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Z. Rutkauskas / A. Bargelis

Knowledge based method for precision products design

Engineering Design

1. Abstract

The paper deals with artificial intelligence method applying knowledge base (KB) for precision products design. Facts, design rules and engineers experience for KB development have been used. The products classification into separate class level was employed. Concurrently, the application of fuzzy logic method for definition product design uncertainties and functionality parameters have been applied. Case study of development testing has been made by design of injection moulds for precision parts.

2. Introduction

The 21st century manufacturing environment has been noticed as precision machines and tooling tendency with high variety level. The biggest role for this increasing tendency is obviously assigned to remarkably advancing products and manufacturing processes design. Medical and measurement equipment as well as robots and tools advances also precision machine parts dimension reduction greatly influence into integration of design and manufacturing processes [1].

The main objective of this research is to develop an intelligent approach of precision products design applying knowledge base and fuzzy logic. Created methodology in Hybrid Manufacturing Systems (HMS) could be used for design and manufacturing precision products.

3. Knowledge base architecture for precision product design

Intelligent approach for precision products design consists of KB and fuzzy logic module.

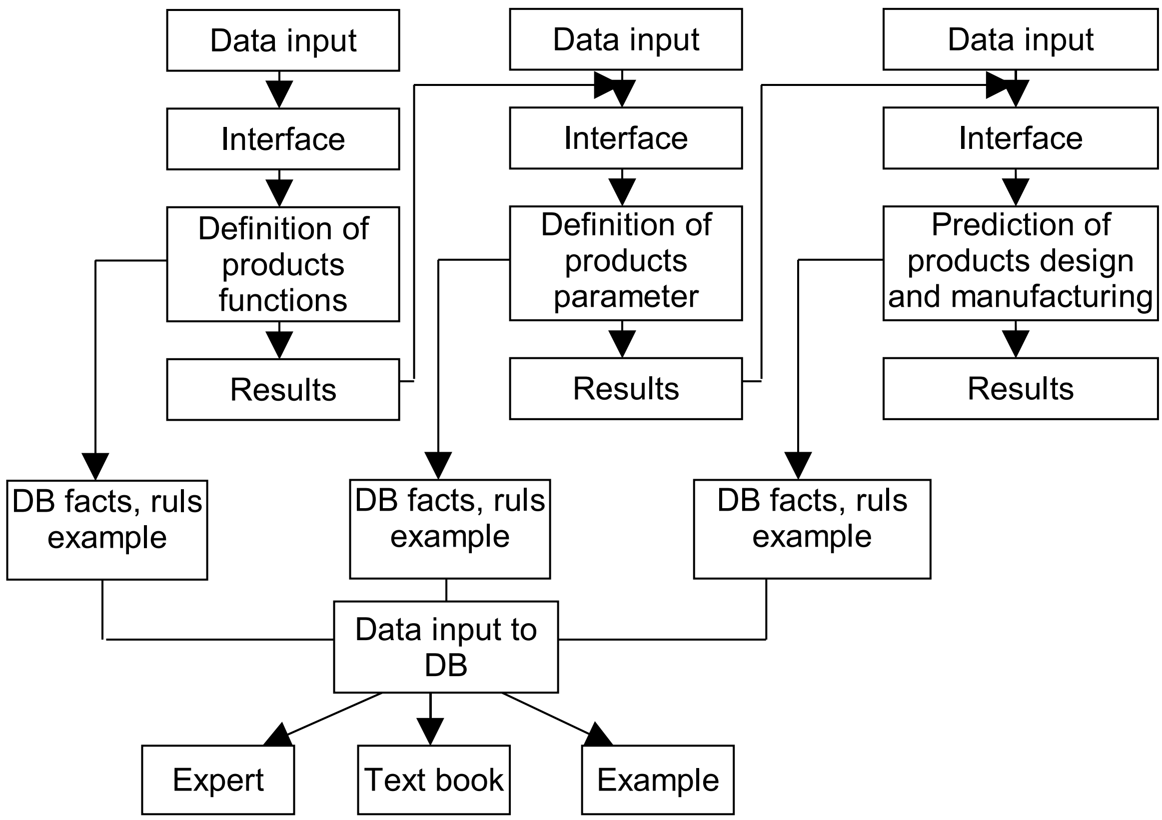


Fig. 1 KB architecture

KB architecture has three subsystems: 1) definition of product functions, 2) definition of product parameters and 3) prediction of product design and manufacturing costs. The input data for precision product design is customer requirements, production volume and delivery time [2, 3]. First KB subsystem defines product functionality according to specified customer requirements. It helps to solve contradictions among customer requirements and product developers aiming functional tasks. Second KB subsystem determines product structure, components and geometrical form, dimensions, mass and quantitative-qualitative parameters [3, 4]. Third KB subsystem for forecasting product development investments and manufacturing costs is devoted. Two interfaces in KB architecture are foreseen to guarantee interfacing among subsystems and user. Developed KB has user interface, inference engine for acquisition domains experts' knowledge and database. Inference engine and data base provide solutions to user via user interface. Leading aspect of developed KB structure is presentation of necessary knowledge and their processing in precision product design. The research is based on the classification of products variety into separate class level. This classifier also fuzzy [5] logic module for definition product design uncertainties and functionality parameters have been applied. Case study is devoted for developed methodology testing in injection moulds design field.

