Phd Research *Dr. Somasundaram Kumanan*

	Title of Research	Research Scholar	Guideship	Year
1	*Investigations on function replacing hybrids for decision making in machining*	**C P Jesuthanam**	**Guide**	**2007**
2.	*Some investigations on modeling, simulation and optimization of product development process*	**C A Shajahan**	**Guide**	**2007**
3.	*Some Investigations on Intelligent Decision Making in Robot Position and Motion Control*	**M Dev Anand**	**Co guide**	**2007**
4.	*Some evolutionary algorithms for facility layout design in FMS*	**R M Sathish Kumar**	**Co guide**	**2008**
5.	*Development of Intelligent Decision Making Tools for Submerged Arc Welding of Mild Steel*	**J Edwin Raja Dhas**	**Guide**	**2008**
6	*Managing manufacturing projects using simulation and meta heuristics*	**K Raja**	**Guide**	**2010**
7	*Hybrid multi criteria decision making techniques for selection of maintenance strategy* *Thesis web Published:http://shodhganga.inflibnet.ac.in/handle/10603/26420*	**K Ilangkumaran**	**Guide**	**2010**
8	*Investigations on Energy Conservation efforts in Industrial systems*	**C Ahilan**	**Guide**	**2012**
9	*Design and evaluation of supply chain Strategies with risk prioritization*	**S Prasanna Venkatesan**	**Guide**	**2012**
10	*Scheduling of flexible manufacturing system using Metaheuristics* *Thesis web Published:http://shodhganga.inflibnet.ac.in/handle/10603/26155*	**P Udaya kumar**	**Guide**	**2012**
11	*Selection of facility location In supply chain using integrated approaches*	**K. Kumar**	**Guide**	**2012**
12	*Investigations on intelligent process planning system for tool based micromachining processes*	**S P LeoKumar**	**Coguide**	**2015**
13	*Investigations on electrochemical drilling of superalloys and titanium alloys*	**N.Manikandan**	**Guide**	**2016**
14	*Investigations on Wire Electrical Discharge And Abrasive Water Jet Machining Of Inconel 617*	**Anish Nair**	**Guide**	**2018**
15	***Some investigations on resource allocation and asset tracking in Field service management***	**G Jegan Jose**	**Guide**	**2021**
16	Investigations on the efforts towards intelligent e-maintenance in heavy engineering industry	**A Andrew**	**Guide**	**2022**
17	**Fabrication and analysis of Inconel 625 parts using wire and arc additive manufacturing**	**M Karmuhilan**	**Guide**	**2024**

1. **Investigations on function replacing hybrids for decision making in machining:** Autonomous factory rely on effective and efficient decision making tools. The decision making is increasingly difficult due to the rapid changes in design due to variety of products and processes. Mathematical models which are derived based on assumptions are limited to model the functioning of the real manufacturing system. There is a need to develop generalized models which can dynamically predict a wide variety of process parameters to assist the intelligent manufacturing system. The intelligent tools such as neural network, fuzzy logic and evolutionary algorithms are being attempted in the decision making process to increase flexibility, accuracy and productivity. The present trend of favoring intelligent tools are due to its enhanced computing power and its ability to find the expected objectives for various inputs by capturing the real conditions and using them to develop a generalized model for future use. The indispensable features such as learning and adapting under uncertainty are the challenges to be addressed. Each intelligent tool has particular strengths and weakness and this made it necessary for combining two or more intelligent tools to improve the performance. Such hybrid intelligent tools are grouped as function replacing hybrid, intercommunication hybrid and polymorphic hybrid. This research is focused on the development and application of intelligent tools and function replacing hybrids for decision making in machining. The different strategies that are adopted for the prediction of machining quality are machining theory approach, experimental investigation, design of experiments and intelligent techniques. The investigations are focused on single point machining namely turning and multi point tool machining namely end milling. The experiments are designed and conducted as full factorial and orthogonal array as per the principles of taguchi's design of experiments. The multiple regression analysis are done to develop multiple regression equations. These equations are used to generate additional data for training the neural networks along with the experimental data. The intelligent tools applied in the modeling of machining processes are a) Backpropagation Neural Networks b) Fuzzy Logic and c) Radial Basis Function Neural Network. These predictive models i.e. intelligent tools are improved as function replacing hybrid models and tested. The hybrid models studied are neural networks trained with genetic algorithm, adaptive neuro fuzzy inference system, neural networks trained with

particle swarm optimization, radial basis function neural network with fuzzy logic, neural network trained with particle swarm optimization supported by genetic algorithm. These function replacing hybrids are compared for their performance in terms of number of epochs required for training the network and results are presented. The scope for further research is identified. [GO TO LIST]

