ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962

Volume-8, Issue-6, December 2018

International Journal of Engineering and Management Research

Page Number: 81-88

DOI: doi.org/10.31033/ijemr.8.6.02

A Survey of Automated Process Planning Approaches in Machining

S.K. Singh[1] and A.M. Mohanty[2]

[1]Research Scholar, Department of Mechanical Engineering, Centurion University, Bhubaneswar Campus, INDIA

[2]Pro-Vice Chancellor, Department of Mechanical Engineering, Centurion University, Bhubaneswar Campus, INDIA

Corresponding Author: ersudeep786@gmail.com

ABSTRACT

Global industrial trend is shifting towards next industrial revolution Industry 4.0. It is becoming increasingly important for modern manufacturing industries to develop a Computer Integrated Manufacturing (CIM) system by integrating the various operational and information processing functions in design and manufacturing. In spite of being active in research for almost four decades, it is clear that new functionalities are needed to integrate and realize a completely optimal process planning which can be fully compliant towards Smart Factory. In order to develop a CIM system, Computer Aided Process Planning (CAPP) plays a key role and therefore it has been the focus of many researchers. In order to gain insight into the current state-of-the-art of CAPP methodologies, 96 research papers have been reviewed. Subsequent sections discuss the different CAPP approaches adopted by researchers to automate different process planning tasks. This paper aims at addressing the key approaches involved and future directions towards Smart Manufacturing.

Keywords-- Computer Aided Process Planning, Computer Integrated Manufacturing, Smart Manufacturing

I. INTRODUCTION

Modern manufacturing industries faced with various challenges like growing product variety, higher quality, shorter manufacturing lead time and lower costs are increasingly turning towards automation by implementing computer based technologies for design and manufacturing like; Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Aided Engineering (CAE), etc. CAPP has proved to be the pivotal link to integrate the product design and manufacturing functions and is often said to be the bridge between CAD and CAM.

Traditionally the individual process planning activities were carried out using the skill and experience of the process planner gained through along involvement with the manufacturing practices on the shop floor. A process planner was a person who was responsible for deciding the shop floor process sequences for manufacturing the product and who would take charge after the design stage and steer it till the final stage of successfully manufacturing it in accordance with the product design specifications. However, the process planners due to their inherent variability as a result of the human nature often used to come up with different process plans for manufacturing the same product design that are not necessarily optimal. Thus a need was felt to standardize and automate the process planning procedure to reduce the inconsistency in generation of process plans and improve productivity and reduce lead time for process planning as well as ensure at the same time optimality and adherence to design specification and quality requirements which was in the mutual interest of both the manufacturer and the consumer.

In order to achieve the above goals of automating the process planning different CAPP approaches have been developed in the past four decades that can be broadly classified into the Variant and Generative CAPP approaches. A variant approach is driven by the motto that, 'Similar components need similar process plan' while the generative approach was mainly driven by the motto of 'Automatically generating the process plan' with least human intervention possible. In variant CAPP approach, an experienced operator was in charge of first of all classifying the similar parts into groups requiring organize and store the information in a database similar manufacturing steps to produce, and then analyze the part design information for a new part, search for a similar process plan from the database and then retrieve to make necessary modifications to it so as to suit the

manufacturing needs for the new part. On the other hand, the generative CAPP is aimed at generating new process plans for each product by using the process planning knowledge and various decision making logics, rules, etc. This method consist of capturing and encoding expert knowledge from experienced process planners, and shop floor engineers in the form of a computer program that is used to automatically generate process plans for new parts from scratch unlike the variant CAPP approach, which can only generate variants of already existing process plans for similar parts.

A number of different approaches have been adopted by the researchers in the past to automate the various functions of Computer Aided Process Planning. These approaches have been used to automate one or more of various process planning functions as well as integration of CAD with Process Planning [PP] and integration of Process Planning with Process Planning and Control [PPC].

II. DIFFERENT CAPP APPROACHES FOR AUTOMATING THE PROCESS PLANNING TASKS

The different CAPP approaches for automating the process planning tasks have been categorized into the following different approaches: algorithm based approaches, analytical methods, graph theoretic approaches, object oriented approaches, expert system/knowledge based methods, fuzzy logic based approaches, neural network based approaches, soft computing based optimization approaches and web based methods.

