XVI IMEKO World Congress
Measurement - Supports Science - Improves Technology - Protects Environment ... and Provides Employment - Now and in the Future
Vienna, AUSTRIA, 2000, September 25-28

SELECTING FLOWMETER WITH A HELP OF AN EXPERT SYSTEM

J. Vindisar and I. Bajsic
Laboratory of Measurements in Process Engineering
Faculty of Mechanical Engineering, University of Ljubljana
SLO - 1000 Ljubljana, Slovenia

Abstract: Fluid flow measurements are probably the most important of all existing measurements in process engineering. Selection of an optimal flowmeter is a difficult task. According to the quantity of knowledge available, a computer program for selection of an optimal flowmeter seems to offer a solution for this problem. For a detailed flowmeter selection procedure, around fifty variables were identified as the most important factors in selection. They were then grouped into five general areas: performance, fluid property, installation, environment and economy. A database for fourteen different types of flowmeters was setup in the way that, together with an algorithm for the main program, it represents a base for developing the knowledge-base and expert system for selection of an optimal flowmeter.
Keywords: flowmeter, flowmeter selection, expert system

1 INTRODUCTION

There are some hundred different types of flowmeters by more than two hundred manufacturers available on the market. This wide choice of flowmeters is one of the factors that makes the selection process of an appropriate flowmeter quite a difficult one. Consequences of an inadequate selection can result in poor quality of measurements, loss of time and money and increased possibility of equipment and installation damage.

Engineers have well contemplated the idea of constructing a universal meter that would be cheap and applicable for all kinds of fluids, with a high level of accuracy (less than 0,25%), wide rangeability (from 0 to ∞) and minimum pressure drops. Though such a meter would require no recalibration or maintenance and its installation would be easy and wouldn't interrupt operation of an application system or its part, it would be quite impractical and many times absolutely inefficient.

There is no doubt now that the very wide spectrum of different fluids and different operating conditions demand installation of an "individual" flowmeter. The task that is thus imposed on engineers is highly demanding; on one side they shall have to cope with a number of constraints of manufacturers and on the other with application requirements of individual users. The process of selection of flowmeters requires an understanding of both the system requirements and the performance of the flowmeters.

A tool is therefore needed that would support engineers in their endeavor to find an optimal solution on the basis of available data and information and with respect to constraints and requirements. The solution that is being offered are expert systems. Until an adequate expert system is made available, flowmeter selection will be an iterative procedure between the user and the manufacturer. Building an expert system is a critical process in which a knowledge engineer transfers the knowledge of an expert to a computer program; this process can be fully or partially automated.

2 FLOWMETERS

There are many classifications of flowmeters according to their operating principles. The most widely used is the classification into twelve major groups as foreseen by the BS 7405 standard [1].

A general classification classifies the meters in two groups: meters for measurements in closed conduits and meters for measurements in open channels. Similarly, with regard to their operating principle, we can group them into energy extractive and energy additive meters. The above classification is presented in Table 1.

In the last twenty years, the trend on the flowmeter market has indicated a decrease in the demand of conventional differential pressure meters from 65% to 40%. Their part has in particularly been taken by electromagnetic meters, ultrasonic, turbine and variable area flowmeters. This shows that the importance of selecting an appropriate flowmeter for a given application has been widely recognized.

Table 1. Flowmeter classification.

GROUP	DESCRIPTION	CATEGORY
1	Conventional DP meters	energy extractive
2	Other DP meters	energy extractive
3	Displacement meters	energy extractive
4	Turbine meters	energy extractive
5	Fluid oscillatory meters	energy extractive
6	Electromagnetic meters	energy additive
7	Ultrasonic meters	energy additive
8	Direct and indirect mass meters	energy extractive/ additive
9	Thermal meters	energy additive
10	Other meters	energy extractive/ additive
11	Solids meters	energy extractive
12	Open channel meters	energy extractive

3 FLOWMETER SELECTION

Selection of an adequate flowmeter is a very complex process. Flowmeters vary widely, not only in type but also in performance and cost. A well-developed selection procedure is a prerequisite to reduce the number of suitable meters in a general sense. After the determination of the application's fluid performances, meters should be considered with regard to five basic general areas: performance, fluid property, installation, environment, safety, and economy. Selection of the flowmeter is therefore a well-bounded problem. The knowledge of flowmeters and how to choose them properly is available in books, handbooks, technical publications, manufacturer data books, and in minds of human experts.

The selection process is based on the elimination method. As soon as it is recognized that a meter does not meet the requirements and conditions of one of the five areas, it is rejected. Hereby, it is important to define the level of importance for each parameter and bear in mind that the optimal flowmeter is the one that does its job satisfactorily at the lowest possible costs. In future, we shall test the importance and impact of certain parameters (attributes) on the final decision about the flowmeter group (class) by automatically building a decision tree. An algorithm for such selection is presented in Figure 1.