4. Case study

Developed intellectual model firstly selects the optimal quantity of cavity number according to clamping force, maximal mass, overall dimensions and part manufacturing time [2]. Next step applying cavity layout scheme is definition and type. After that according to designer’s criterions the dimensions of moulding plate are selected. Main factors that influence the dimensions of cavity number are: quantity of cavity number, geometrical form/shape, cavity layout order, moulding system, cooling system, cost of mould, weight of mold, disposable moulding equipment stock. After analysis of information sources [2, 3, 5, 6, 7, 8, 9] the algorithm of moulding plate dimensions selection was developed.

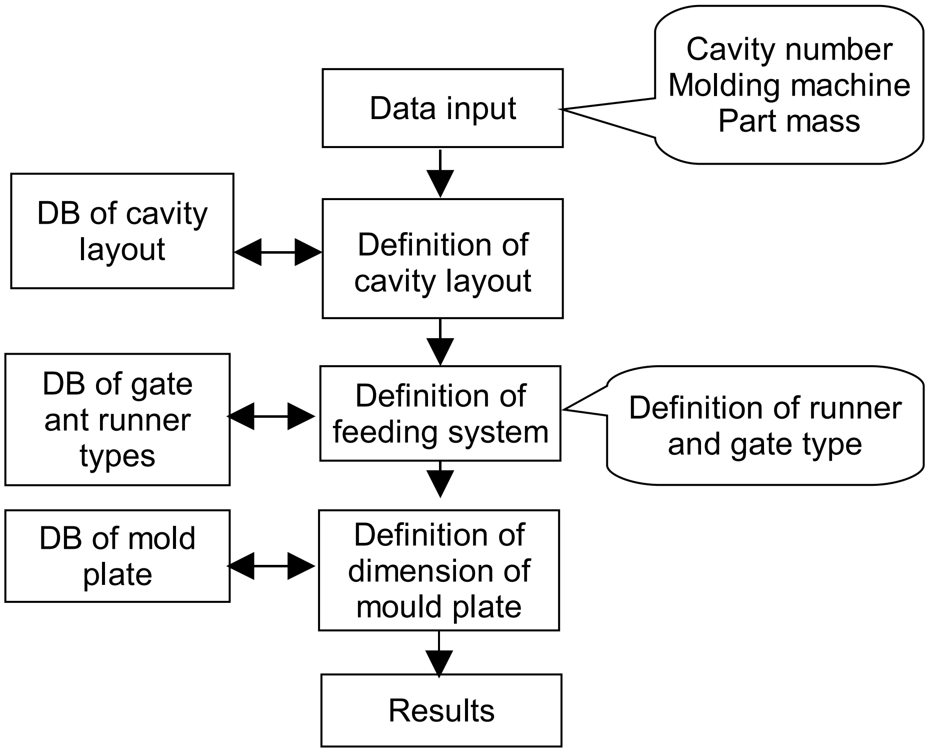


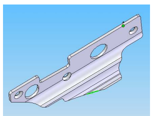
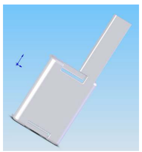
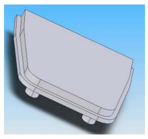
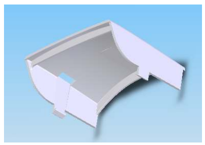
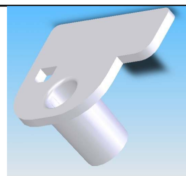
Fig. 2 Structure of definition mould plate

The developed method is tested using experimental data of 5 moulded plastic parts and 5 mould machines in company X. The tested parts and machine data are presented in Table 1 and Table 2. The results of experiments are presented in Fig. 3 – 12.