2.1 Algorithm based Approaches

An algorithm is a set of rules that precisely define a sequence of operations with well-defined instructions for calculating one or more function. There have been numerous applications of algorithm based approaches to automate various process planning tasks such as feature recognition from CAD database, operation and tool selection, operation sequencing, setup planning, etc. Srinivasan and Sheng [1], Dipper et al. [2], Li et al. [3], Zheng et al. [4] have implemented an overall sequencing algorithm in order to handle feature interactions. An algorithmic approach feature extraction from STEP AP224 has been reported by Azmi and Taib [5], Arivazhagan et al. [6], Sunil and Pande [7] and using common metrological equipment for extracting inspection features from CAD. In their paper Arivazhagan et al. [8] implemented 234 features; out of which, 32 are normal and 202 are tapered and developing 17 “feature type”-specific methodologies for calculation of the finish-cut machinable volume. Combined Surface Recognition and Operation Sequencing using comprehensive surface recognition approach proposed by Bok and Mansor [9] and combined Tool Selection and Operation sequencing have been dealt by Gologlu [10]. Phing et al. [11] proposed an algorithmic approach implemented using a vertex classification method for prismatic part features recognition. Sivakumar and Dhanalakshmi [12] took up Feature Extraction for cylindrical components. Zhang et al. [13] investigated machining simulation using STEP-NC. Precedence Selection for Interactive and Non-interactive STEP-NC Machining Features has been proposed by Mokhtar et al. [14] using Rule-based Geometric reasoning approach. Kretz et al. [15] proposed a generative Process Planning using ISO Standard 10303, Setup Planning and Fixture Planning and their integration has been proposed by Joneja and Chang [16], Sun et al. [17], Kannan and Wright [18]. Sun and Chen [19], Gadakh and Shinde [20] selected cutting parameters. Process Planning using STEP-NC proposed by Qiu et al. [21]. Denkena et al. [22] proposed integration of process planning and production control using adaptive process. Optimization of different process planning functions has been reported by Gologlu[10] [2004a], Ridwan et al. [23]. An integrated module has been developed by Hargroove [24] for fixture design and fixture planning. Selvakumar et al. [25] proposed a machining fixture layout design and optimization. Machining Processes Time calculation has been developed by Blanch et al. [26] to present computer-aided software to calculate cutting time and unproductive time when machine operations are designed and integrate it with the CAPP.

2.2 Approaches Based on Mathematical Models

Mathematical models have been used by Hwang and Miller [27] for sequencing interacting features and operations selection, by Xu and Li [28] for process parameter selection in process planning using mathematical logic called ML-PPS and Nee et al. [29], Qin et al. [30] for fixture design, fixture clamping sequence analysis and optimization,

Manufacturability Evaluation for several machining processes of slot feature identified using STEP and the ascendant generation of process method proposed by Martin and Acunto [31] has been used to compare and evaluate the slot machining process by using experimental plan [Taguchi method] for the test procedure. Tests were carried out on machining centre using carbide-tipped drill bit for drilling.

Machining operations optimization carried by Raja and Baskar [32] and cutting parameter optimization by An et al. [33].

2.3 Graph Theory Based Approaches

Graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between related objects. A "graph" in this context is made up of "vertices" or "nodes" and lines called edges that connect them. Sunil et al. [34] proposed Interacting machining feature recognition using CAD part model in B-Rep format. Process graph proposed by Gologlu [10], Gadakh and Shinde [20] used the Graph Theory and Matrix Approach [GTMA] and Multiple Attribute

Decision-Making [MADM] methods to rank and select the cutting parameters. Huang et al. [35] used graph theory accompanied with matrix theory embedded into the main frame of GA has been used for implementing process planning optimization for operation sequencing.

2.4 Object Oriented Approaches

Object-Oriented Programming [OOP] is a programming paradigm that represents concepts as "objects" having data fields. Teich et al. [36] proposed visualization of manufacturing features. Operations sequencing using object oriented approach has been proposed by Grabiwik et al. [37]. Ong and Nee [38] have used objects representation for representing inexact relationships among features required and features present on a final part along with Fuzzy Sets and production rules to generate Setup Planning. Wu and Zhang [39] used object-oriented technology to represent the set-up planning knowledge and generate the alternative set-ups. Gologlu [40] used geometric relationship between the fixture and the machine tool, represented in an object-oriented format which gives the free regions on the workpiece. Sun and Chen [17] implemented cutting data decision system based on knowledge classification and the basic data model. Integration of CAD/CAPP/CAP Systems using object-oriented modeling has been proposed by Grabowik and Kalinowski [41] having main components as Technological Knowledge Base [TKB] and Scheduling Knowledge Base [SKB]. The proposed methodology is focused on supporting effective decision making in the verification of production orders and optimizing the production flow. Benavente et al. [42] presents a CAD/CAPP/CAM object oriented prototype system compliant with ISO 14649 [STEP-NC] for the remote manufacturing of mechanical components using the Internet in order to implement remote design and manufacture. Denkena et al. [22] used an object oriented part model based on STEP-NC standard 'Technological Knowledge Base' [TKB] to compare the process parameters e.g. cutting velocity, feed rate.