2. **Some investigations on modeling, simulation and optimization of product development process :** The market is highly challenging with customers demanding a variety of products at competitive prices. To make a product competitive, it needs to be introduced quickly without compromising on its performance or quality. Thus, reduction of product development cycle time has become essential for companies to thrive and sustain in the market. A product development process is a sequence of activities done to conceive, design and commercialize a product. Product development is a complex activity that requires challenging management skills. Project management approach has been identified as a useful tool for managing product development. Since product development process involves a large amount of information flow and associated iteration, the traditional project management techniques are limited in application for its management. Simulation is a powerful technique for solving a wide variety of problems**.** Modeling and simulation can help in reduce product development cycle time, reduce cost and the amount of testing that must be done during development. Spread sheet flexibility and versatility makes Excel an appropriate platform for designing generic models that can be easily customized to the needs of a specific problem. A process model is developed, and using Microsoft Excel it is simulated. The model incorporates interrelated dynamic tasks with iterations, uncertainty of activity duration and complex resource scheduling that can represent realistic behavior of a complex design project. Using the SimQuick software, product development process is modeled and the completion time is estimated. The estimation is done for unlimited and constrained resource environment. The application of Petri nets for modeling of product development process is illustrated. A Petri nets based software called Petri- PM is used to model the process. Information like maximum activity usage and

probable project completion time are displayed graphically. Non- traditional search techniques are proposed and developed to find an optimized sequence for a set of design activities with the goal to minimize the total Product Development Iterative Time. The proposed non traditional algorithms are simulated annealing, a modified simulated annealing, particle swarm optimization and shuffled frog leaping algorithm. The proposed algorithms are illustrated and validated. Multiple criteria approach is proposed and developed for Design Structure Matrix sequencing problem of product development process. For multiple criteria optimization, the combined objectives of minimizing the effect of iteration by minimizing the distance of feed back marks and reduce the overall time by increasing concurrency by adjusting the marks within the Design Structure Matrix are proposed and used. The hybrid particle swarm optimization algorithm and hybrid shuffled frog leaping algorithms are proposed and developed for multiple criteria optimization. Scheduling is the allocation of resources over time to perform a collection of tasks. A methodology is proposed for scheduling of product development projects using design structure matrix and a genetic algorithm. A combined objective function, which simultaneously minimizes the project duration and reduces the effect of iteration under constrained resource environment, is used for finding out an optimal schedule. The proposed methodology is exemplified with a case study. This research work is focused on modeling, simulation and optimization of product development process.

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3. **Some Investigations on Intelligent Decision Making in Robot Position and Motion Control** Robotic systems rely on effective and efficient decision making tools. The decision making is increasingly difficult due to the rapid changes in design, parameters and environments due to variety of applications. Mathematical models which are derived based on the assumptions are limited to model the functioning of the real robotic system. There is a need to develop generalized models which can dynamically predict a wide variety of robot issues (affecting the entire system) such as position, motion, fault tolerance and selection and also others to assist the intelligent robotic system. The problem of positioning a robot arm in

the three dimensional space has been studied for a long time. However, most solutions developed until now, despite the fact of providing great reliability and flexibility but they lack the necessary accuracy to permit the arm to move in an unstructured dynamic environment.. A new robust neuro-fuzzy control system offers not only the benefit of the parallel nature of its computations, but also the ability to learn the control of an arm by following a human's example. A computationally efficient processing scheme for fuzzy control to reasoning about obstacle avoidance using artificial neural network namely, the intelligent dynamic motion planning has been developed. This newly developed robust neuro-fuzzy controller generate the commands for the servo systems of the robot so it may choose its way to its goal autonomously, while reacting in real- time to unexpected events. This scheme has been successfully simulated and several neuro-fuzzy controllers are trained using the sample data obtained from a human's control of a robotic arm. Their performance is quantified and compared. This work addresses the neuro fuzzy systems which are used for both residual generation and analysis based on fault detection and tolerance applications in robotic manipulators. A multilayer perception is employed to reproduce the dynamics of the robotic manipulator. Its outputs are compared with fuzzy threshold fixed with fault free condition of actual position and velocity measurements generating the residual vector. An intelligent fault tolerance framework is developed and simulated in which a fault rule base and detection algorithm work together to detect and tolerate sensor and/or motor failures in a robot system. Selection of a robotic system is an important task for the dynamic scenario.. This developed model is based on the fuzzy analytic hierarchy process method to consider both the subjective and objective criteria for robotics system selection.. Each intelligent tool has particular strengths and weakness and this made it necessary for combining two or more intelligent tools to improve the performance. This research is focused on the development and application of intelligent tools with function replacing and intercommunication for decision making in robot issues.

