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C O N T E N T

Computerized Generic Model for Selection of Manufacturing Method Based on Multiple Objectives and Functions

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ABSTRACT: Presently many manufacturing methods are available and the challenge before the organizations is the selection of appropriate manufacturing method based on organization objective and functional requirements. Owing to the dynamic nature of business environment every organization focuses on next stage of excellence by constantly updating and upgrading its business objectives. As the installation of a manufacturing method might be a very time consuming and expensive project, organization needs a tool support for the same. There is no single solution that is best for everyone. The problem boils down to proposing methods that are mapped according to the multiple objectives and functions aimed at improving organizational performance. In the current research, the authors have designed and implemented a generic manufacturing method selection model for the selection of the appropriate manufacturing process based on organizational objectives and functions.

Keywords: Auxiliary Solution, Grading Table, Manufacturing Method, Method Selection Matrix, Philosophical Solution, Software Solution, Technological Solution.

Introduction

The systematic analysis of organizational objectives and functional requirements is a basis for manufacturing method selection. Hence more than 110 manufacturing methods belonging to different classes have been proposed. For every strategic choice that organization makes for the manufacture of a new product, cost and quality management initiatives must be validated by selection of appropriate manufacturing method in order to meet organizational multi criteria economic objectives. The basic objective is to make the entire value chain faster, better and more profitable. The manufacturing method selection approach is conceptualized and designed to meet organization's specific requirements based on their objectives and functional requirements. This system revolves around four pivots, method selection based on single objective, multi objectives, single function and multi-functional requirements offering cost conscious and cost improvement methods

Manufacturing methods are categorized primarily into 5 different categories based on technological solution, software solution, management solutions, philosophical solutions, and auxiliary solutions. In order to provide a useful tool for managers in the selection of the best manufacturing method, two mapping methods based on organizational objectives and functions crucial to the organization are available. Gideon Halevi (Halevi 2003) has proposed 16 different manufacturing objectives, 24 different organizational functions grouped in four categories containing six functions each and 110 different manufacturing methods. The author has presented a review of manufacturing methods and their objectives (Halevi 2003). In the current work, the objectives as proposed by Gideon Halevi are considered for selection of a particular manufacturing method.

The applicability of each method to a particular objective is assigned one of the following grades based on its significance to the organization.

- Excellent for a particular objective
- Very Good
- Good
- Fair

Objective and Function Grading Table

The structure of the objective and function grading table is shown in Fig. 1.

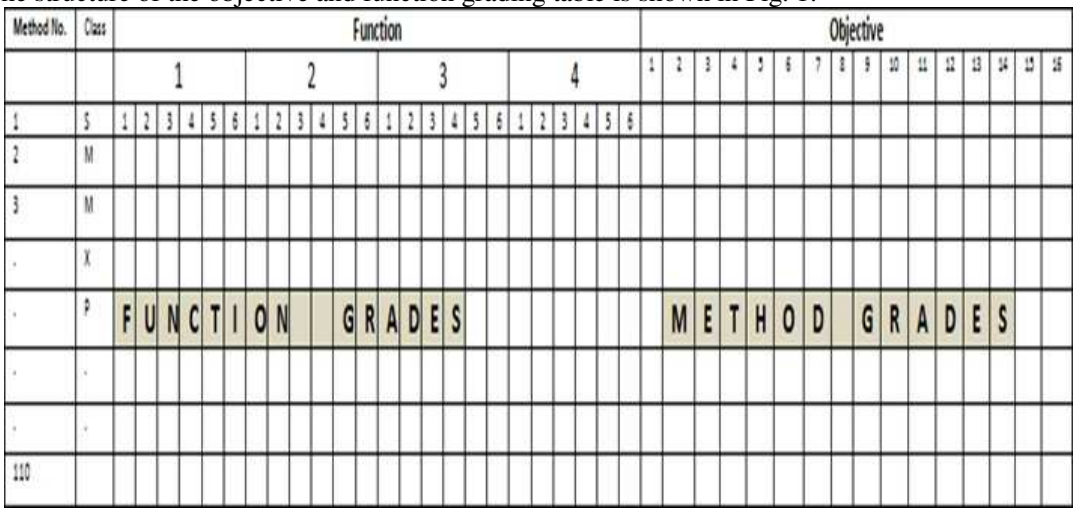


Fig. 1. Structure of Objective and Function Grading Table.

The objective and function grading table consists of 110 rows and 42 columns. The second column refers to the method classification. The columns in the range 3-26 refer to 4 different functions grouped into 6 different categories. The last 16 columns refer to the 16 different objectives. If the method in a particular row is not applicable to the objective or function in the corresponding column then the cell is indicated as blank.

In the current research the authors have designed a computer based framework for selection of manufacturing method based on multiple objectives and multiple functions. The method is generic and easily accommodates new objectives and functions.