2.5 Expert System / Knowledge [Rule] Based Approaches

An expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. Wong et al. [43], Bansal et al. [44], Marchetta and Forradellas [45], Nagarajan and Reddy [46], Ong and Nee [47], Chlebus et al. [48], Deb et al. [49], Chu et al. [50], Liu and Wang [51], Deja and Siemiatkowski [52], Kojima et al. [53], Gupta et al. [54] automated various process planning functions. Sun et al. [55] used three rules to implement Dissimilarity Degree matrix. Gologlu [10] developed ProPlanner CAPP system which uses KAPPA-PC expert system development tool for automating tools selection. In yet another paper, Gologlu [40] used geometric reasoning and heuristics about the features to generate precedence relations. Deb and Ghosh [56] automated setup formation, operation sequencing, and selection of locating and clamping surfaces using knowledge-based approach implemented in CLIPS Expert system shell. Mokhtar and Xu [14] proposed precedence of interacting features using a rule-based system developed and implemented based on the information about machining precedence of the interacting features, Deja, M. and Siemiatkowski [57] presented process alternatives identification and sequencing working steps. Deb et al. [58], Ong and Nee [38], Ong and Nee[59] [1995], Ong and Nee [60], Wu and Zhang [39] proposed setup planning using Knowledge Based approach combining object oriented and fuzzy set. Cakir and Cavdar [61], Stampfer [62], Hazarika et al. [63] Hazarika et al. [64] Singh and Deb [65] used knowledge-based approach for generation of set-up plan.

Lin and Yang [66] used AI based approach for Modular Fixture Design Face milling operations have been automated using the expert system developed in this paper. Collaborative and Interoperable Product Design/Development proposed by Valilai and Houshmand [67] uses a three-layered integrated and interoperable platform, named INFELT STEP. Amaitik [68] implemented an integrated CAD/CAPP system. A Knowledge-based system developed for product cost modeling by Shehab and Abdalla [69] has been applied at early design stage. Iqbal et al. [70] proposed optimization for milling parameters. A feed-rate optimizing system presented by Ridwan et al. [71]. STEP-NC data model has been used to perform the tasks and EXPRESS language was used to construct the data model. Liu et al. [72] proposed NC machining optimization using Polychromatic sets theory for box shaped parts. Prakash et al. [73] evaluated cost optimization in CIM system using Knowledge-Based Artificial Immune System [KBAIS] to optimize scrap cost, raw material cost, processing cost. Machining Optimization using STEP-NC has been proposed by Ridwan et al. [74].

2.6 Fuzzy Logic Approaches

Fuzzy logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact. Md. Adnan et al. [75] discussed about the Fuzzy Logic components for prediction of machining performance. Ong and Nee [38] applied the fuzzy set theory to set-up planning. Ong and Nee [59] implemented Set-up Planning using Fuzzy sets, fuzzy relations and fuzzy matrices have been used to model and represent these feature relations. Ong and Nee [60] used use of fuzzy sets, fuzzy relations and fuzzy matrices in the representation and manipulation of the constraints and feature relations in set-up planning to ensure the validity of the produced setup for setup planning. Ong and Nee [47] Wu and Zhang [39] have used Fuzzy-set based optimization algorithm. Hazarika et al. [63] and Hazarika et al. [64] handled the uncertainties associated with the work material, clamp material, and clamping torque using fuzzy arithmetic. Linear triangular

fuzzy membership functions are assumed for the fuzzy parameters. Machinability Data Selection [MDS] proposed by Hashmi et al. [76] used fuzzy logic model to describe the relationship between a given material hardness and the drilling speed using fuzzy relations for different cutting tool materials, hole diameters and feed rates. Yilmaz et al. [77] presented a system, called as CAS-CUPFUL [Computer Aided Selection of CUtting Parameters by using FUzzy Logic] developed using Matlab Fuzzy Logic Toolbox and Matlab Programming Language to implement cutting parameter selection for turning operations. Xu [78] proposed machinability data selection for part programming using cutting tool and cutting parameters selection process for efficient utilization of machine tools. Cutting Speed Prediction and Feed Rate Prediction have been presented by Razali et al. [79]. Fuzzy modeling has been implemented for peripheral end milling process where wrought carbon steel has been chosen as work piece material and High Speed Steel as the cutting tool. Kovac et al. [80] modeled surface roughness. Iqbal et al. [70] optimized milling parameters for hard milling using a forward-chaining expert system shell named Fuzzy CLIPS [fuzzy extension of C language integrated production systems] where max–min inference method used for fuzzyfying and CoG method was employed as the defuzzification taking the converted experimental data as ANOVA and numeric optimization output to develop the knowledge-base in form of Fuzzy IF–THEN rules. Machining Feed-rate Optimization has been proposed by Ridwan et al. [23] where the machine behavior is acquired by a cutting force sensor and driven by a fuzzy control algorithm. In yet another paper, Ridwan and Xu [81] presented feed-rate optimization.