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4. **Some Evolutionary Algorithms for Facility layout design in FMS** Facility layout design deals with the arrangement, location and distribution of the equipment and support services in a manufacturing facility to achieve minimization of material handling cost, maximization of operational and arrangement flexibility, maximization of factory output in conformance with production schedules. Flexible manufacturing systems (FMSs) can be viewed as one among the family of modern manufacturing methods, which have the merits of job shop flexibility and flow shop efficiency. For the last two decades, researchers have started concentrating on solving different types of layout problems in advanced manufacturing systems. The facility layout problems (FLPs) are known as NP complete problem and exact algorithms such as Branch and Cutting algorithms have been proposed by researchers to solve FLP. The conventional techniques are not efficient when search space is too large and the convergence is mostly towards local optima. The computational complexity of FLPs demands the requirement for effective algorithms. The advanced manufacturing system composed of components such as roots, CNC machining centre, automated guided vehicles (AGVs), conveyors, automated storage and retrieval system. Complex routing decisions, decision regarding the sequencing and scheduling of parts and resources can be modeled using simulation. This research work focuses on the design of single row layout(SRL), Multi-row Layout and Loop Layout (LL) problems in FMS. The design of FMS involves the following two major issues (i) Layout of machines with the consideration of material handling devices. (ii) Study of operational and performance issues of the layout. Due to high capital investment costs involved in the implementation of FMS, the layout issue must be given attention in the early stages of the design. In this research work, optimal layout for single row, multi-row and loop layout are obtained by employing evolutionary algorithms..*In this work, a pr*ocedure is proposed to introduce the CT in the flow path and to find the position of the CT which yields minimum material handling distance. A comparison has been made between the SRL problem and unidirectional LL problems based on the same objective measure of minimization of flow times distances. This study, finds its usefulness in the selection of the best layout type. This work also describes the optimization of layouts using a multi criteria approach and considers both the quantitative and qualitative objectives to solve the layout problem.

Analytical Hierarchy Process (AHP) is used to derive the closeness rating matrix in the multi criteria model. The better layouts need to be studied to understand the efficiency and operational easiness. In this work, the performance and operational issues in the FMS layout are investigated through simulation models. The developed simulation model, considers the effect of real time constraints such as scheduling rules, routing flexibilities, part mix ratios and bottleneck in the process etc. The operational performances I terms of makes pan and average machine utilization of the layouts are analyzed through WITNESS simulation software. A case study has been considered to understand the developed optimization and simulation models.

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5. **Development of Intelligent Decision Making Tools for Submerged Arc Welding of Mild Steel** Product Variety, Quality level and stiff competition have driven the manufacturing systems to be automated. Success of automation depends on effective and efficient decision making tools. Traditionally the desired parameters are chosen based from charts or handbook which are suboptimal and are not universal. The other method of representing the interplay of these parameters is by developing empirical relations in which the parameters have some constant exponents whose value is chosen/estimated on the basis of experience. This choice of the exponents introduces a lot of subjectivity and is fixed. There is a need to develop generalized models, which can predict a wide variety of process parameters to assist the manufacturing system. Artificial intelligence is becoming widely used in all aspects of manufacturing process to assist humans. Artificial Intelligent tools such as expert systems, artificial neural network, and fuzzy logic support supports decision making manufacturing systems. These tools are capable of responding to changes in the automated manufacturing environment, and having the ability to capture vast manufacturing knowledge. These tools predict the requisite value for given set of parameter combinations. The vital features of learning and adjusting under uncertainty are addressed. Still these tools are limited in application when used as individually and could be combined for better

performance. This research is focused on the application of intelligent tools and the development of hybrid models which scopes to build an effective intelligent decision making system to enhance SAW automation. The investigations are focused on predicting the quality of weldment in the SAW process. Experiments are designed by orthogonal array as per the principles of Taguchi's design of experiments and are conducted. Data are acquired by conducting experiments and by Finite Element Simulation. The intelligent tools applied in the modeling of welding processes are a) Backpropagation Neural Networks and b) Fuzzy Logic. These predictive models i.e. intelligent tools are improved as hybrid models and tested. The hybrid models used are neural networks trained with Genetic Algorithm (GA), Particle Swarm Algorithm (PSO) and Neural Networks embedded with Fuzzy Logic, Adaptive Neuro Fuzzy Inference System. These hybrids are compared for their performance in terms of number of epochs required for training the network and results are presented. The proposed and developed models are validated by running confirmatory experiments and are forwarded to predict weld quality under different weld conditions. Evolutionary techniques GA and PSO are used to optimize SAW parameters to achieve good quality of weld. The performances of GA and PSO algorithms are compared. The scope for further research is identified.Finally, a summary of the research and contributions of the research study are highlighted. The possible extensions for future research are also suggested in the conclusion chapter of this thesis. An extensive reference on the subject is included. A substantial part of this research work is reported in various international journals / national journals / international conferences / national conferences. A list of papers published / presented based on the work reported is given at the end.

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6 . **Managing manufacturing projects using simulation and meta heuristics :** Companies today find themselves in a highly competitive environment of rapidly changing operational requirements. The need is to manage increasing product complexities, shorter time to market, newer technologies and threats of global competition. The project management