Literature Review

Manufacturing methods can be systematically categorized on the basis of their main focus. Methods like Computer Aided Design (CAD) / Computer Aided Manufacturing (CAM), flexible manufacturing systems and manufacturing execution systems are supported by manufacturing hardware (Halevi 2003, Gardan & Minich 1992) In order to cater the needs of industry, knowledge management emerged as key area of research which resulted in focus on areas like expert system, artificial intelligence etc. (Co-Davies 1986, Coyne et.al. 1989). During the recessionary trends survival of organizations was crucial. This led to focus on improvement in productivity and to sustain lean phase in business cycle, organizations employed total cost management to remain competitive which resulted in emergence of methods like lean manufacturing, optimized production technology, theory of constraints etc. focusing on production planning and production control (Munro 1999, Goldratt 1988). Then focus shifted to more simplification of production processes, this led to emergence of group technology, just-in-time, constant work in process for the efficient utilization of organizational resources (Rao & Scheraga 1988). Cost leadership equips organizations with competitive advantage. Cost efficiency of organization's activities reflects its ability to perform similar activities better than its competitors. This led to emergence of methods like activity based costing, cost estimation, statistical process control etc. (Turny 1990). Competitive environment compelled organizations to fine tune their product design strategies. As a long term strategy, many organizations focused on building capacities for product design and development. The challenges faced by the organizations were controlling engineering costs against targets and mainly conforming product development process to meet time to market targets. These strategic initiatives led to emergence of methods related to product design and development (Datz 1987). Efficient human resource management removes redundancy and powers productivity. Efficient

performance management is proving to be an excellent cost optimization tool in the hands of smart organizations. It is the employee who drives the process rather than organization. The individuals input ensures an achievement oriented culture especially where change management is concerned. The main objective was to build learning organization to meet future challenges through development of high performing, energetic and enthusiastic human resource. This led to dedicated efforts in the direction of human resource development and management related methods such as executive excellence, cross functional leadership etc. (Becker & Gerhart 1996).

Research Methodology

The following section presents the mathematical mode for selection of manufacturing method based on multiple objectives and functions. The conceptual model is presented

Mathematical Formulation - Method Selection Matrix

The possible manufacturing methods suitable for a specific objective are organized in a matrix of order 11x10 in a method selection matrix. The method selection matrix has an element 1 if a particular manufacturing method is suitable for that objective, irrespective of its grade, otherwise the corresponding entry has a value 0.

Multi Objective Multi Function Criterion for Manufacturing Method Selection

Let $M^{(k)}$ represent a method selection matrix of order 11x10 for k^{th} objective where the ij^{th}element of $M^{(k)}$ is given by

$m_{ij}^{(k)} = 1$ if $(i+j)^{th}$ method has a grade 'a' or 'b' for the objective k, where 1 <= k <=16 ora function f where f ϵ [1.1-1.6, 2.1-2.6, 3.1-3.6, 4.1-4.6]

in the case of single objective and/or single function criteria,

= g * c * o if the $(i+j)^{th}$ method is applicable to objective kin the case of multi objective criteria and
= g * c * f if the $(i+j)^{th}$ method is applicable to function kin the case of multi-function criteria.

In the above expressions g, c, o and f, refer to grade weight, class weight, objectiveweight and function weight, respectively.

We define the union operation on the method selection matrices M and M' as follows.

Let $M = [m_{ij}]$ and $M' = [m'_{ij}]$ represent two method selection matrices.

$M \cup M' = m_{ij} + m'_{ij}$ iff $m_{ij} <> 0$ and $m'_{ij} <> 0$
= 0, otherwise.

With this type of representation, where various methods available for each objective and function are represented in a matrix form, it becomes plausible to address various cases pertaining to the manufacturing method selection for

- Single Objective
- Single Function
- Single Objective and Single function
- Multi Objective
- Multi Function
- Multi Objective and Multi Function

Without such a representation, the number of various permutations and combinations to be considered in various cases ignoring different classes are depicted Table 1.

Table 1. No of Permutations for Selection of Manufacturing Method in variousScenarios

Selection Type	No. of Permutations
Single objective	16
Single function	24
Single objective and single function	384
Multiobjective	$^{16}c_1 + {}^{16}c_2 + {}^{16}c_3 + \ldots + {}^{16}c_{16} = 2^{16}-1 =$ 65,536
Multi-function	$^{24}c_1 + {}^{24}c_2 + {}^{24}c_3 + \ldots + {}^{24}c_{24} = 2^{24}-1 =$ 1,67,77,216
Multi-objective and multi-function	$(2^{16}-1) * (2^{24}-1) = 10,99,51,16,27,776$

As seen from the Table 1., no. of permutations for multi-objective, multifunction criteria boils down to 10 trillion. Hence the above model tries to address this issue through data matrix representation thereby offering the solution in polynomial time. Without such a representation, the number of various permutations and combinations to be considered in various cases are depicted Table 1. The work flow of the conceptual model is depicted in Fig. 2.