Table 1 Data of moulding machine

Mark	Machine type	F, kN	D, mm	b mm	l mm
M_1	Demag 55	550	36	480	480
M_2	Battenfeld HM 600/130	600	30	550	530
M_3	Allrounder 420s 1000 - 150	1000	35	650	650
M_4	Demag KD100	1000	38	580	580
M_5	Batenfeld HM 1600/350	1600	40	810	805

Table 2 Data of parts

					
Material	POM	PA6	PS	PS	PS
Mass *(g)*	9	8	7	24	4
Overall dimensions *(mm)*	113 x 35,8 x 18,2	104 x 40 x 10	42,2 x 41,5 x 4,1	92 x 77,2 x 41,3	42 x 34 x 20,8
Projection area *(mm²)*	2973	2815	1644	7280	1083
Cycle time *(s)*	9,63	15,56	40,89	14,41	23,31

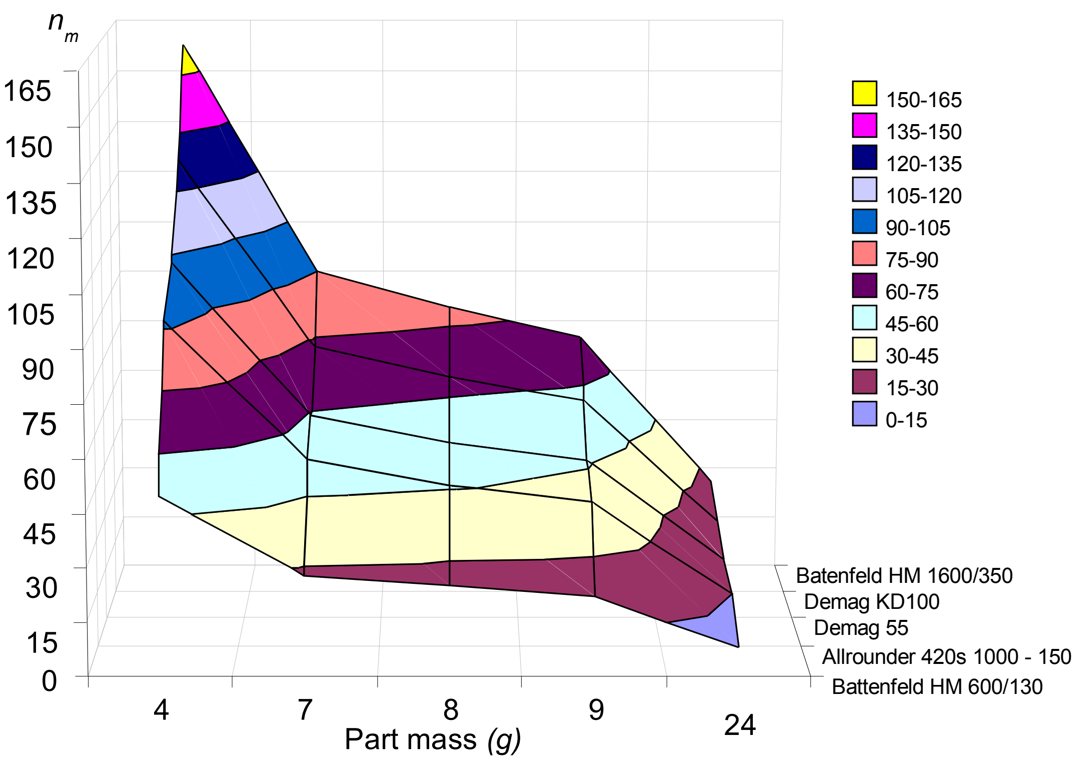


Fig. 3 Cavity number n_m definition according to the maximal part mass

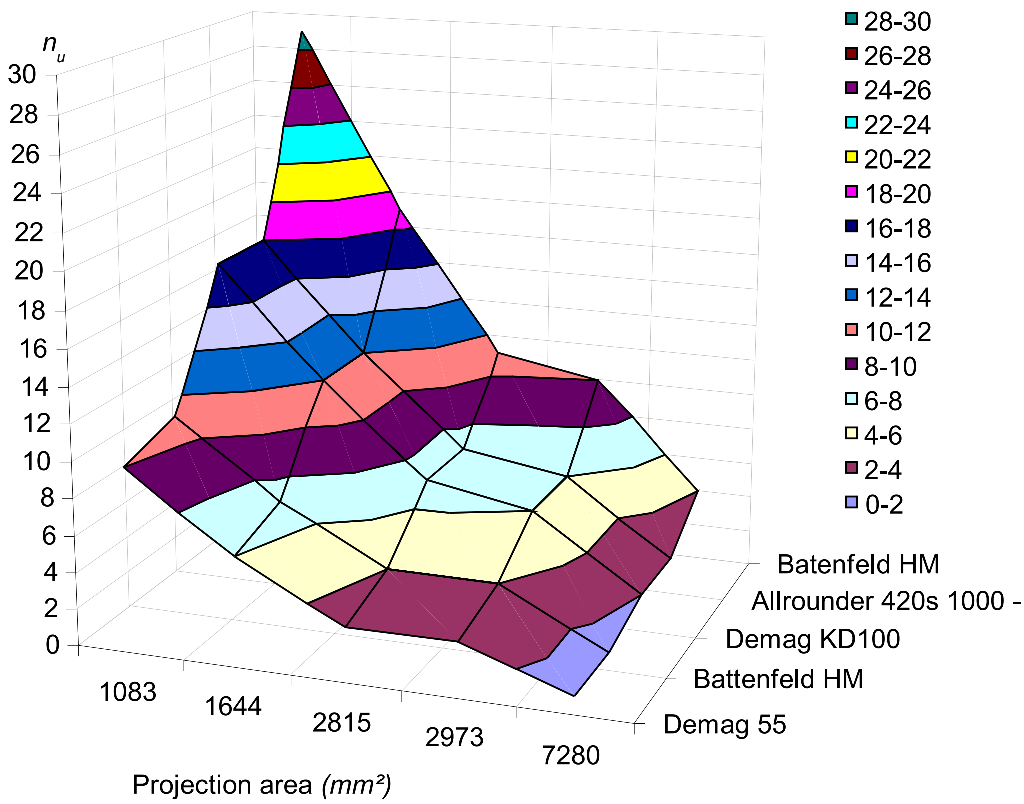


Fig. 4 Cavity number n_u definition according to the clamping force

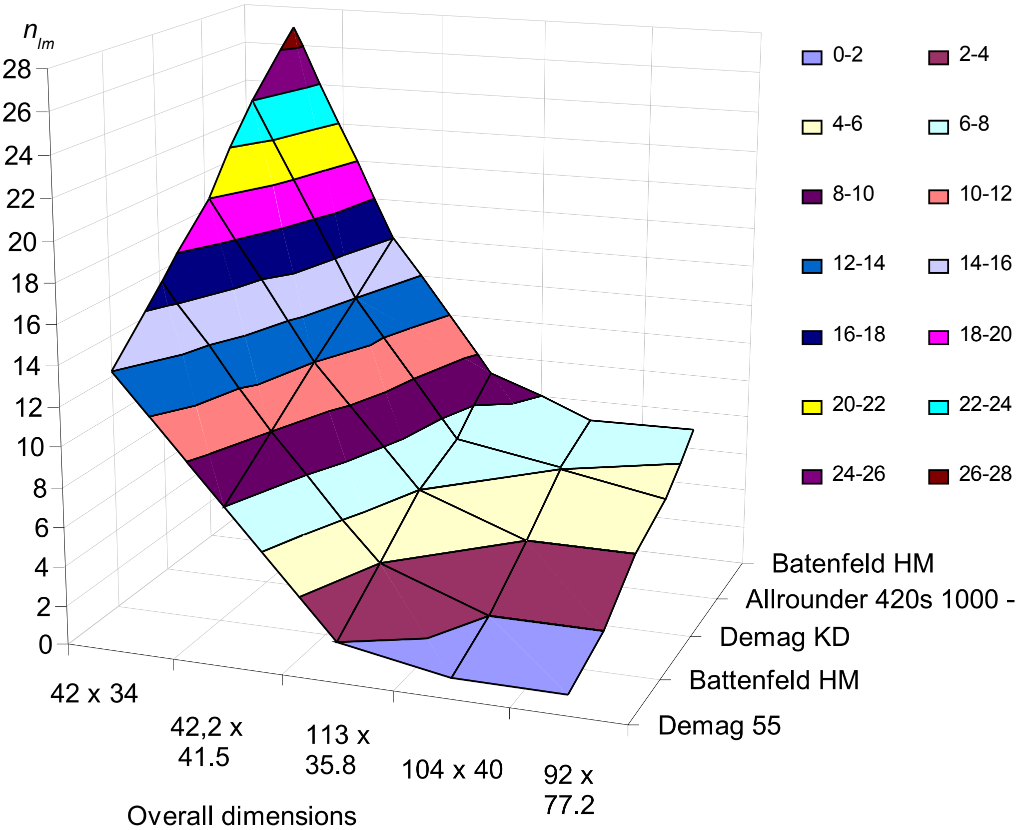


Fig. 5 Cavity number n_{lm} definition according to the dimension of plate

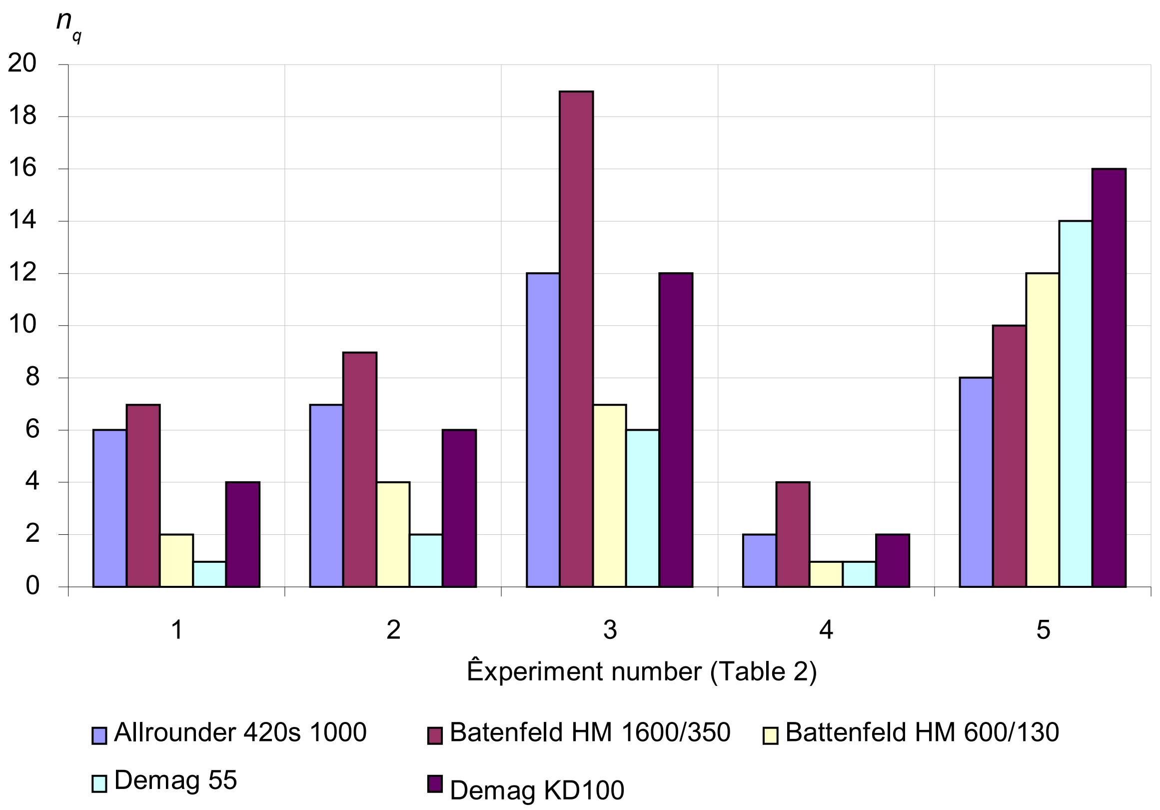


Fig. 6 Definition of qualitative cavity number n_q