techniques need to be revisited to improve its application and effectiveness. The most popular methods for project planning and management are based on a network diagram such as Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM). These tools did not consider number of factors which are important for real-life project management. The extensions on these tools like decision CPM (DCPM), Graphical Evaluation and Review Technique (GERT), and Venture Evaluation and Review Technique (VERT) are limited in application. The need for powerful graphical and analytical tools arises in project management to meet the growing applications. Simulation is a powerful technique for solving a wide variety of problems**.** Modeling and simulation can help in reduce projects cycle time; reduce cost and the amount of testing that must be done during development project. The manufacturing projects need fast and reliable decision making tool for better management. Random selection of activity duration with its appropriate probability distribution will make the project estimation close to reality. The methods for estimation of project completion time with rework probability, with increased resources and with stochastic activity duration are developed and demonstrated using spread sheet simulation. Cost management of the manufacturing projects is exemplified using spread sheet simulation. The application of Petri Net (PN) for modeling, simulation and analysis for manufacturing projects is detailed Resource leveling is the project management function of resolving project resource over-allocation. This process of rescheduling of project activities without affecting the project completion date will result in effective resource usage and cost effective project schedule. Memetic algorithms and Particle Swarm Optimization (PSO) algorithms are developed for resource leveling application and are validated. The proposed methodology is easy to handle and proposed alternative schedules which allows flexibility in managing. Resource allocation procedures are aimed at obtaining the shortest project schedule and minimum cost by allocating the available limited resources to project activities. It is a process of scheduling the project activities as and when the required resources are ready or in other words a process of allocating the limited resources period by period basis to some subset of activities that requires attention. Proposed procedures provide optimal alternate solutions in terms of minimizing the project completion time.. This work confirms an alternative and efficient methodology for solving resource constrained project scheduling problems and

opening the application of Bacteria Foraging Optimization Algorithm (BFO), genetic algorithm and memetic algorithm to the optimization of scheduling of manufacturing projects under resource constrained environment. Managing multiple projects is a complex task. It involves the integration of varieties of resources and schedules. The researchers have proposed many tools and techniques for single project scheduling. Mathematical programming and heuristics are limited in application. In recent years non-traditional techniques are attempted for scheduling. This research proposes the use of a heuristic and meta heuristics for scheduling a multi-project environment with an objective to minimize the make span of the projects. The proposed method is validated with numerical examples.

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7. **Hybrid multi criteria decision making techniques for selection of maintenance strategy** Maintenance system plays a key role in achieving organizational goals. It contributes in reducing equipment downtime, improving quality and increasing productivity. Inadequate maintenance results in higher levels of asset failure and penalty costs. The choice of suitable maintenance strategy is vital. The Maintenance Strategy Selection (MSS) is approximated with few factors makes the decision unrealistic. The selection of maintenance strategy is a multi faceted problem with conflicting criteria. The application of Multi Criteria Decision Making (MCDM) techniques in maintenance management needs attention. This research is focused on the development and application of hybrid multi criteria decision making techniques for selection of maintenance strategy. he Analytical Hierarchy Process (AHP) and fuzzy AHP models are proposed and developed for maintenance strategy selection. The proposed models are used to examine the strengths and weaknesses of the possible maintenance strategy by comparing them with respect to appropriate criterion. The proposed AHP model is illustrated with a case example from a textile industry. The fuzzy set theory is integrated with AHP and proposed as FAHP model to eliminate the uncertainty and vagueness of the decision maker during the pair wise comparison process. The sensitivity analysis is conducted to observe the effect of criterion weights on maintenance strategy decision making. The FAHP

integrated with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is proposed and developed for application in maintenance management. The FAHP procedure is applied to analyze the hierarchical structure of the maintenance strategy problem and to determine the weights of the criterion. The TOPSIS method is used for final ranking. Fuzzy TOPSIS model is proposed and developed to overcome the cumbersome pair-wise comparison process and inconsistencies in hierarchical structuring process. The criterion weights are assessed by means of linguistic values. The linguistic ratings are expressed in triangular fuzzy numbers to express the subjective judgments of evaluators. The FAHP-TOPSIS and fuzzy TOPSIS models are illustrated with a case example from a paper industry for selecting maintenance strategy for the boilers. The effect of criterion weights on the decision alternatives are analyzed and reported after sensitivity analysis.The proposed FAHP-VIKOR model is illustrated with a case example from a paper industry for selecting maintenance strategy for the pumps. The fuzzy VIKOR model is proposed and developed to resolve the uncertainty and vagueness inherent in the group decision making process. It is capable of assessing the suitability of best alternative and compromise solutions. Fuzzy VIKOR model is illustrated with an industrial application. A sensitivity analysis is conducted and reported. The AHP-TOPSIS model integrated with linear programming is proposed and developed to consider qualitative criteria for MSS with resource constraints. The software is developed using visual basic to reduce the tedious computations. The developed software is demonstrated with a case example for selection of maintenance strategy for tea industry equipment. The AHP procedure is applied to analyze the hierarchical structure of the MSSP and to determine the weights of the criterion. The criterion weights are computed through pair wise comparison matrix. The linear programming model is integrated to find the best maintenance strategy with optimum maintenance cost. The proposed methods could be extended to other multi criteria decision making problems like project selection, personnel selection and machine tool selection.