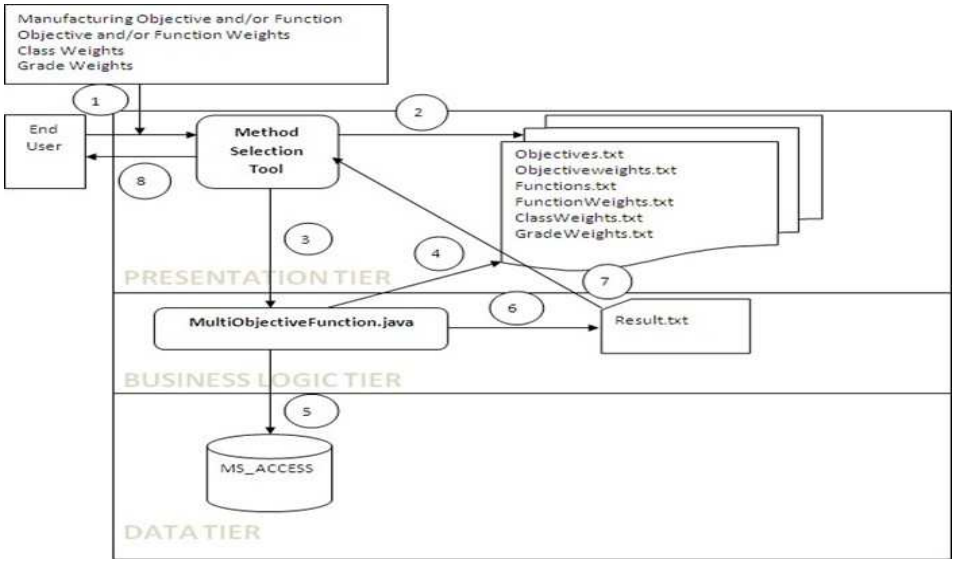
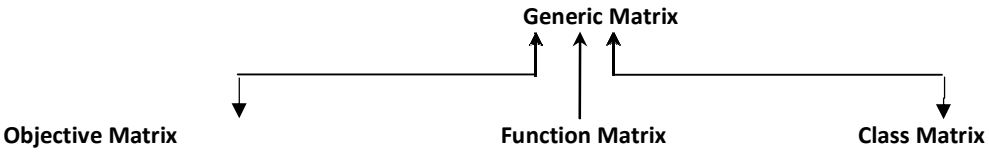


Fig. 2. Work Flow of the Conceptual Model

Class Diagram for Implementation of Business Logic

Generic Matrix
name : String grade : int[][]
Generic Matrix (Name: String, Grades :int[][]) to String(void):String
Union (GenericMatrix gm):Generic Matrix Find Method (Om: Objective Matrix): Method



Objective Matrix, Function Matrix and Class Matrix are simply the symbolic names for Generic Matrix having the same structure as Generic Matrix.

Method
method number :int method name : string classification code : string value : int
method(int, String, String, int):void to String(void):String

MultiObjectiveFunction
grade : int[][]
main(string[]):void create Objective Grade Matrix():voidcreate Function Grade Matrix():void find Methods (type: String): String[]

Results and Experimental Work

The model developed in section 3 is applied for the selection of manufacturing method based on multi objectives and multi functions.

Problem Definition: Select a set of manufacturing methods for a hypothetical organization conforming to the following organizational objectives.

Objective 2– Reduce Production costs
Objective 3– Rapid response to market demands – product design
Objective 6 – Progress towards zero inventory – increase inventory turnaround
Objective 7 – Improve management knowledge and information– enterprisecommunication
Objective 13– Improve enterprise integration – improving supply chain globally,

The weights assigned to different objectives, classes and grades are depicted in Tables2.1-2.3

Table 2.1 Objective Weights

Objective	Weight
2	10
3	8
6	8
7	6
13	6

Table 2.2 Class Weights

Class	Weight
M	4
P	3
S	5
T	5
X	1

Table 2.3 Grade Weights

Grade	Weight
a	6
b	4
c	3
d	1

Solution :

The method selection matrix is formulated for each of the objectives taking into account, corresponding objective weights, weight of the class to which the method belongs and objective's grade weight as given in Table 2.1-2.3.

The method selection matrices for objectives 2 and 3 are depicted in Fig. 3 and similar matrices exist for other objectives.

Note : Matrix starts with zero index

Method Numbers for Objective 2					
1	22	43	57	77	94
3	24	44	58	79	95
6	26	46	60	82	97
8	27	47	62	84	98
9	30	48	67	86	99
13	33	50	68	87	101
14	34	51	69	88	103
16	37	52	70	91	105
19	38	53	73	92	107
20	39	56	76	93	

0	150	0	120	0	0	120	0	90	120
0	0	0	120	40	0	90	0	0	150
150	0	30	0	150	0	160	90	0	0
90	0	0	50	150	0	0	30	10	200
0	0	0	120	120	0	90	30	90	0
120	160	90	120	0	0	160	90	120	0
40	0	120	0	0	0	0	90	200	120
120	0	0	90	0	0	30	120	0	120
0	0	50	0	150	0	90	30	90	0
0	40	150	120	120	150	0	30	40	40
0	160	0	120	0	30	0	90	0	0
0	0	0	0	0	0	0	0	0	0

Fig. 4.

