

तब शोध, सुविधा लेआउट के डोमेन में बिग डेटा एनालिटिक्स की प्रयोज्यता की खोज करता है। बिग डेटा के 3 वी के FLP को मैप किए जाते हैं, फिर फैक्टर कटौती और एमएडीएम तकनीकों का उपयोग करके एक एमओ-एसडीएफएलपी मॉडल तैयार किया गया था, जिसे संकर मेटा-अनुमानी

अंत में, प्रस्तावित एसडीएफएलपी मॉडल के आवेदन को वास्तविक उद्योग के लिए लेआउट डिजाइन करने का अध्ययन किया गया। शर्ट मैनुफैक्चरिंग यूनिट लिया गया था, जहां प्रत्येक सीज़न के लिए उत्पाद की मांग अनिश्चित होती है। उपयोग किए गए डेटा को उद्योग में उपलब्ध विभिन्न रिपोर्टों से एकत्र किया गया था और प्रबंधन के साथ चर्चा के बाद आसानी से उपलब्ध नहीं होने वाले कुछ आंकड़े एकत्र हुए थे। विश्लेषण के बाद, मामला एसडीएफएलपी के रूप में तैयार किया गया था और हाइब्रिड मेटा- अंत में, विनिर्माण इकाइयों के लेआउट में सुधार के लिए परिणाम और सुझाव प्रबंधन के साथ साझा किए गए थे।

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