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8. **Investigations on energy conservation efforts in industrial systems:** Energy is the vital input for economic and social development of a country. With an increase in industrial and agricultural activities the demand for energy is also rising. Setting up additional generating facilities to meet increasing energy demands is not only a very expensive substitute, but also very time consuming approach. As energy consumption is rising more than 2% /year, energy saving is one of the main tasks of present times and it is likely to become even more important in the next decades, as the economic growth is being pursued in developing countries. As a consequence, researchers, industries and governments are required to make significant efforts in this field. The increasing energy demand along with the growing concern for environmental issues have led to more and more stringent regulations on pollution and CO2 emissions, which means limiting energy consumption. Industrial sector is a major energy-consuming sector accounting for about half of the commercial energy available. Industrial system consumes energy, but the utilization of energy is differing from company to company due to personal policies and practices. Owing to old and outdated industrial technologies and machinery the extent of energy wastage is very high. Steep rise in fuel price and power costs, energy saving has become an essential and unavoidable activity in most of the industries. In view of these scenarios, there is an urgent need to review the present energy management approach.. This research is focused on energy conservation activities in industries. In this research work, energy conservation efforts in manufacturing system, air conditioning system and heat exchanger system are considered. In manufacturing industries one of the most important and complex phase of energy management is optimization of process parameters to maximize the value addition and increases profits. This research aims to bridge the gap between the concept of machining economics and the energy conservation..An efficient use and control of these systems could result in energy and economical savings without affecting the users comfort. There is a pressing need to identify and implement strategies for saving energy while maintaining a comfort environment in buildings with air conditioner. The experimental set-up is developed and the intelligent controller is designed for achieving human comfort and energy saving. Fuzzy logic controller is proposed and developed for a split type air conditioner. Developed intelligent controller is implemented in real system

and the results are compared with conventional control system. The performance indices of the system are studied by changing regulatory condition of the system. In heat exchanger system, the performance of heat exchanger deteriorates with time due to fouling on the heat transfer surface. It is necessary to assess periodically the performance in order to maintain at a high efficiency level. The performance of the shell and tube heat exchanger is assessed by online monitoring system. The various stages adopted to achieve energy performance assessment are through experimentation, design of experiments and online monitoring system. Experiments are conducted as per full factorial design of experiments and the results are used for artificial neural network model development. The predictive model is used to predict the overall heat transfer coefficient of clean/design heat exchanger. Fouled/real system value is computed with online measured data. Overall heat transfer coefficient of clean/design system is compared with the fouled/real system and reported. This proposed online energy performance system is implemented into the real system and the adoptability is validated. The scope for further research is identified.

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9. **Design and evaluation of supply chain Strategies with risk prioritization**: The supply chain is an integrated system of suppliers, manufacturers, retailers, distributors and customers. In recent years, supply chains have become increasingly vulnerable to risks resulting in poor financial performance and customer service. Managing supply chain risk is a challenging task. Researchers are attempting to evolve strategies to design a robust supply chain. This research is focused on the design and evaluation of the supply chain strategies under risks. Supply chain risk management is dealt in stages of risk identification, risk assessment, risk prioritization and risk mitigation strategies. Limited attention is devoted for mitigating the risks in supply chain. The reasons are the inconsistent set of robustness metrics for supply chain and the confliction among the strategies to enhance operational efficiency and supply chain robustness. To select the appropriate robustness measure and to tailor the mitigation approaches the supply chain risks are to be prioritized. Supply chain risk prioritization is a Multi Criteria

Decision Making (MCDM) problem. MCDM models for supply chain risk prioritization needs attention. In this research, a hybrid AHP-PROMETHEE approach is proposed and developed for supply chain risk prioritization. Case examples of a typical plastic industry and a tractor industry are presented to illustrate the application of the proposed AHP-PROMETHEE approach.Effective allocation of customers demand to multiple warehouses is significant in designing a robust supply chain. Minimizing the shipping cost and the delivery lead time are the contending objectives for warehouse allocation. Multi objective meta-heuristic optimizer for warehouse allocation needs attention. A Multi Objective Particle Swarm Optimization algorithm (TV-MOPSO-CD) is proposed and validated for a warehouse allocation problem. In supply chain, distribution planning has an important role in maintaining uninterrupted flow of goods and materials between the manufacturer and customers. Researchers have developed models to minimize the cost associated with distribution planning. Multi objective supply chain distribution planning problem that consider the trade-off between the cost and customer responsiveness needs attention. A Multi Objective Particle Swarm Optimization algorithm (TV-MOPSO-CD) is proposed and developed for a distribution planning problem and the performance is compared with a Non Dominated Sorting Genetic Algorithm II (NSGA II) and a Random Weight based Genetic Algorithm (RWGA). The design of production distribution network has a significant impact on supply chain performance. Multi objective production distribution network design considering the trade-off between costs, customer service and volume flexibility needs attention. In this research, a Multi Objective Discrete Particle Swarm Algorithm (MODPSA) is proposed for production distribution network design. A case example of a typical tractor industry is presented. The performance of the proposed MODPSA algorithm is compared with NSGA II. The supply chain sourcing strategy design considering price, exchange rate risk and supplier delivery reliability needs attention. A hybrid optimization and simulation approach is proposed to design and evaluate the supply chain sourcing strategy. A Multi-objective Binary Particle Swarm Optimization algorithm (MOBPSO) is developed and the Pareto optimal supplier policies are analyzed. Simulation models are built using Witness software and the Pareto optimal supplier policies

are evaluated under price, exchange rate and demand risks. A case example of a typical plastic industry is presented to exemplify the performance of the proposed approach.