In this case the qualitative quantity of cavity number by projection area of parts, overall dimensions, clamping force of moulding machine and possible size of mould plate has been defined.

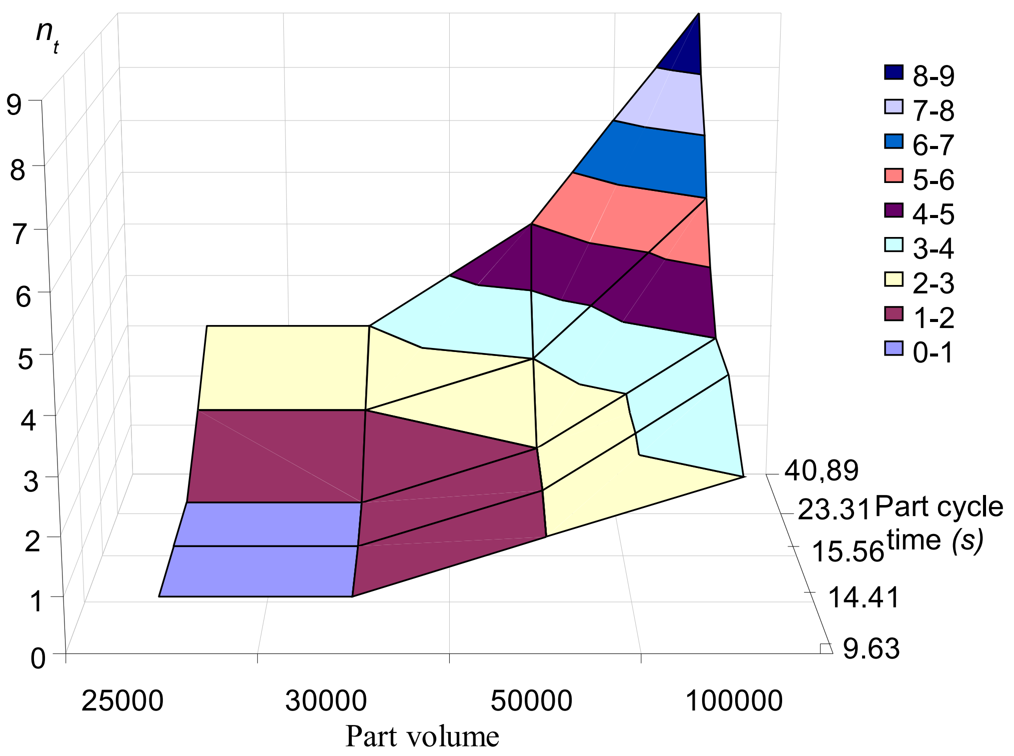


Fig. 7 Cavity number n_t definition according to the delivery time

Before evaluation of results it is necessary to consider: if quantity of cavity number according to product delivery time n_t is less than qualitative quantity of cavity number n_q, it is necessary to increase the manufacturing time or to change the moulding plate. Attained results are presented in Fig. 8.