Method Numbers for Objective 3						
2	21	38	50	67	83	98
3	23	39	51	68	85	101
4	25	42	52	69	86	102
7	27	43	53	70	88	103
8	29	44	54	73	90	104
9	31	45	57	75	91	105
12	32	46	58	77	92	106
14	34	47	61	79	93	109
15	35	48	62	80	94	110
20	37	49	65	82	95	

0	0	32	96	24	0	0	160	24	128
0	0	160	0	24	40	0	0	0	0
40	160	0	72	0	24	0	72	0	24
0	160	240	0	120	144	0	24	24	160
0	0	24	128	96	240	24	24	24	32
72	128	24	96	128	0	0	96	32	0
0	24	128	0	0	72	0	72	120	128
128	0	0	24	0	32	0	128	0	96
24	0	160	96	0	96	24	0	24	0
160	24	40	32	128	160	0	0	128	0
0	128	160	128	160	96	160	0	0	96
72	0	0	0	0	0	0	0	0	0

Fig. 3.

Method Selection Matrices for Objectives 2 and 3.depicts the application of union operation on the method selection matricesfor objectives 2 and 3.

Objective 2 U Objective 3

Method Numbers for Objective 2 and Objective 3			
3	43	58	86
8	44	62	88
9	46	67	91
14	47	68	93
20	48	69	95

Method Numbers for Objective 2 and Objective 3			
27	50	70	
34	51	73	
37	52	77	
38	53	79	
39	57	82	

0	0	0	216	0	0	0	0	114	248
0	0	0	0	64	0	0	0	0	0
190	0	0	0	0	0	0	162	0	0
0	0	0	0	270	0	0	54	34	360
0	0	0	248	216	0	114	54	114	0
192	288	114	216	0	0	0	186	152	0
0	0	248	0	0	0	0	162	320	248
248	0	0	114	0	0	0	248	0	216
0	0	210	0	0	0	114	0	114	0
0	64	190	152	248	310	0	0	168	0
0	288	0	248	0	126	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Fig. 4. Application of Union Operation on the Method Selection Matrices forObjectives 2 and 3

Similarly, performing the union of method selection matrices for objectives 2, 3, 6, 7 and 13, we get the final matrix shown in Fig. 5.

Objective 2 U Objective 3 U Objective 6 U Objective 7 U Objective 13

Method Numbers for Objective 2 and Objective 3 and Objective 6 and Objective 7 and Objective 13			
9	39	98	
14	43		
20	50		
37	68		
38	94		

0	0	0	0	0	0	0	0	0	544
0	0	0	0	138	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	134	100	760
0	0	0	544	0	0	0	0	0	0
390	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	690	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	544	0	0	0	440	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Fig. 5. Final Selection Matrix for the Objectives 2, 3, 6, 7 and 13.

The generic model presented above is implemented in Java in a business tier with MS-Access as back end for storing the domain specific information. The structure of the database is shown in Figure 5. The Graphical User Interface is developed in VB which invokes the business logic for generating the required output. The output is routed to atext file which is retrieved and displayed by the presentation tier logic. The graphical userinterface of presentation tier is depicted in Figure 6.