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10 Scheduling of flexible manufacturing system using Meta-heuristics: Manufacturing companies are to manage increasing product complexities, shorter time to market, newer technologies, threats of global competition and rapidly changing environment. To cope with the manufacturing competition, flexible manufacturing system (FMS) is established. FMS is an integrated manufacturing system that consists of multi-functional numerically controlled machine tools connected with an automated material handling system. The objective of FMS is flexibility in production without compromising quality of products. The FMS flexibility depends on the flexibility of CNC machines, automated material handling devices and control software's. There are a number of problems faced during the life cycle of an FMS. These problems are classified into design, planning, scheduling and control problems. During the implementation and operation phase of the FMS, the user requires adjusting and fine-tuning of the FMS to the best operating conditions. Researchers are continuously putting efforts to solve design and operational problems of FMS. The dynamic planning of FMS operation needs attention. The traditional techniques are limited in application and yield a local optimal solution. The use of metaheuristics to solve scheduling problems of FMS needs attention. These techniques are population based and yield a global optimal solution. In this research, metaheuristics such as genetic algorithm, simulated annealing algorithm, ant colony optimization algorithm and particle swarm optimization algorithm have been proposed and developed to solve the FMS scheduling problems. Job and tool flows are the two key factors in the operation of FMS. The work centre of FMS can process a group of jobs. he FMS completes a task by performing a series of operations through the workstations and the parts are transported between the workstations by the AGV's. The problem of task scheduling in an FMS can be stated as finding a schedule for the AGV's among the workstations such that the tasks can be completed in the shortest time. Some metaheuristic techniques are proposed

and developed for routing, dispatching and task scheduling problem of AGV in FMS and are exemplified with illustrations. Suitable production planning for the enhancement of FMS needs attention. Job descriptions are known in advance and processing time for each job is independent of its position in the job sequence. Hence, single machine scheduling problem is addressed.Single machine scheduling is a central task in production planning of FMS. Some metaheuristics have been proposed and developed for single machine scheduling with an objective to minimize the total weighted tardiness. The objective of the total weighted tardiness problem is to find a processing order of all the jobs; this order is a schedule that minimizes the sum of the weighted tardiness of all jobs. The proposed metaheuristics are validated with benchmark problems. To improve the productivity of FMS, sequencing and scheduling of material handling system needs attention.The effects of production and Material Handling System (MHS) scheduling decisions on the FMS performance are investigated. In this research, the importance of production schedule and MHS schedule in FMS is focused. The Giffler and Thompson algorithm with different PDRs is developed to minimize the makespan in the FMS production schedule. Its output is used for MHS scheduling where the distance traveled and the number of backtrackings of the AGV are minimized using metaheuristics technique. The proposed metaheuristics are validated with benchmark problems. [GO TO LIST]

11 Selection of facility location In supply chain using integrated approaches : A supply chain is a network of facilities designed to procure, produce and distribute goods at the right quantities, at right location and at right time. A facility location provides the infrastructure for the supply chain and establishes the base from which operating economies are realized. The suitable selection of a facility location is a crucial component in the eventual success and strategic importance on the firm's better performance and competitiveness. Researchers are attempting to explore efficient methods for solving location problems. The growing complexity of socio-economic problems in location selection issues call for further research. The recognition of the need to consider more criteria in order to achieve closer solutions to reality and configuring robust integrated location models is significant for effective decision making. This research is focused on the selection of facility

location in supply chain using integrated approaches. The interdependence between strategic and tactical decisions focuses the significance of integrated facility location analysis in supply chain practices. A combined mathematical optimization and simulation approaches provide optimum solutions and take into account the dynamic and stochastic nature of supply chain elements. In this research, a mathematical modeling and simulation is proposed and exemplified for a multi- plant, multi-warehouse capacitated location allocation problem. A mixed integer linear programming (MILP) model is formulated for a location–inventory problem and exemplified. Location selection is a multi-staged and multi-criteria decision process. In this research, an integrated K-Means clustering and a ranking heuristics are proposed and developed for a location selection. The locations are clustered out of several alternatives as suitable and unsuitable locations by a K-Means clustering algorithm. The most suitable location is selected through systematic ranking mechanism. The proposed model is exemplified with a typical pump manufacturing unit. An integrated fuzzy C- Means clustering and TOPSIS approach is proposed and developed for the selection of a facility location. The fuzzy C- Means clustering algorithm shortlists suitable locations and TOPSIS is used to formulate and rank each location alternatives. Fuzzy based QFD tools are proposed for capable of dealing imprecise and vague criteria in house of quality (HOQ) for a customer requirement perspective in location selection.An integrated Fuzzy QFD with AHP is proposed and developed. Fuzzy approach is used to measure the relative degree of importance for each location requirement (LR) with location criteria (LC) in the QFD process. A case example is presented to illustrate the application of the proposed fuzzy QFD-AHP approach. A hybrid rough set enhanced QFD with AHP model is proposed and developed for a location selection. A case example is illustrated for a typical plastic industry location selection and the results are validated with FQFD and AHP approach. The comparison of prioritization of location criteria (HOWs) using symmetrical triangular fuzzy number (STFN) and rough number (RN) is executed. A fuzzy QFD–AHP-TOPSIS approach is proposed and developed for a location selection. A case example is presented and the result of the proposed approach is validated with the fuzzy QFD and AHP approach for solution robustness.A continuous facility location model is proposed and developed using simulated annealing algorithm. A Particle Swarm Optimization (PSO) algorithm with fuzzy C- Means clustering approach

is proposed and developed to find a suitable location. The proposed PSO algorithm is used to select the location of particular locality and the clustering-PROMETHEE approach is used for the selection of final site in the locality.