After the reduction of the number of flowmeters with regard to the method to be employed (1, 2), the list of acceptable flowmeters is further cut down by considering general working conditions of the searched for flowmeter and application characteristics (3, 4, 5, 6). The final selection is made upon an assessment of the flowmeter price (total costs) and performances (7).

4 KNOWLEDGE BASE FOR AN EXPERT SYSTEM FOR SELECTION OF AN OPTIMAL FLOWMETER

An expert system is a group of computer programs (software) that is intended to solve problems of a particular professional domain [6]]. Organization of knowledge in expert systems (Figure 2) is based on dividing it on knowledge about the domain itself (knowledge base) and knowledge about the general problem solving and communication between the system and the user (inference engine). The last one includes an inference mechanism (IM) which decides on how to use rules for achieving new knowledge and schedule for determining the sequence of rules. The inference mechanism is an algorithmical part of decision making. As it is separated from other parts of an expert system, we can use the same inference mechanism for various knowledge bases.

The task of the systems is to provide in the shortest possible time results of the same quality as those by human experts experienced in the same field.

Expert systems also include knowledge about themselves (self - knowledge) so as to give their users explanations about why certain actions were taken and why additional information is needed. The aim is to increase the system confidence and to simplify and accelerate error detection thus assuring faster development of a system.

Above are the facts that shall well be taken into account when the knowledge base and inference mechanism for an expert system for the selection of an optimal flowmeter are created. This is an aspect which makes this system different from the existing expert systems developed by manufacturers of the flow measuring equipment themselves. When using these systems the user has to decide for a certain manufacturer at the very beginning of the selection process. As the number of

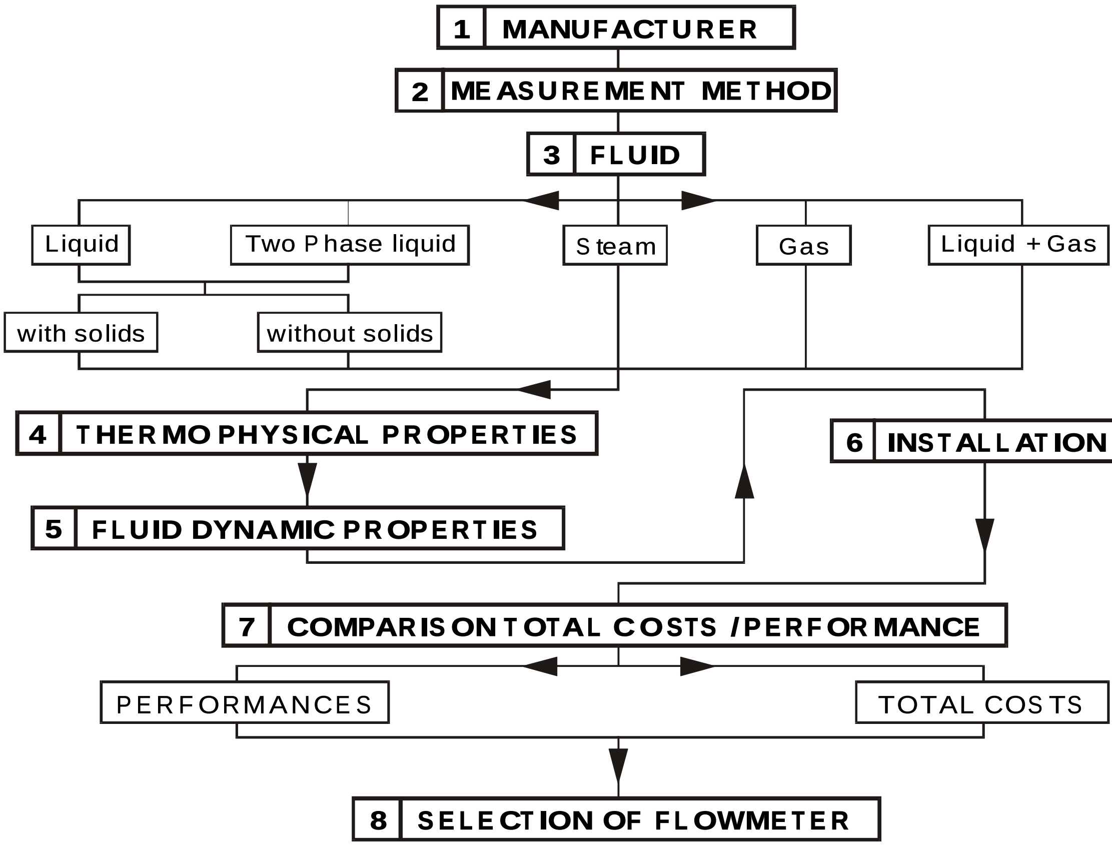

Figure 1. Algorithm for selecting the optimal flowmeter [4].