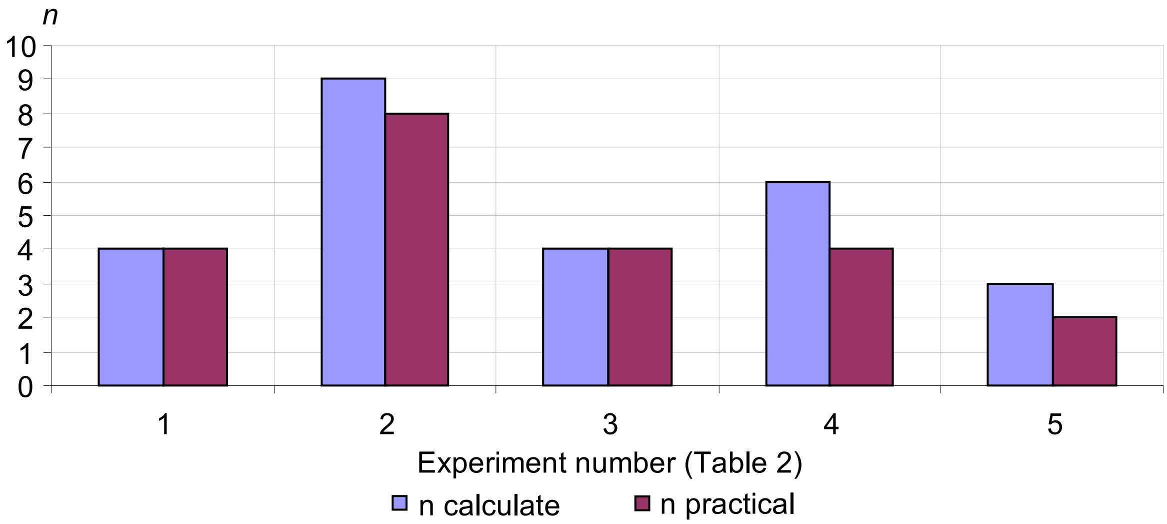


Fig. 8 Practical and theoretical comparison of cavity number quantity

Table 3 Practical and theoretical comparison of moulding machine

Experiment number	Calculate	Practical
1	Allrounder 420s 1000 – 150 Batenfeld HM 1600/350 Demag KD100	DemagKD100 Demag D55
2	Allrounder 420s 1000 – 150 Batenfeld HM 1600/350 Battenfeld HM 600/130 Demag KD100	Demag KD100
3	Allrounder 420s 1000 – 150 Batenfeld HM 1600/350 Demag KD100	Demag KD100
4	Batenfeld HM 1600/350	Batenfeld HM 1600/350
5	Allrounder 420s 1000 – 150	Demag KD100 Demag D55

Discrepancy of results in 2, 4 and 5 cases are due to difference of theoretical and practical cavity number cycle time. The investigated enterprise has a low automation level of operations; therefore some operations are performed manually.