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12 Investigations on intelligent process planning system for tool based micromachining processes Miniaturization of product plays an important role for technological development in the field of aerospace, automobile, bio medical, semi conductor industries, etc. Micromachining is the key technology for the realization of miniaturized products with augmented number of functions. Micro machine tools are capable enough to produce precision parts with desired accuracy, but deficient in decision making. It purely depends on expertise skill and inconsistent in nature. Hence, the development of decision support system for manufacturing planning in micromachining needs research attention. Process planning using computer is an effective approach to automate the range of decision required to convert the raw material into finished parts. In this research work, an effort has been made to develop Intelligent Process Planning System (IPPS) for conventional tool based micromachining processes. DT110 Multi process micromachining centre is considered for the investigation. Tool based micro turning, micro drilling and end milling processes are taken into account. IPPS development activities comprise of four essential elements; it includes 1.Data acquisition through experimentation, 2.Feature based modeling and part feature extraction, .Manufacturing logic formulation and process planning system development and 4.Validation. Primarily, experimentation on Poly-methyl methacrylate and C360 Brass work materials were carried out for micro end milling process. C360 Brass material is chosen for micro turning and micro drilling processes. Response surface methodology and Taguchi based design of experiments were carried out. Analysis of variance has been performed to examine the influence of process variables. Process parameters optimization [GO TO LIST]

13 Investigations on electrochemical drilling of superalloys and titanium alloys Due to the increasing demands for machining these kind of advanced materials, a more effective and efficient manufacturing process is required. Hence the application of novel and advanced technologies need attention for quickly converting the raw materials into finished products by machining of these hard to machine materials. Electrochemical machining (ECM) is an unconventional process of metal removal that is used for machining the extremely hard and difficult to machine materials.ECM has been recognized for its potential for machining of these electrically conductive hard materialswith better precision. Cylindrical holes and revolving components are frequently used in various engineering applications and plays a vital role in precision engineering. The form and orientation errors of machined surfaces play a dynamic role in mechanical design and quality control of geometrical product. The control of form and orientation tolerance errors is an important aspect in manufacturing process. The effective and efficient measurement and evaluation of performance measures such as material removal rate, surface roughness, overcut, circularity error and perpendicularity error helps the product to be manufactured as more precise and accurate. The experiments are designed and conducted as per Taguchi's orthogonal array. The significance of process variables are analyzed by analysis of variance. Multiple regression analysis is performed and the empirical relations are obtained for various desired performance measures. Multiple objectives such as material removal rate, surface roughness, overcut, circularity error and perpendicularity error are optimized by Taguchi based grey approach. The optimum process variable is verified by confirmation test.A Grey based Adaptive Neuro Fuzzy Inference System is proposed and developed to predict the multi performance characteristics of electro chemical drilling of super alloys. Grey relational coefficients of various performance measures are given as the input for modeling the system.

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14 Investigations on Wire Electrical Discharge And Abrasive Water Jet Machining Of Inconel 617 Superalloys are being developed to face the challenges of higher temperature applications in aerospace, turbo machinery and other power plant applications. Power plant development widely depends on superalloys. Inconel 617 is a nickel based super alloy which belongs to hard to machine materials and is a candidate material for various high temperature components like headers, pipes and turbine blades in ultrasupercritical power plants. Conventional machining processes are limited in processing these superalloys. Hard to machine materials are best processed using non-traditional machining methods. Processing of superalloys using non-traditional machining methods needs attention. Wire Electrical Discharge Machining (WEDM) and Abrasive Water Jet Machining (AWJM) of Inconel 617 are focussed in this research. Cylindrical holes and revolving components are used in various precision engineering applications. The form and orientation accuracy of machined surfaces are important in these functional products. The evaluation of performance measures such as material removal rate, surface finish, and geometric accuracy in circularity, perpendicularity, cylindricity and parallelism are important in precision manufacturing. The experiments are designed and conducted as per Taguchi's orthogonal array. The significance of process variables is analysed byanalysis of variance. Multiple regression analysis is performed and the empiricalrelations are obtained for various desired performance measures. Multiple objectives such as material removal rate, surface roughness, overcut, circularity error, cylindricity error, perpendicularity error and parallelism error are optimized by Taguchi based grey approach. A multiobjective genetic algorithm is formulated for optimising the WEDM and AWJM parameters based on multi performance characteristics. The objectives are balanced out to give a Pareto optimal solution. Statistical optimization techniques such as grey relational analysis and weighted principal components analysis have been employed and the optimal parameters for the said objectives in WEDM and AWJM of Inconel 617 have been established. An Adaptive Neuro Fuzzy Inference System is proposed and developed to predict the multi performance characteristics in the WEDM of Inconel 617.

