A
Project Presentation
on

Fuzzy-Genetic Approach to Optimize Machining Process Parameters of AWJM

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Guide
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Introduction to AWJM

- Advanced Machining Process
- Fine jet of ultrahigh pressure water and abrasive slurry
- First initiated by Franz in 1968 and was first introduced as a commercial system in 1983
- Distinct advantages:
  - To cut electrically non-conductive as well as difficult-to-machine materials
  - Multi-directional cutting capacity
  - No thermal and deformation stresses
  - Recycling of abrasive particles, etc.

Introduction to AWJM

- Applications:
  - Factory applications: to cut difficult-to-cut materials, in pattern cutting, etc.
  - Food industry: to cut breads, in trimming fats from meats, etc.
  - Cleaning, etc.

- Other Key Features:
  - Positioning accuracy: ± 0.003 mm
  - Cutting accuracy: ± 0.01 mm (Depending on material and thickness)
  - Kerf width: 0.3 mm
  - Surface quality: equivalent to Ra1.6 micro meters
  - Maximum work piece size: 1000 x 600 mm

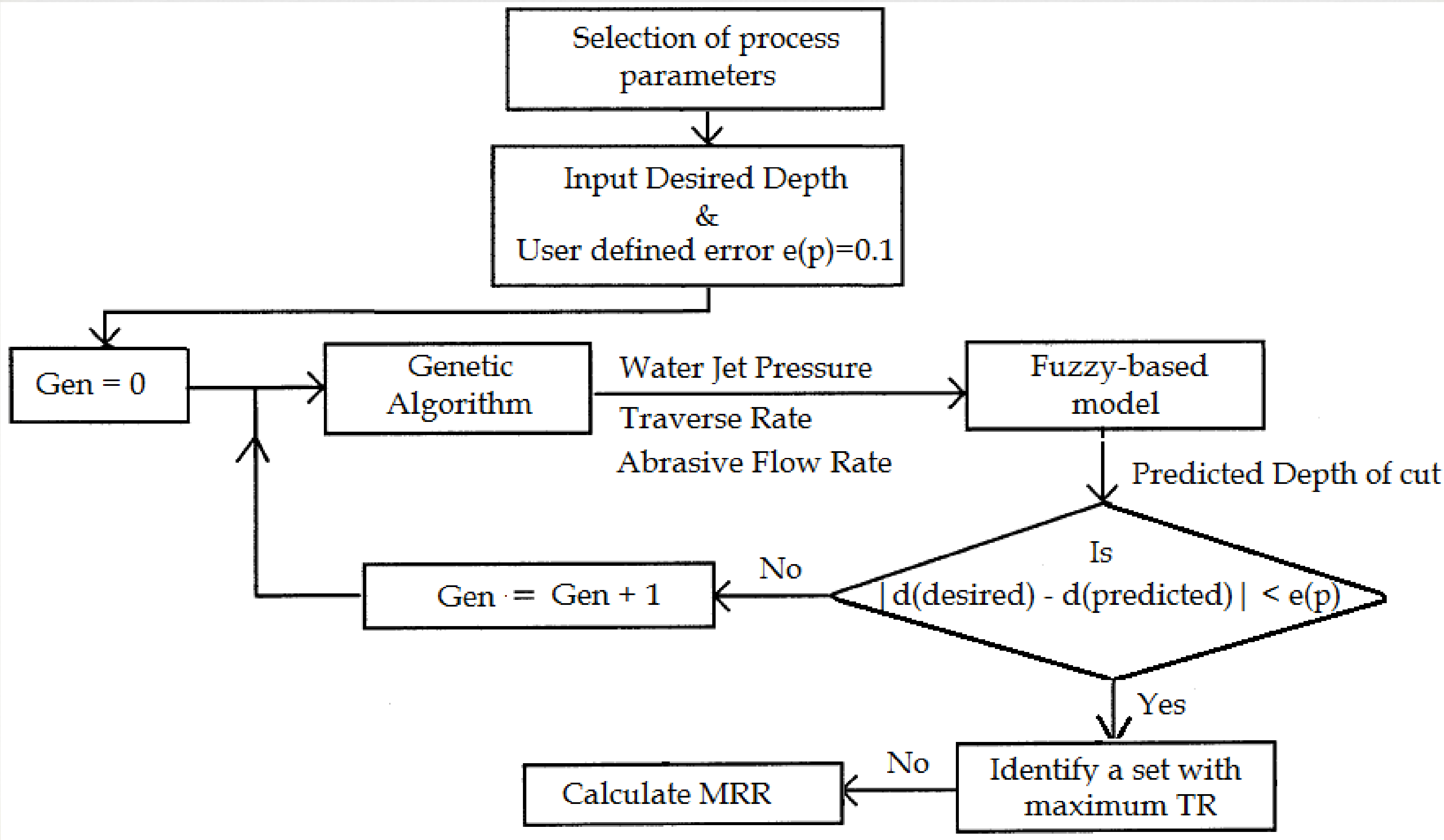
Literature Review

- Kovacevic and Fang [1994]
  - Used Fuzzy Rules
  - Employed an iterative procedure
- Chakravarthy and Babu [2000]
  - Hybrid Approach of Fuzzy Logic and Genetic Algorithm
  - Not Disclosed Fuzzy Rules used
- Aggarwal and Singh [2005]
  - Reviews the literature on optimization techniques
- Issues:
  - nowhere fuzzy rules are disclosed
  - fuzzy principles may give rise to several combinations of process parameters

Objectives of Project Work

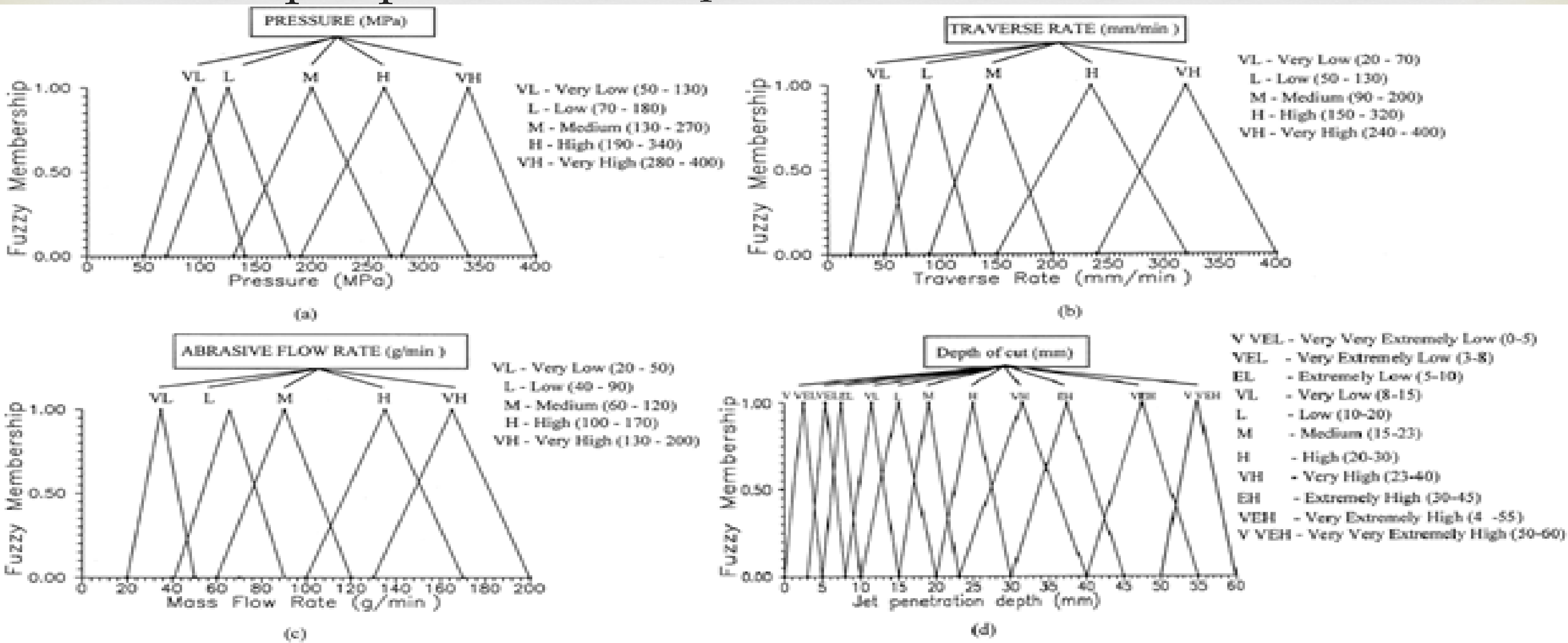
- To establish rules to build fuzzy model for predicting depth of cut
- To optimize the process parameters of AWJM using GA for maximizing MRR