2.7 Neural Network Based Approaches

The term neural network was traditionally used to refer to a network or circuit of biological neurons. The modern usage of the term often refers to artificial neural networks, which are composed of artificial neurons or nodes. Optimized back-propagation artificial neural network trained with a large set of feature patterns, following 12-node feature representation vector scheme was used by Sunil and Pande [7] for feature recognition. Deb et al. [49] used back propagation learning based Neural Network approach for automation of operation selection. Joshi et al. [82] proposed setup planning using unsupervised learning Neural Network Approach Machining operation selection has been developed by Deb et al. [58]. This paper aims at contributing to the applicability of back-propagation neural network method for the selection of all possible operations for machining rotationally symmetrical components, by pre structuring the neural network with prior domain knowledge in the form of heuristic or thumb rules. It has been achieved by developing two forms of representation for the input data to the neural network. Amaitik [68] integrated CAD/CAPP System using a hybrid approach of neural network and expert system used as the inference engine of the proposed CAPP system. Artificial Neural Networks [ANN]-based algorithm with Design of Experiments [DoE] has been proposed by Selvakumar et al. [25] to design an optimum fixture layout in order to reduce the maximum elastic deformation of the work piece caused by the clamping and machining forces acting on the work piece while machining for implementing machining fixture layout design. Mahdavinejad et al. [83] proposed milling parameters optimization.

2.8 Soft Computing based Optimization Approaches

Earlier computational approaches could model and precisely analyze only relatively simple systems. A number of soft computing based optimization techniques have been developed such as Genetic Algorithm [GA], Ant Colony Algorithm [ACO], Particle Swarm Optimization [PSO], etc. Joshi et al. [82], Wang et al. [84], Raja and Baskar [32], Kafashi et al. [85], Nallakumarasamy Huang et al. [35], Kumar and Deb [86], Li et al. [87], Sreeramulu et al. [88], Wen et al. [89] implemented setup planning and operation sequencing. Baskar et al. [90], Bouaziz and Zghal [91], An et al. [33] developed an algorithm for the generation optimal set of cutters. Sardinaz et al. [92], Mahdavinejad et al. [83], Othmani et al. [93], Yildiz [94], Yildiz [95] optimized cutting parameters. Wang et al. [96] also optimized process planning to handle uncertainty in the decision of process planning using the multi-objective optimization function established. Prakash et al. [73] proposed cost optimization in CIM System using Knowledge-Based Artificial Immune System [KBAIS] to optimize scrap cost, raw material cost, processing cost. The output unit cost has been minimized by considering precedence relationships, availability of machines, tools, TAD and scrap. The proposed algorithm has three basic steps: initialization, selection and hyper-mutation.

2.9 Web Based Approaches

Web-based approach is the invocation of computer services over the World Wide Web, specifically through a web browser. Increasingly, the web is being looked upon as an environment for providing modeling and simulation applications, and is an emerging area of investigation within the process planning community. Kojima et al. [53] used internet technology, including XML markup language and the Java programming language, has been used for developing the system. Benavente et al. [42] proposed remote design and manufacture.

III. CONCLUSIONS AND PLAN FOR FURTHER WORK

From the above literature, it was found that, knowledge based system is able to automatically generate a detailed sequence of machining operations including the manufacturing precedence constraints subject to which the operation sequences are to be determined, the different machining setups in accordance with the given Tool Approach Directions, the operations to be performed

within each setup, the method of locating and clamping the component for fixturing it as well as generation of the setup sequence. It is necessary to further optimize the generated operation sequences subject to the precedence constraints by considering various factors like number of cutting tool changes, machine tool changes, setup changes, etc. as well as the manufacturing time and the cost. It is proposed to explore various new soft computing based techniques for optimization and compare their results with the existing approaches found in the literature like GA, PSO, ACO, etc. Energy spent is a key aspect of the manufacturing cost which needs to be addressed along with attempts to reduce the generated scrap.

REFERENCES

[1] Srinivasan, M. & Sheng, P. (1999). Feature based process planning in environmentally conscious machining–Part 2: macroplanning. *Robotics and Computer-Integrated Manufacturing*, *15*(3), 271-281.

[2] Dipper, T., Xu, X., & Klemm, P. (2011). Defining, recognizing and representing feature interactions in a feature-based data model. *Robotics and Computer-Integrated Manufacturing*, *27*(1), 101-114.

[3] Li, X., Gao, L., & Li, W. (2012). Application of game theory based hybrid algorithm for multi-objective integrated process planning and scheduling. *Expert Systems with Applications*, *39*(1), 288-297.

[4] Zheng, Y., Taib, J. M., & Tap, M. M. (2012). Decomposition of interacting machining features based on the reasoning on the design features. *The International Journal of Advanced Manufacturing Technology*, *58*(1-4), 359-377.

[5] Azmi, A. I. & Muhammad, Z. (2003). Feature Extraction from STEP AP224 file sets. *Jurnal Mekanikal*, (16), 31-46.

[6] Arivazhagan, A., Mehta, N. K., & Jain, P. K. (2008). Development of a feature recognition module for tapered and curved base features. *The International Journal of Advanced Manufacturing Technology*, *39*(3-4), 319-332.