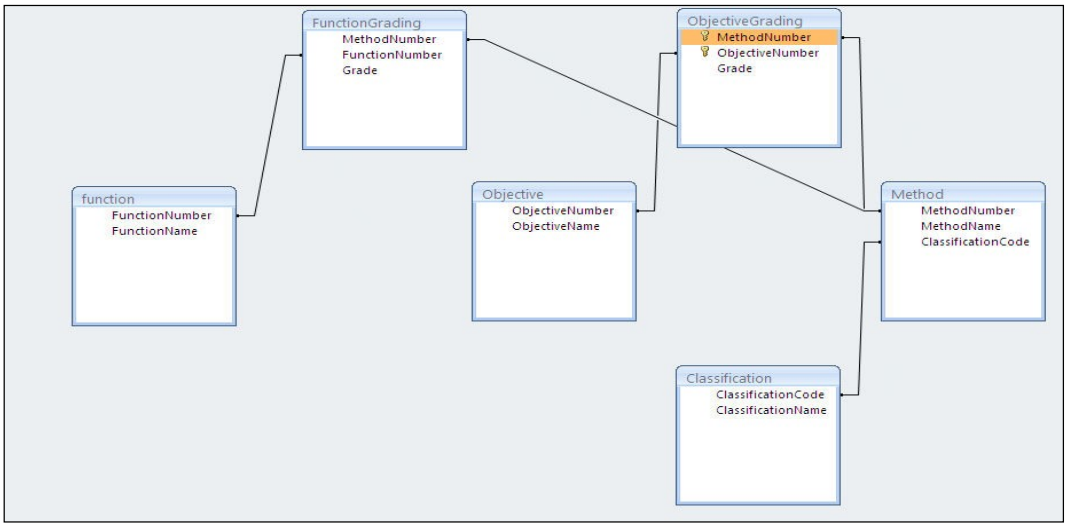


Fig. 6. Structure of Manufacturing Database

Fig. 7. Graphical User Interface for Presentation Tier

Fig. 8(a)-8(b) depict the selection of manufacturing method based on asingle objective for all classes and class M, respectively.

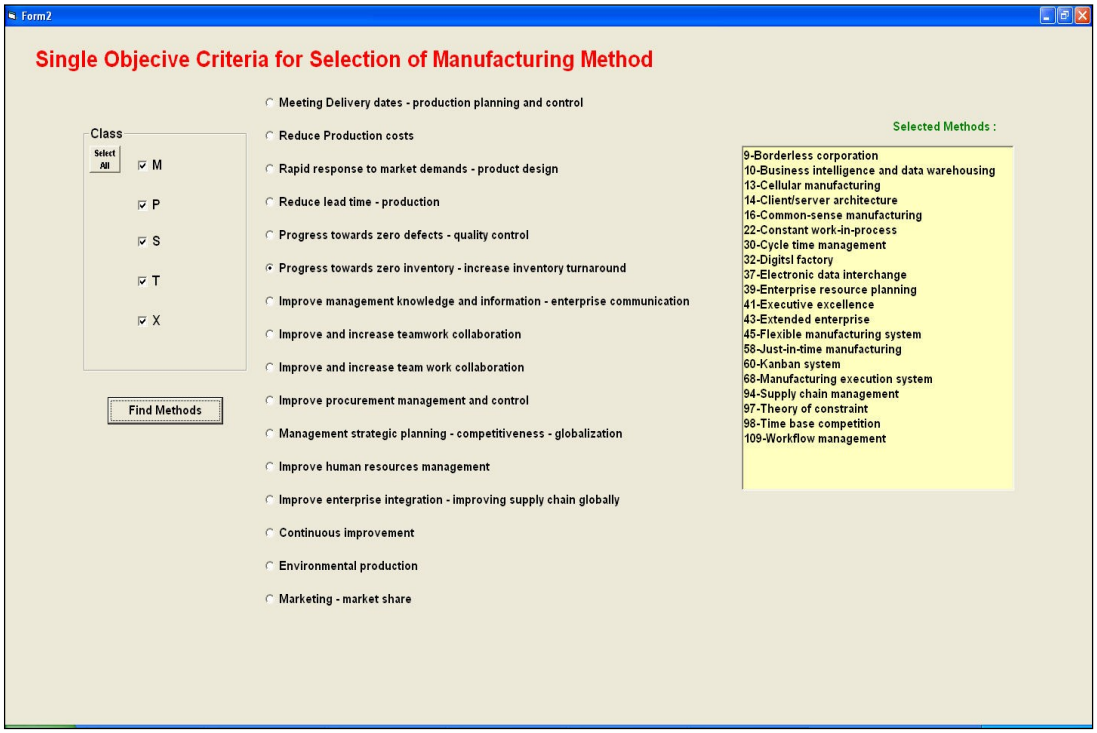


Fig. 8 (a) Selection of Manufacturing Methods for a Single Objective (Objective 6) for allclasses