Methodology



Development of fuzzy model

- Input Parameters: Water Jet Pressure (WP), Traverse Rate (TR) and Abrasive Flow Rate (AFR) are divided into 5 levels
- Output parameter: Depth of cut is divided into 11 levels

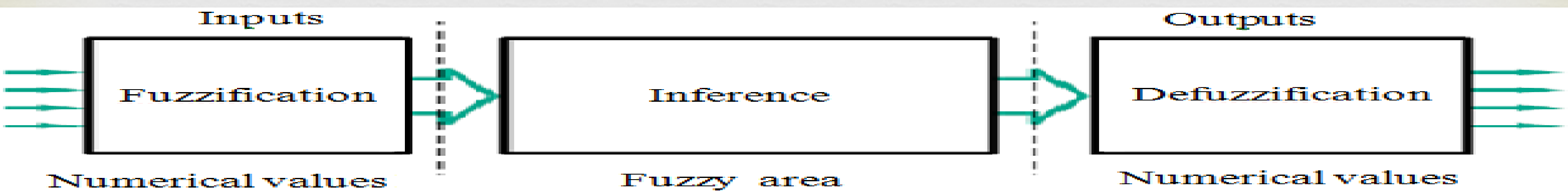


Development of fuzzy model

- Data acquisition: 125 experiments were conducted by varying each of three input process parameters at five different levels
- Knowledge base: 125 fuzzy rules
  - Rule 1:IF WP is VL AND TR is VL AND AFR is VL THEN depth of cut is EL
  - Rule 40: IF WP is M AND TR is VH AND AFR is L THEN depth of cut is VEL
  - Rule 71: IF WP is VH AND TR is VL AND AFR is M THEN depth of cut is EH
- Use of triangular membership function

Development of fuzzy model

- Fuzzy model contains
  - Fuzzification module
    - crisp value to membership value
  - Inference module
    - Scans the knowledge base (Knowledge base is formulated in terms of 125 fuzzy inference rules
    - Fuzzy rules act as decision makers
  - Defuzzification module
    - Output of inference module is fuzzy
    - Need to defuzzify in to a crisp value
    - Use of centroid method



Automatic selection of optimal process parameters

- Initial population: generated randomly
- Fitness function: $F_i = |e_{max} - e_{string}|$
- Reproduction: formation of mating pool
  - *p_select* plays important role

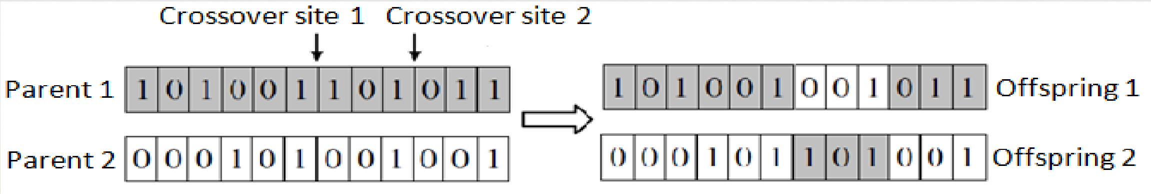
Combination set number	Input parameter values			Fitness value F_i	Probability of selecting combination, $p\_select = \frac{Fi}{Favg}$	Actual count	Additional count
	WP (MPa)	TR (mm/min)	AFR (g/min)				
1	257	204	154	13.65	1.55	1	1
2	314	307	70	2.49	0.28	0	0
3	313	117	122	10.81	1.23	1	0
4	335	309	187	20.64	2.34	2	0
5	147	228	192	3.06	0.35	0	0
6	298	307	154	4.42	0.50	0	1
F_{avg}				8.82	Total count	4 + 2 = 6	