[7] Sunil, V. B. & Pande, S. S. (2009). Automatic recognition of machining features using artificial neural networks. *The International Journal of Advanced Manufacturing Technology*, *41*(9-10), 932-947.

[8] Arivazhagan, A., Mehta, N. K., & Jain, P. K. (2009). A STEP AP 203–214-based machinable volume identifier for identifying the finish-cut machinable volumes from rough-machined parts. *The International Journal of Advanced Manufacturing Technology*, *42*(9-10), 850-872.

[9] Bok, A. Y., & Mansor, M. S. A. (2013). Generative regular-freeform surface recognition for generating material removal volume from stock model. *Computers & Industrial Engineering*, *64*(1), 162-178.

[10] Gologlu, C. (2004). A constraint-based operation sequencing for a knowledge-based process planning. *Journal of intelligent manufacturing*, *15*(4), 463-470.

[11] Phing, G. Y. W., Taib, J. M., & Tap, M. M. (2012). Efficient vertex classification method to recognise the orthogonal and non-orthogonal prismatic. *Jurnal Mekanikal*, *34*, 83-94.

[12] Sivakumar, S. & Dhanalakshmi, V. (2012). An approach towards the integration of CAD/CAM/CAI through STEP file using feature extraction for cylindrical parts. *International Journal of Computer Integrated Manufacturing*, [ahead-of-print], 1-10.

[13] Zhang, Y., Bai, X. L., Xu, X., & Liu, Y. X. (2012). STEP-NC based high-level machining simulations integrated with CAD/CAPP/CAM. *International Journal of Automation and Computing*, *9*(5), 506-517.

[14] Mokhtar, A. & Xu, X. (2011). Machining precedence of 2½D interacting features in a feature-based data model. *Journal of Intelligent Manufacturing*, *22*(2), 145-161.

[15] Kretz, D., Militzer, J., Neumann, T., & Teich, T. (2011, May). Developing an integrated solution for generative process planning based on ISO standard 10303. In *Communication Software and Networks [ICCSN], IEEE 3rd International Conference*, 61-65.

[16] Joneja, A. & Chang, T. C. (1999). Setup and fixture planning in automated process planning systems. *IIE transactions*, *31*(7), 653-665.

[17] Sun, J., & Chen, W. (2010, May). Cutting data decision system based on knowledge classification and basic data model. In *Industrial Mechatronics and Automation [ICIMA], 2010 2nd International Conference*, *1*, 347-349.

[18] Kannan, B. & Wright, P. K. (2004). Efficient algorithms for automated process planning of 2.5 D machined parts considering fixturing constraints. *International Journal of Computer Integrated Manufacturing*, *17*(1), 16-28.

[19] Sun, J. & Chen, W. (2010, July). Research on cutting data evolution based on cultural algorithm. In *Computer Science and Information Technology [ICCSIT], 2010 3rd IEEE International Conference*, *3*, 70-72.

[20] Gadakh, V. S. & Shinde, V. B. (2011). Selection of cutting parameters in side milling operation using graph theory and matrix approach. *The International Journal of Advanced Manufacturing Technology*, *56*(9-12), 857-863.

[21] Qiu, X. L., Xu, X., & Liu, X. J. (2011). Interoperable STEP-NC Enabled process planning for intelligent machining. *Advanced Materials Research*, *211*, 850-855.

[22] Denkena, B., Lorenzen, L. E., & Schmidt, J. (20120. Adaptive process planning. *Production Engineering*, *6*(1), 55-67.

[23] Ridwan, F., Xu, X., & Ho, F. C. L. (2012). Adaptive execution of an NC program with feed rate optimization. *The International Journal of Advanced Manufacturing Technology*, *63*(9-12), 1117-1130.

[24] Hargrove, S. K. (1995). A systems approach to fixture planning and design. *The International Journal of Advanced Manufacturing Technology*, *10*(3), 169-182.

[25] Selvakumar, S., Arulshri, K. P., Padmanaban, K. P., & Sasikumar, K. S. K. (2012). Design and optimization of