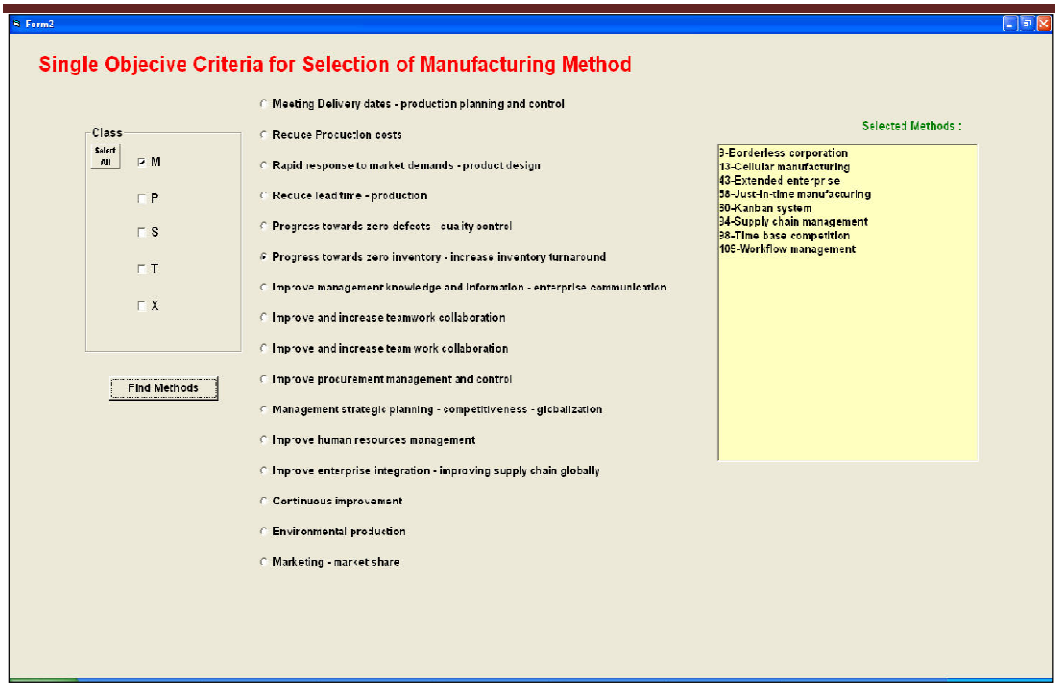


Fig. 8 (b) Selection of Manufacturing Methods for a Single Objective (Objective 6) forClass M

Figure 9(a) depicts the selection of manufacturing methods for the function 4.3,Focus on Management Control with Figure 9 (b) depicting the execution of business logic in middle tier.