Automatic selection of optimal process parameters

- Solutions from mating pool are undergoes recombination operators
- Binary values of process parameters are very efficiently and effectively used during recombination operators

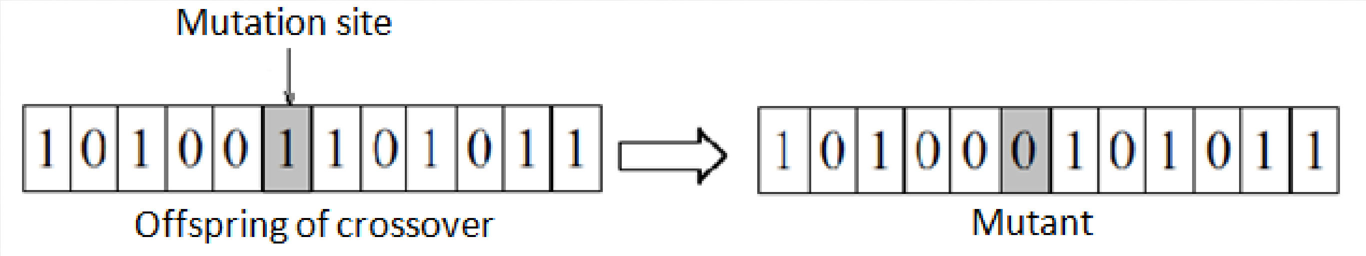
101001110	100001100	10001101
334 MPa	268 mm/min	0.141 kg/min

- Crossover:
  - p_cross is high, more strings in the initial population will be subjected to crossover
  - p_cross = 0.9
  - give a local optimum



Automatic selection of optimal process parameters

- Mutation:
  - avoid any loss of feasible solutions obtained after the crossover operation
  - higher values of p_mut may lead to negative effects in terms of discarding the best strings
  - p_mut = 0.1



Automatic selection of optimal process parameters

- New mating pool
  - after recombination operators new fitness values are calculated
  - combination of process parameters with higher fitness value enter into new mating pool for next generation
- Procedure is repeated until feasibility test for all solutions is satisfied.
- Gives several optimal combinations for process parameters
- MRR depends on TR

$$MRR = h \times w \times TR$$

Results and Discussions

Water jet pressure (MPa)	Traverse rate (mm/min)	Abrasive flow rate (kg/min x 10^{-3})	Depth of cut (mm)			Deviation of predicted depth of cut (%)	
			Experimental value	Reported value [1]	Predicted value	Reported [1]	Predicted
300	30	21	31	34	33.99	9.00	8.80
325	30	107.6	45	44	41.15	-2.20	-9.36
350	30	65.2	43	47	44.36	8.50	3.06
150	150	90	11	9.38	9.37	-1.72	-1.72
180	70	30	15	15	15	0.00	0.00
200	70	110	17	19	18.08	10.50	5.97
220	70	130	21	22.14	19.59	5.14	-7.20
Average deviation of predicted depth of cut (%)						4.17	-0.06

Results and Discussions

- Fuzzy-genetic approach is illustrated with

  population size = 32,

  p_cross = 0.9

  p_mut = 0.1

  user defined error of 0.1 mm

Desired Depth (mm)	Predicted values for			Predicted depth of cut (mm)	Experimental Depth of cut (mm)	MRR (mm^3/min x 10^{-3})
	Water jet pressure (MPa)	Traverse rate (mm/min)	Abrasive flow rate (kg/min x 10^{-3})			
22	300	30	21	22.026	22.09	2.256

Conclusions & Future scope

- Conclusions:
  - Fuzzy logic is used as decision maker technique
  - GA is used as optimization technique
  - Fuzzy model developed in present work can be used to efficiently predict the depth of cut for a given set of input process parameters
  - Predicted and experimental depths of cut are within the user defined tolerance limits
- Future scope:
  - Allows to consider different objectives
  - Can be extended to other materials.
  - One can include other input and output parameters depending on the objectives

References

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Thank you….