machining fixture layout using ANN and DOE. *The International Journal of Advanced Manufacturing Technology*, 1-14.
[26] Blanch, R., Pellicer, N., G.-Romeu, M. L., & Ciurana, J. (2011). Machining processes time calculating tool integrated in computer aided process planning [CAPP] for small and medium enterprises [SMEs]. *International Journal of Computer Integrated Manufacturing*, *24*(1), 40-52.
[27] Hwang, J. S. & Miller, W. A. (1997). Using mixed-type reasoning in computer-aided process planning for feature interactions. *Journal of Intelligent Manufacturing*, *8*(4), 297-306.
[28] Xu, H., and Li, D. (2009). Modeling of process parameter selection with mathematical logic for process planning. *Robotics and Computer-Integrated Manufacturing*, *25*(3), 529-535.
[29] Nee, A. Y. C., Kumar, A. S., & Tao, Z. J. (2000). An intelligent fixture with a dynamic clamping scheme. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *214*(3), 183-196.
[30] Qin, G., Zhang, W., & Wan, M. (2006). Analysis and optimal design of fixture clamping sequence. *Transactions-American Society of Mechanical Engineers Journal of Manufacturing Science and Engineering*, *128*(2), 482.
[31] Martin, P. & D'Acunto, A. (2008). Method of determining the process applied for feature machining: experimental validation of a slot. *The International Journal of Advanced Manufacturing Technology*, *37*(9-10), 898-907.
[32] Raja, S. B. & Baskar, N. (2010). Optimization techniques for machining operations: a retrospective research based on various mathematical models. *The International Journal of Advanced Manufacturing Technology*, *48*(9-12), 1075-1090.
[33] An, L. B., Feng, L. J., & Lu, C. G. (2011). Cutting parameter optimization for multi-pass milling operations by genetic algorithms. *Advanced Materials Research*, *160*, 1738-1743.
[34] Sunil, V. B., Agarwal, R., & Pande, S. S. (2010). An approach to recognize interacting features from B-Rep CAD models of prismatic machined parts using a hybrid [graph and rule based] technique. *Computers in Industry*, *61*(7), 686-701.
[35] Huang, W., Hu, Y., & Cai, L. (2012). An effective hybrid graph and genetic algorithm approach to process planning optimization for prismatic parts. *The International Journal of Advanced Manufacturing Technology*, *62*(9-12), 1219-1232.
[36] Teich, T., Militzer, J., Jahn, F., Kretz, D., & Neumann, T. (2010). Using ISO 10303-224 for 3D Visualization of Manufacturing Features. In *Advanced Manufacturing and Sustainable Logistics*, 198-209].
[37] Grabowik, C., Krenczyk, D., & Kalinowski, K. (2012). The hybrid method of knowledge representation in a CAPP knowledge based system. In *Hybrid Artificial Intelligent Systems*, 284-295].
[38] Ong, S. K. & Nee, A. Y. C. (1994). Application of fuzzy set theory to setup planning. *CIRP Annals-Manufacturing Technology*, *43*(1), 137-144.
[39] Wu, R. R. & Zhang, H. M. (1998). Object-oriented and fuzzy-set-based approach for set-up planning. *The International Journal of Advanced Manufacturing Technology*, *14*(6), 406-411.
[40] Gologlu, C. (2004). Machine capability and fixturing constraints-imposed automatic machining set-ups generation. *Journal of Materials Processing Technology*, *148*(1), 83-92.
[41] Grabowik, C. & Kalinowski, K. (2011). Object-oriented models in an integration of CAD/CAPP/CAP systems. In *Hybrid Artificial Intelligent Systems*, 405-412.
[42] Benavente, J. C. T., Ferreira, J. C. E., Goulart, C. M., & Oliveira, V. G. D. (2012). A STEP-NC compliant system for the remote design and manufacture of mechanical components through the Internet. *International Journal of Computer Integrated Manufacturing*, [ahead-of-print], 1-17.
[43] Wong, F. S. Y., Chuah, K. B., & Venuvinod, P. K. (2006). Automated inspection process planning: Algorithmic inspection feature recognition, and inspection case representation for CBR. *Robotics and Computer-Integrated Manufacturing*, *22*(1), 56-68.
[44] Bansal, S., Nagarajan, S., & Reddy, N. V. (2008). An integrated fixture planning system for minimum tolerances. *The International Journal of Advanced Manufacturing Technology*, *38*(5-6), 501-513.
[45] Marchetta, M. G. & Forradellas, R. Q. (2010). An artificial intelligence planning approach to manufacturing feature recognition. *Computer-Aided Design*, *42*(3), 248-256.
[46] Nagarajan, S. & Reddy, N. V. (2010). STEP-based automatic system for recognising design and manufacturing features. *Molecular Physics*, *48*(1), 117-144.
[47] Ong, S. K., and Nec, A. Y. C. [1997]. Automating set-up planning in machining operations. *Journal of materials processing technology*, *63*(1), 151-156.
[48] Chlebus, E., Krot, K., & Kuliberda, M. (2011). Rule-based expert system dedicated for technological applications. In *Hybrid Artificial Intelligent Systems*, 373-380).
[49] Deb, S., Parra-Castillo, J. R., & Ghosh, K. (2011). An Integrated and Intelligent Computer-Aided Process Planning Methodology for Machined Rotationally Symmetrical Parts. *International Journal of Advanced Manufacturing Systems*, *13*(1), 1-26.
[50] Chu, X., Tang, C., Xue, D., Su, Y., & Sun, X. (2012). Identification of machining features based on available resources of cutting tools. *International Journal of Production Research*, *50*(15), 4141-4157.