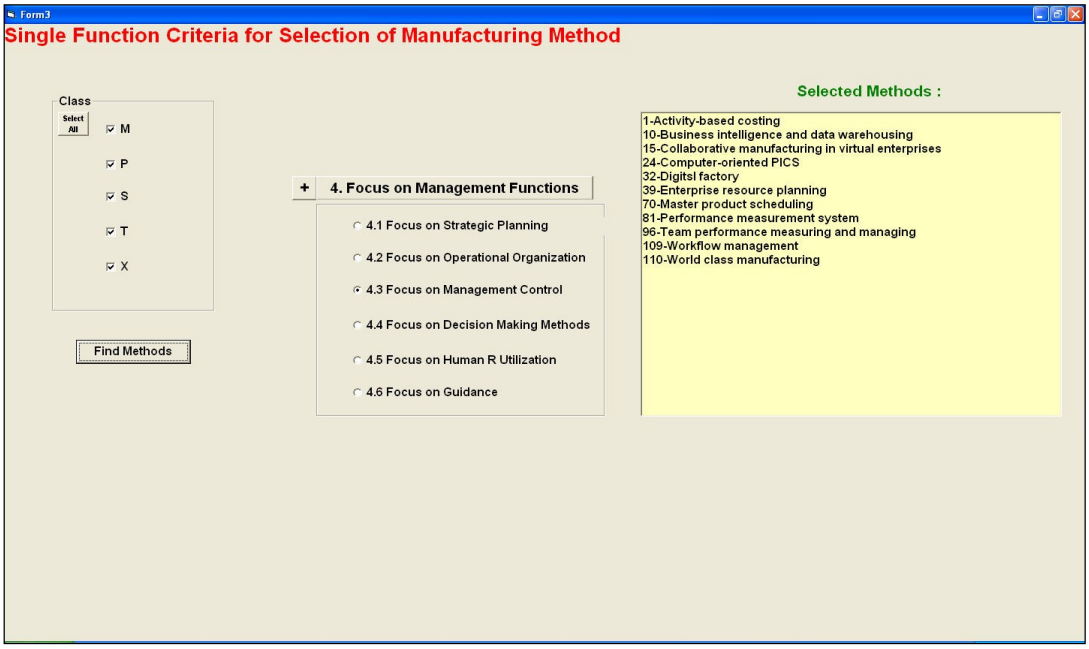


Fig. 9 (a) Selection of Manufacturing Methods for a Single Function 4.3

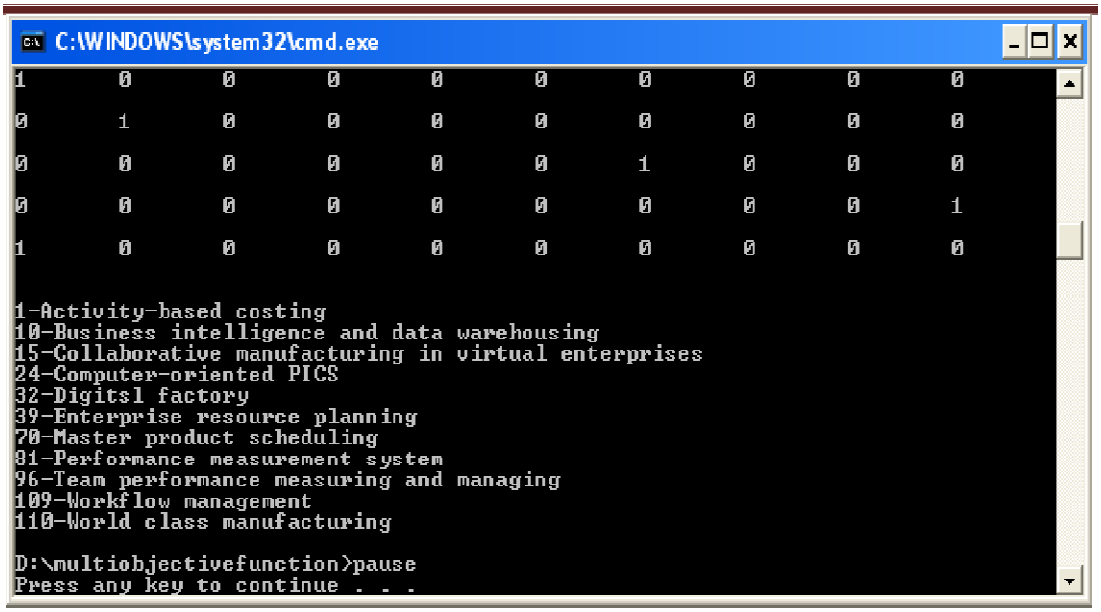


Fig. 9(b) Execution of Business Logic in Middle Tier

Figure 10(a) and 10(b) depict the selection of manufacturing methods basedon multi objectives and multi objectives and multi functions, respectively.

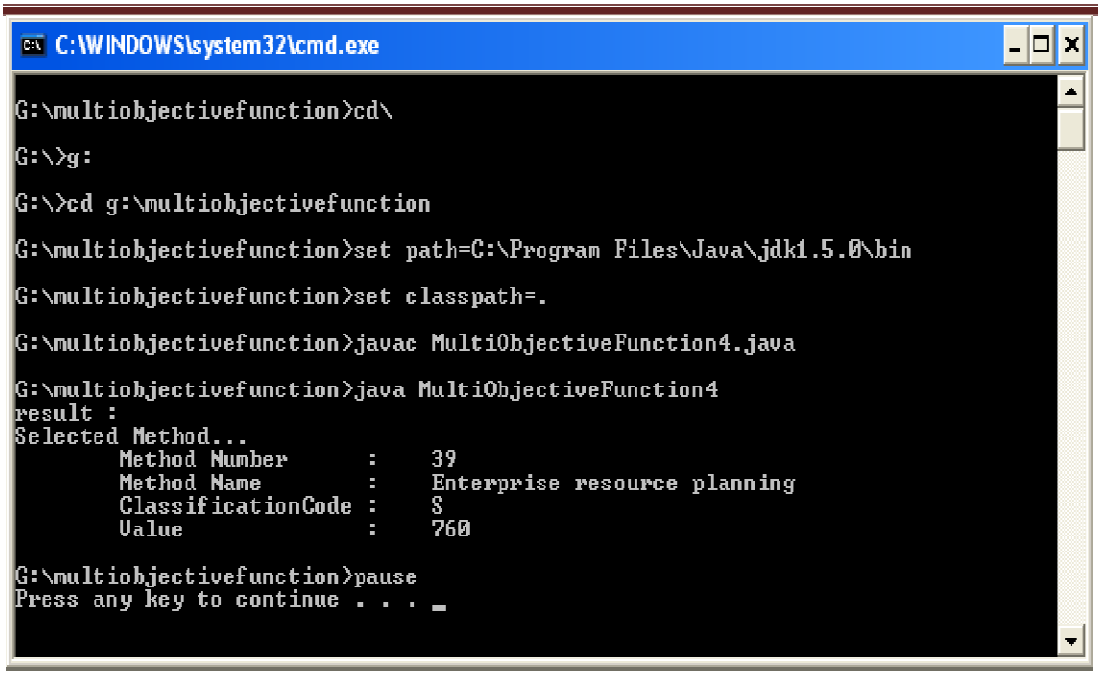


Fig. 11(b) Execution of Business Logic in Multi objective Method Selection

Fig. 10(a). Selection of Manufacturing Methods Based on Multi Objectives andMulti Functions