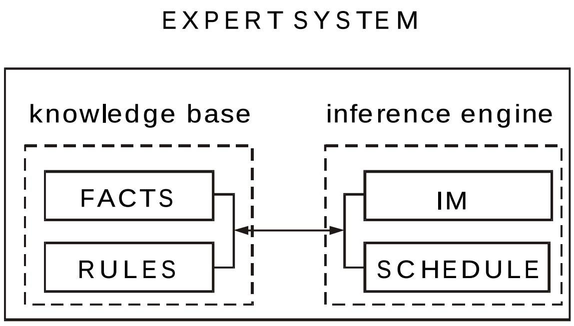

Figure 2. Organization of knowledge in an expert system.

used parameters is limited, the greatest disadvantage of these systems is absence of a particular component which would help the user to follow and understand the selection algorithm itself.

Creating the knowledge base is the vital part of the expert system developing process. The knowledge base is made of the flowmeter database, application database (user defined) and all calculations needed. The data quality depends on understanding theoretical principles of measurement methods and operating principles of different kinds of flowmeters. Processing of these data and defining the relevant rules must follow the fundamental principles of the flowmeter selection.

The basic characteristics of a good expert system are a high professional level and a most simple use and understanding of its actions.

Our database includes data about fourteen different flowmeters [5]. We selected them so as to cover all the existing measurement techniques and to indirectly satisfy the greatest number of possible applications. Data were collected from different sources [1, 2, 3]. As we did not use real flowmeters – our aim was to represent only their flowmeter group – we used their average values for parameters.
Our database provides data about these flowmeters:

1. Sharp edged orifice
2. Venturi tube
3. Flow nozzle
4. Variable area flowmeter - rotameter
5. Target meter
6. Averaging Pitot tube
7. Rotating vanes meter
8. Turbine meter
9. Vortex shedding meter
10. Electromagnetic meter
11. Doppler meter
12. Time-of-flight meter
13. Coriolis meter
14. Thermal meter (heat loss)

The inference mechanism (set of rules) is designed so that the system lists the selected meters according to the application demands and user requirements and desires. In the selection process it is possible to follow the algorithm procedure.

5 CONCLUSION

This paper presents a concept of a database with the purpose of creating an expert system for the selection of an optimal flowmeter. Our target was to spread the knowledge about selecting an appropriate meter for a particular application and to simplify this generally complex and time-consuming procedure. Participants (engineers involved with process industry) in Workshops on Fundamentals of Flow Measurements, organized by the Laboratory of Measurements in Process Engineering of the Faculty of Mechanical Engineering in Ljubljana, showed great interest in having and using a proposed expert system.

In future, the developed database will be updated. This will mostly be achieved by introducing the confidentiality factor (CF) that would in particular be related to data and set of rules. This will assure probability that a certain flowmeter is optimal for the requirements of a particular application.

In the next phase, the developed expert system shells will be estimated and the most suitable one selected with regard to the requirements of the task envisaged. The knowledge base will then be updated and a demonstration prototype designed. When such a prototype satisfies all our demands and expectations, the development of an expert system will be proceeded with a scientific prototype.

REFERENCES

[1] BS 7405: *Guide to selection and application of flowmeters for the measurement of fluid flow in closed conduits,* 1991.
[2] B.M. Muhammad Azam: *Use of an expert system for selection of flowmeters*, M.Sc. Thesis, Mississippi State University, 1994.
[3] D.W. Spitzer (Editor): *Flow Measurement: Practical Guides for Measurement and Control,* Instrument Society of America, 1991, p. 539-573.
[4] J. Vindišar, I. Bajsiæ, Development of an expert system for selection of an optimal flowmeter (in Slovene), in: B. Zajc (ed.) *Proceedings of the Sixth Electrotechnical and Computer Science Conference ERK¢97*, Vol. A (Portorož , 25-27. September 1997), Slovenian Section IEEE, Ljubljana, Slovenia, 1997, p. 471-474.
[5] J. Vindišar, I. Bajsiæ, L. Zadnik-Stirn: Selecting an optimal flowmeter with a help of an expert system, in: V. Rupnik, L. Stirn (ed), *Proceedings of the 5th International Symposium on Operational Research SOR¢99* (Preddvor, 30. September - 2. October 1999), Slovenian Society Informatika, Ljubljana, Slovenia, 1999, p. 147-152.
[6] Donald A. Waterman, *A Guide to Expert Systems*, Addison-Wesley Publishing Company, 1995.

AUTHORS: Dipl.-Ing. Jure VINDIŠAR and Ass. Prof. Dr. Ivan BAJSIÆ, Laboratory of Measurements in Process Engineering, Faculty of Mechanical Engineering, University of Ljubljana, Aškerèeva 6
SLO-1000 Ljubljana, Slovenia, Phone +386 61 1771131, Fax +386 61 218 567
E-mail: ivan.bajsic@fs.uni-lj.si