[51] Liu, Z. & Wang, L. (2007). Sequencing of interacting prismatic machining features for process planning. *Computers in Industry*, *58*(4), 295-303.
[52] Deja, M. & Siemiatkowski, M. (2010). Generation of Optimal Process Plan Alternatives for Manufacturing Mechanical Components. *Solid State Phenomena*, *165*, 250-255.
[53] Kojima, T., Sekiguchi, H., Kobayashi, H., Nakahara, S., & Ohtani, S. (2000). An expert system of machining operation planning in Internet environment. *Journal of materials processing technology*, *107*(1), 160-166.
[54] Gupta, D. P., Gopalakrishnan, B., Chaudhari, S. A., & Jalali, S. (2011). Development of an integrated model for process planning and parameter selection for machining processes. *International Journal of Production Research*, *49*(21), 6301-6319.
[55] Sun, X., Chu, X., Xue, D., Su, Y., & Tang, C. (2012). An integrated setup/fixture planning approach for machining prismatic parts. *International Journal of Production Research*, *50*(4), 1009-1027.
[56] Deb, S., & Ghosh, K. (2007). An Expert System Based Methodology for Automating the Set-Up Planning in Computer Aided Process Planning for Rotationally Symmetrical Parts. *International Journal of Advanced Manufacturing Systems*, *10*(2), 81-93.
[57] Deja, M. & Siemiatkowski, M. S. (2012). Feature-based generation of machining process plans for optimised parts manufacture. *Journal of Intelligent Manufacturing*, 1-16, doi:10.1007/s10845-012-0633-x.
[58] Deb, S., Ghosh, K., & Paul, S. (2006). A neural network based methodology for machining operations selection in computer-aided process planning for rotationally symmetrical parts. *Journal of Intelligent Manufacturing*, *17*(5), 557-569.
[59] Ong, S. K. & Nee, A. Y. C. (1995). Process modelling and formulation for the development of an intelligent set-up planning system. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *209*(6), 455-467.
[60] Ong, S. K. & Nee, A. Y. C. (1996). Fuzzy-set-based approach for concurrent constraint set-up planning. *Journal of Intelligent Manufacturing*, *7*(2), 107-120.
[61] Cakir, M. C. & Cavdar, K. (2006). Development of a knowledge-based expert system for solving metal cutting problems. *Materials & design*, *27*(10), 1027-1034.
[62] Stampfer, M. (2009). Automated setup and fixture planning system for box-shaped parts. *The International Journal of Advanced Manufacturing Technology*, *45*(5-6), 540-552.
[63] Hazarika, M., Dixit, U. S., & Deb, S. (2010). A setup planning methodology for prismatic parts considering fixturing aspects. *The International Journal of Advanced Manufacturing Technology*, *51*(9-12), 1099-1109.
[64] Hazarika, M., Deb, S., Dixit, U. S., & Davim, J. P. (2011). Fuzzy set-based set-up planning system with the ability for online learning. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *225*(2), 247-263.
[65] Singh, S. K. & Deb, S. (2012). A Knowledge Based Approach for Automatic Process Plan Generation for Machining. *International Conference on Agile Manufacturing (ICAM-2012)*, 180-185.
[66] Lin, Z. C. & Yang, C. B. (1995). An expert system for fixturing design for face milling using modular fixture. *The International Journal of Advanced Manufacturing Technology*, *10*(6), 379-388.
[67] Valilai, O. F. & Houshmand, M. (2010). INFELT STEP: An integrated and interoperable platform for collaborative CAD/CAPP/CAM/CNC machining systems based on STEP standard. *International Journal of Computer Integrated Manufacturing*, *23*(12), 1095-1117.
[68] Amaitik, S. M. (2012). An Integrated CAD/CAPP System based on STEP Features. *International Conference on Industrial Engineering and Operations Management*, 665-673.
[69] Shehab, E. & Abdalla, H. (2002). An intelligent knowledge-based system for product cost modelling. *The International Journal of Advanced Manufacturing Technology*, *19*(1), 49-65.
[70] Iqbal, A., He, N., Li, L., & Dar, N. U. (2007). A fuzzy expert system for optimizing parameters and predicting performance measures in hard-milling process. *expert systems with applications*, *32*(4), 1020-1027.
[71] Ridwan, F., Xu, X. W., & Liu, G. (2010, January). Generic Feed-Rate Optimization Based on a Predicted Power Force Model. In *Proceedings of the 6th CIRP-Sponsored International Conference on Digital Enterprise Technology*, 401-417).
[72] Liu, E. F., Liu, X. Y., & Fang, Y. X. (2012). Study on the Optimization Process Technology in NC Machining Based on the Polychromatic Sets Theory. *Advanced Materials Research*, *383*, 1007-1012.
[73] Prakash, A., Chan, F. T. S., & Deshmukh, S. G. (2012). Application of knowledge-based artificial immune system (KBAIS) for computer aided process planning in CIM context. *International Journal of Production Research*, *50*(18), 4937-4954.
[74] Ridwan, F., Xu, X., & Liu, G. (2012). A framework for machining optimisation based on STEP-NC. *Journal of Intelligent Manufacturing*, *23*(3), 423-441.
[75] Adnan, M. R. H., Zain, A. M., & Haron, H. (2011). Consideration of Fuzzy Components for Prediction of Machining Performance: A Review. *Procedia Engineering*, *24*, 754-758.
[76] Hashmi, K., Graham, I. D., & Mills, B. (2000). Fuzzy logic based data selection for the drilling process. *Journal of Materials Processing Technology*, *108*(1), 55-61.
[77] Yılmaz, O., Görür, G., & Dereli, T. (2001). Computer aided selection of cutting parameters by using fuzzy logic. In *Computational Intelligence. Theory and Applications*, 854-870.
[78] Xu, L. (2010, March). Machinability data selection by using a fuzzy logic expert system. In *Education*