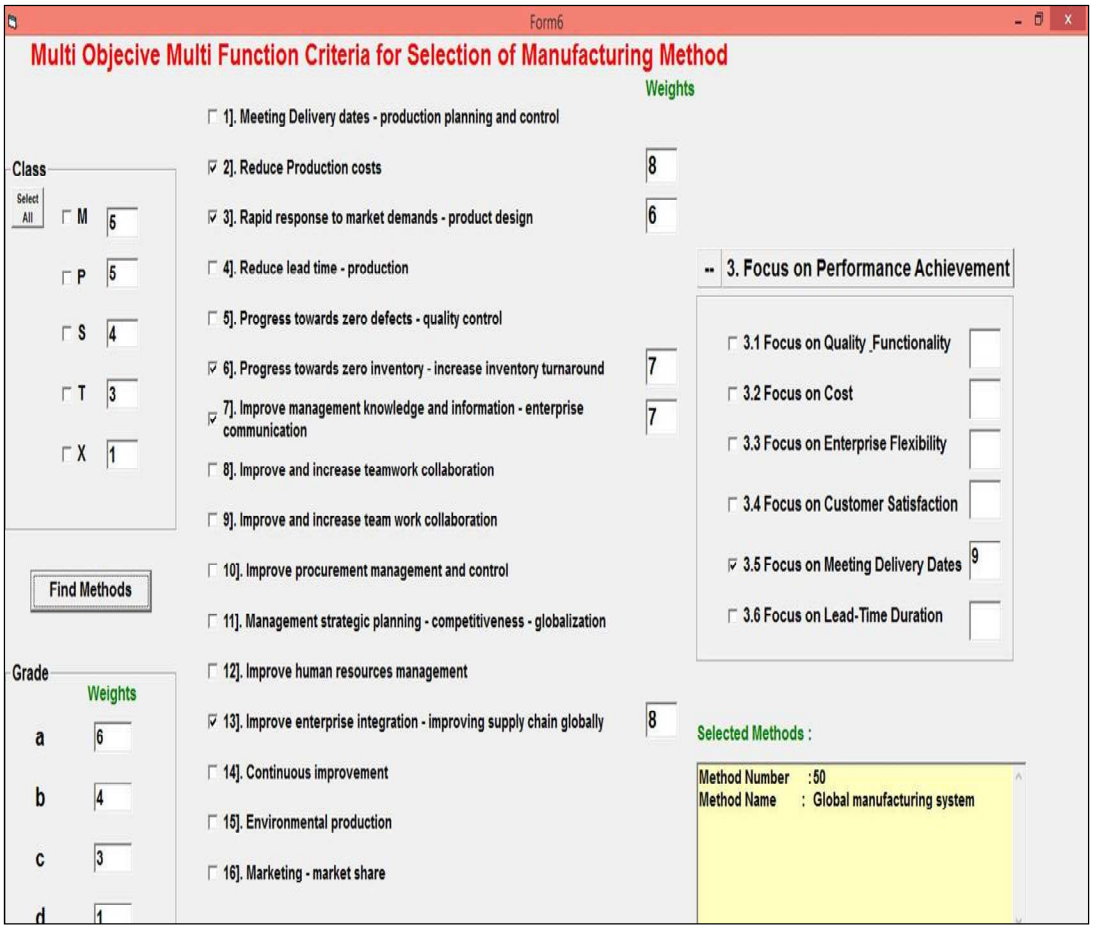
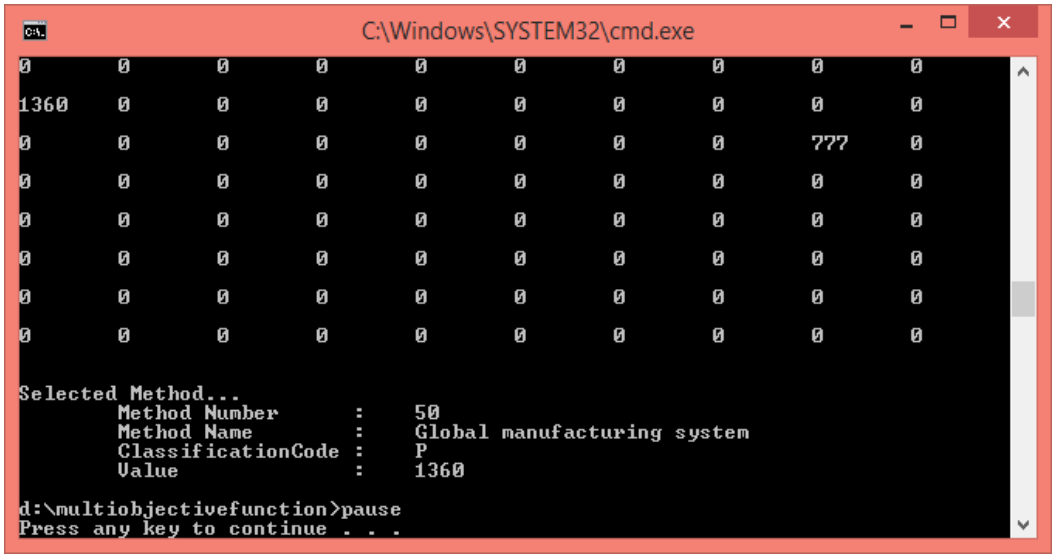


Fig. 10(b) Execution of Business Logic in Multi objective and Multi Function Method Selection



Scope for Future Work

The current research can be extended further to develop a model based on fuzzy logic for fine tuning the selection criteria providing a blended approach where a single method fails to meets the objectives and functions.

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