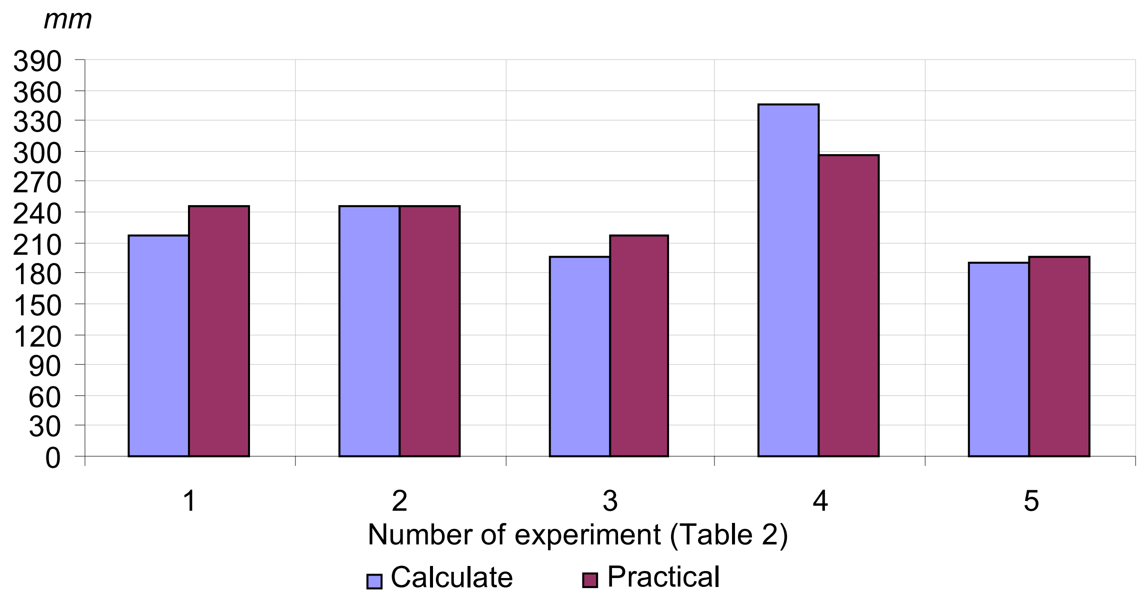


Fig. 9 Practical and theoretical comparison of mould plate length

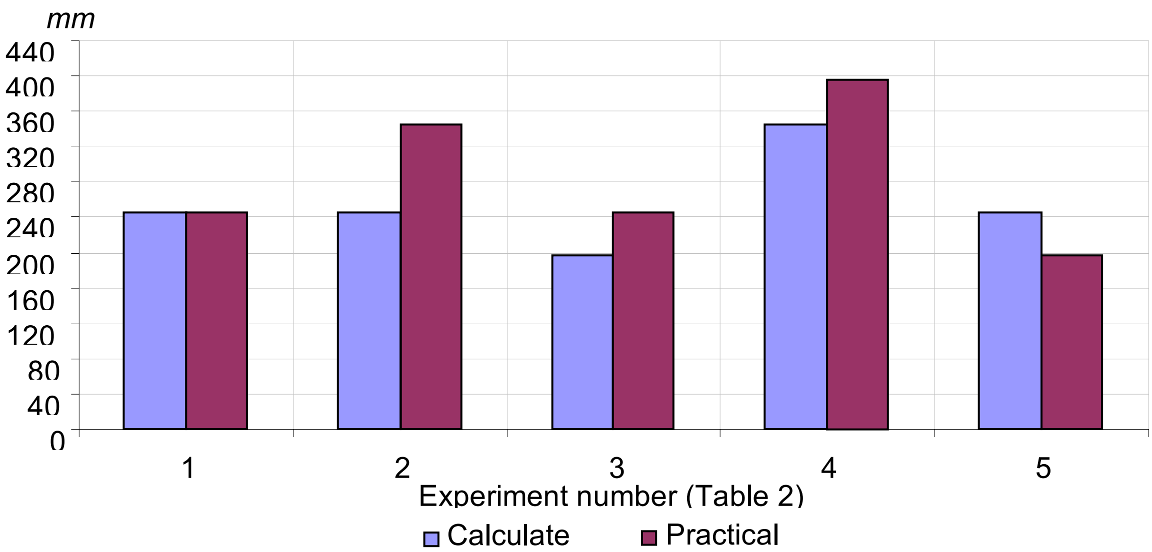


Fig. 10 Practical and theoretical comparison of mould plate width

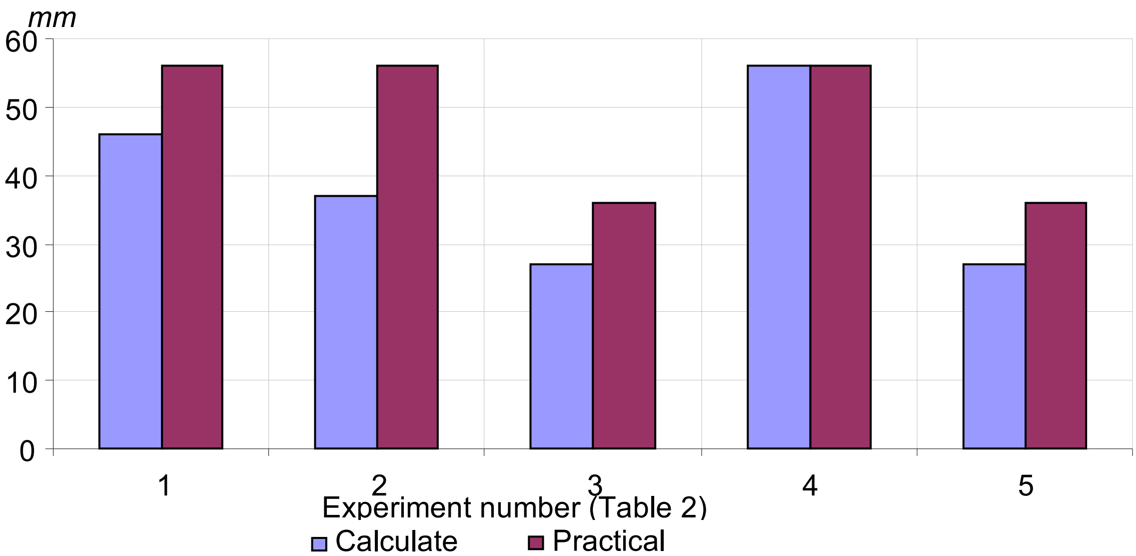


Fig. 11 Practical and theoretical comparison of mould plate thickness

Discrepancy of theoretical and practical results appears due to different distance between cavities (Fig. 12, 13). Engineers often select bigger assurance coefficient of a mould design. Developed model selects mould plate dimensions according to the mould plate cost. Parts filling and complexity of manufacturing is unheeded.