Technology and Computer Science (ETCS), 2010 Second International Workshop, *3*, 256-259.
[79] Razali, S. Z., Wong, S. V., & Ismail, N. (2011, February). Fuzzy logic modeling for peripheral end milling process. In *IOP Conference Series: Materials Science and Engineering*, *17*(1), 012050.
[80] Kovac, P., Rodic, D., Pucovsky, V., Savkovic, B., & Gostimirovic, M. (2012). Application of fuzzy logic and regression analysis for modeling surface roughness in face milliing. *Journal of Intelligent Manufacturing*, 1-8.
[81] Ridwan, F. & Xu, X. (2013). Advanced CNC system with in-process feed-rate optimisation. *Robotics and Computer-Integrated Manufacturing*, 29, 12-20.
[82] Joshi, R. S. & Sharma, A. (2008, April). Setup planning and operation sequencing using neural network and genetic algorithm. In *Information Technology: New Generations, Fifth International Conference*, 396-401.
[83] Mahdavinejad, R. A., Khani, N., & Fakhrabadi, M. M. S. (2012). Optimization of milling parameters using artificial neural network and artificial immune system. *Journal of mechanical science and technology*, *26*(12), 4097-4104.
[84] Wang, L., Cai, N., Feng, H. Y., & Ma, J. (2010). ASP: an adaptive setup planning approach for dynamic machine assignments. *Automation Science and Engineering, IEEE Transactions*, *7*(1), 2-14.
[85] Kafashi, S., Shakeri, M., & Abedini, V. (2012). Automated setup planning in CAPP: a modified particle swarm optimisation-based approach. *International Journal of Production Research*, *50*(15), 4127-4140.
[86] Kumar, C. & Deb, S. (2012). Generation of optimal sequence of machining operations in setup planning by genetic algorithms. *Journal of Advanced Manufacturing Systems*, *11*(01), 67-80.
[87] Li, X., Gao, L. & Wen, X. (2012). Application of an efficient modified particle swarm optimization algorithm for process planning. *The International Journal of Advanced Manufacturing Technology*, 1-15.
[88] Sreeramulu, D., Singh, S. K., & Rao, C. S. P. (2012). Generation of optimum sequence of operations using ant colony algorithm. *International Journal of Advanced Operations Management*, *4*(4), 253-271.
[89] Wen, X. Y., Li, X. Y., Gao, L., & Sang, H. Y. (2012). Honey bees mating optimization algorithm for process planning problem. *Journal of Intelligent Manufacturing*, 1-14.
[90] Baskar, N., Asokan, P., Saravanan, R., & Prabhaharan, G. (2006). Selection of optimal machining parameters for multi-tool milling operations using a memetic algorithm. *Journal of Materials Processing Technology*, *174*(1), 239-249.
[91] Bouaziz, Z. & Zghal, A. (2008). Optimization and selection of cutters for 3D pocket machining. *International Journal of Computer Integrated Manufacturing*, *21*(1), 73-88.
[92] Sardinaz, R. Q., Santana, M. R., & Brindis, E. A. (2006). Genetic algorithm-based multi -objective optimization of cutting parameters in turning processes. *Engineering Applications of Artificial Intelligence*, *19*, 127-133.
[93] Othmani, R., Hbaieb, M., & Bouzid, W. (2011). Cutting parameter optimization in NC milling. *The International Journal of Advanced Manufacturing Technology*, *54*(9-12), 1023-1032.
[94] Yildiz, A. R. (2013). A new hybrid differential evolution algorithm for the selection of optimal machining parameters in milling operations. *Applied Soft Computing*, *13*(3), 1561-1566.
[95] Yildiz, A. R. (2013). Cuckoo search algorithm for the selection of optimal machining parameters in milling operations. *The International Journal of Advanced Manufacturing Technology*, *64*(1-4), 55-61.
[96] Wang, J., Du, B., & Ding, H. (2011). A Modified Genetic Algorithm (GA) for Optimization of Process Planning. *Journal of Computers*, *6*(7), 1430-1437.