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15 **Some investigations on resource allocation and asset tracking in Field service management** F ield service management (FSM) is to manage and mobilise technicians to customer locations for maintenance of assets. It is a network of functionalities designed to fulfill demands at customer site. The focus of field service is to improve financial performance and customer service level through effective resource allocation and asset management. Increasing competition and decreasing margins force manufacturers of industrial equipment to augment with effective field service planning. Technician selection and allocation are essential cornerstones of the field service planning. Efficient delivery of field services is a challenging task. Decisions are typically made under a dynamic and uncertain environment with facilities installed at geographically dispersed locations. Researchers have explored the heuristics, algorithms and knowledge-based analysis for resource selection and allocation in field services. Attention is sought to find methods for addressing selection and allocation of technicians comprehensively. In addition to allocating technicians, field service managers need to track a lot of moving parts, tools and equipment's at any given time despite the fact that these assets move from one location to another in fulfilling customer's needs (Oshios, et al. 2020). All these assets are to be monitored and maintained properly for easy accessibility by field service technicians to ensure proper utilization and a better service reliability. Also, asset tracking can mitigate the rising cost of operations in field service. Existing literature has shown that organizations face several challenges in managing their assets. Research on developing a system for tracking and monitoring the assets location, and utilization in field services deserve attention. To fulfill the above cited research gaps, this thesis focuses on developing hybrid models to rank and allocate technicians to spatially distributed field services. A real-time equipment monitoring system is also developed using barcodes technology to provide information relating to assets location, status and condition to increase utilization, improve service quality, reduce downtime of equipment's and decrease asset damage and lost. The developed models are illustrated using the data obtained from a power generating company and tool center.

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16. **Investigations on the efforts towards intelligent e-maintenance in heavy engineering industry**

Fast pace development of industries in the areas of power, automotive, electronics, etc. with highly competitive global market calls for cost-effective and time-effective maintenance of machine tools and equipment for productivity improvement and to enrich operational consistency. In today's economy, the survival capacity of the companies depends on their ability to quickly improve and update. The search for best methods and practices for improving quality, cost and productivity are increasing. To meet this challenge, business leaders evaluate the performance of their organizations and improvement processes against domestic and international competitors. With this background, the research carried out in a heavy engineering industry exploring for a framework and scope of intelligent tools in Planning, Scheduling and Control of Maintenance to enable the industry to upgrade the Maintenance process from conventional corrective and preventive maintenance to predictive intelligent e-maintenance. A fuzzy linguistic model for RPN evaluation combining qualitative and subjective information about the parameters in more flexible and logically consistent and it allows a more realistic application of RCM embedded approach to maintenance strategy selection. This work can be applied not only to heavy industries but also to aircraft maintenance, railway department etc. The Artificial Neural Network using back propagation algorithm was able to solve model free spare inventory system of an orbital TIG welding machine and proved to yield better results. The performance demonstrated by the system clearly shows that it can be applied for other machine tools and equipment in industries and also in warehouses, super markets etc. The fuzzy logic system proposed by this research is very versatile and easy to implement with few inputs for PM frequency determination can be applied to industries all nature and sizes. The integrated approach explained in this thesis suggests selection of Key Performance Indicators using integrated model which has more significance than randomly selected Key Performance Indicators in other models. The integrated approach was suggested to heavy industries for better maintenance measurement.

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17 Fabrication and analysis of inconel 625 parts using wire and arc additive manufacturing

Superalloys based on Nickel are essential components in the aircraft industry and are extensively employed in the vital parts of aero engines. These parts are to be processed using traditional machining techniques and machining of these hard to machine materials is difficult and time consuming. Although numerous studies have been attempted to increase its machinability, their effectiveness was still limited. Additive manufacturing (AM) is an alternative method and is preferred in the modern manufacturing industries due to its high flexibility in fabricating complex parts, shorter manufacturing time, and reduced material waste. This method is applied for manufacturing medical, aerospace, marine, and nuclear components. Wire and Arc Additive Manufacturing (WAAM), a metal additive manufacturing technique that permits the fabrication of components at a high deposition rate with ease. Due to the high heat transfer during this process, it is necessary to provide pauses between the deposition of succeeding layers so that the workpiece integrity is preserved. A novel method is developed for identifying heat accumulation behavior for the wire-arc additive manufacturing process using simulation. The simulation data is processed using idle times for the deposition of each layer to provide a steady inter-pass temperature. With the knowledge derived from simulation, the experiments are planned to study the influence of Inter-pass layer temperature on the microstructural and mechanical characterization of Inconel 625. Three samples were additively manufactured for three different inter-pass layer temperatures using the WAAM technique. The analysis shows that the grain morphology varies with different IPTs. Electron Backscatter Diffraction (EBSD) identified the grain size increase with increasing IPT. Grain boundary distribution angles also significantly varied with a change in IPTs. The variation in peak intensity identified the preferred crystal orientation through X-Ray Diffraction (XRD). The decrease in inter-pass layer temperatures increased Ultimate Tensile Strength (UTS) and Yield Strength (YS). The average microhardness values increased with a reduction of IPT.

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