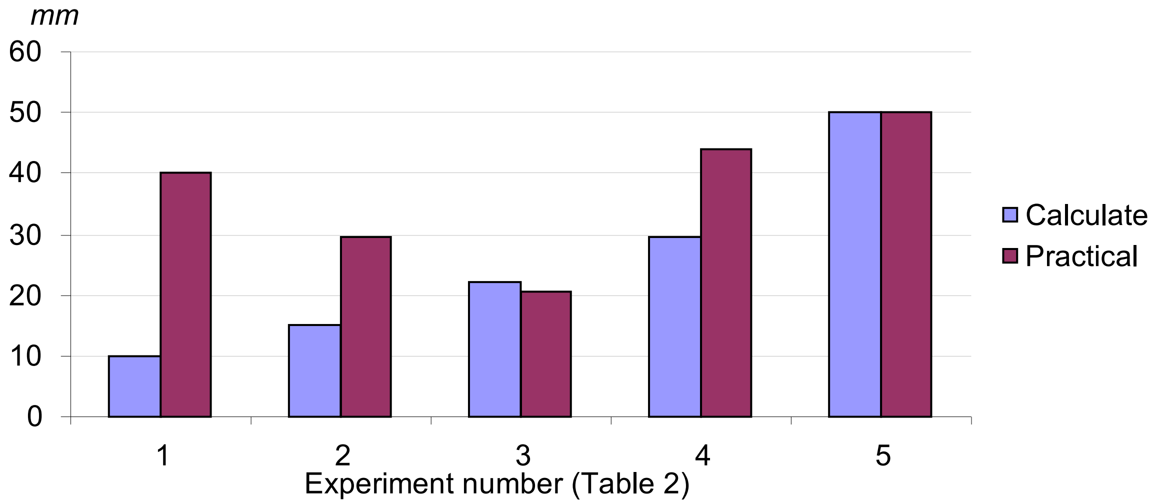


Fig. 12 Practical and theoretical comparison of distance among cavities by axes x

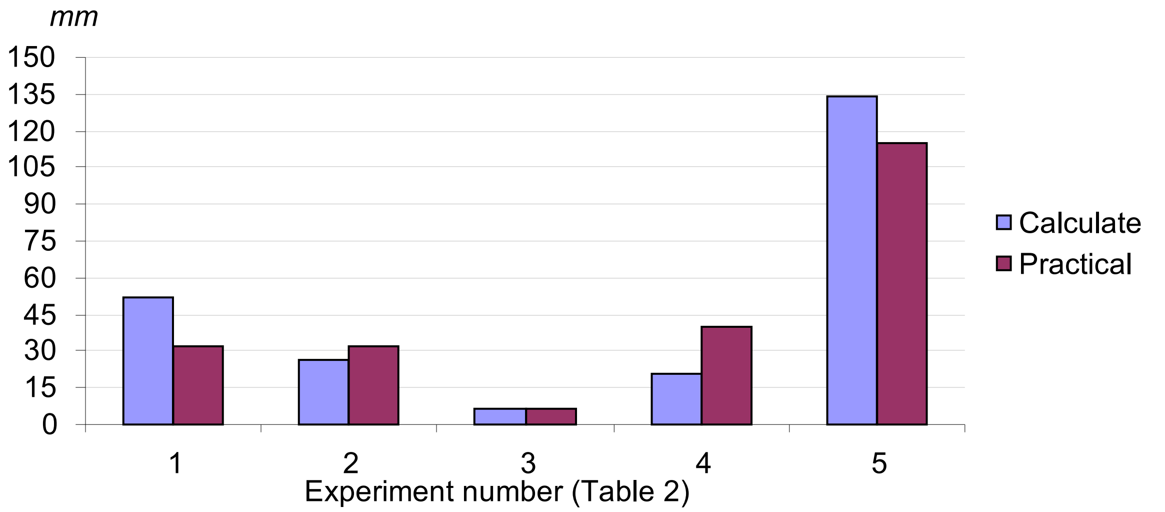


Fig. 13 Practical and theoretical comparison of distance among cavities by axes y

5. Conclusion

Developed an intelligent approach of precision products design applying knowledge base and Fuzzy logic for avoid mistakes at the product conception stage can be used. It also economize the product development time and cost. Created methodology is able to optimize the product design and is useful in Hybrid Manufacturing Systems (HMS).

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