MICROPROCESSORS IN PROCESS CONTROL

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Preface

The microprocessor has revolutionised many fields of industrial and business activity over the last decade, and industrial measurement and control is no exception. Equipment systems now available are very much more reliable and have almost 100% availability. They also offer scope for implementing many control strategies which, though they have been theoretically possible for many years, it has not been practicable to implement until now. The reasons for this are firstly digital computing power which became available in the 1960s when DDC systems were introduced, and secondly distributed processing which is the product of microprocessor technology.

The skills required by instrumentation and control engineers in the process industries are more diverse than in many other disciplines. To this must now be added considerable knowledge of electronics and communication technology, if they are to be able to understand and take advantage of these systems. The process engineer is responsible for the structure of the *control* systems as opposed to the *equipment* systems; he must understand much more about the equipment than was necessary with analogue systems, if their advantages are to be fully exploited. This book is written in the hope that it will provide an introduction to the subject matter for these two groups of engineer at a level which is both acceptable to them and also adequate for them to comprehend the technologies involved. It is not written for those who aspire to design the equipment systems themselves, though it may serve as introductory reading even for this group. There are many excellent books on each of the technologies which contribute to these systems, written by engineers who have much deeper knowledge of a specific technology than the author of this book.

The first part of the book describes the technology of measuring, in an industrial context, the most common and therefore most important variables: pressure, level, flow and temperature. Part 2 of the book endeavours to provide a minimal basis in the established techniques by which process plant is regulated and controlled. These have not yet changed greatly as a result of the much greater equipment flexibility; in the immediate future they will certainly begin to do so. The pace of change of such technologies is, however, by its nature, much slower than that of the electronics technologies which have revolutionised the equipment systems. The third part of this book sets out to describe how these microprocessor-based equipment systems function and how they are constructed from the standard components available in 'chip' form. The later chapters of Part 3 introduce the reader to the problems of transfer of data within these systems and describe how security of operation is built into these systems to provide the reliability and availability necessary. Finally Part 4 reviews the way that measurement and control strategies can be (yet sometimes are not) implemented using these equipment systems.

JOHN BORER

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Contents

Part 2

CHAPTER 1

Principles of Industrial Measurement

1.1 GENERAL

In order to operate chemical plant processes, e.g. chemical reactions, petroleum distillation, etc., it is essential to know the values of physical states of the process fluids, such as pressure, temperature and density, as well as rates of flow and often analytical data. Industrial instruments have been developed to measure all these parameters and in turn the instruments themselves depend on physical laws. Before we can use any tool (and instruments are tools for measuring) we need to know its capability. It is necessary to define limits of performance for any measuring instrument or system, and before we can do this the terminology used needs to be defined.

1.2 INSTRUMENT PERFORMANCE

It is important to determine with what precision measurements can be made using the instrument or system, but this will depend on many factors. Because of slack in linkages, friction and many other imperfections, repeated measurements made with the same system will only give the same result within a certain *error band*. This limitation on performance of a measuring system is referred to as *repeatability*. No matter how repeatable the results there will be a limit on the *resolution* with which they can be indicated or recorded. The measuring system will have a range or *span* over which it can work, and ideally a graph of the relationship of measured variable to instrument indication (or recording) will be a straight line (Fig. 1.1). In fact this will never be the case, and *accuracy* will be defined as the limit of confidence which can

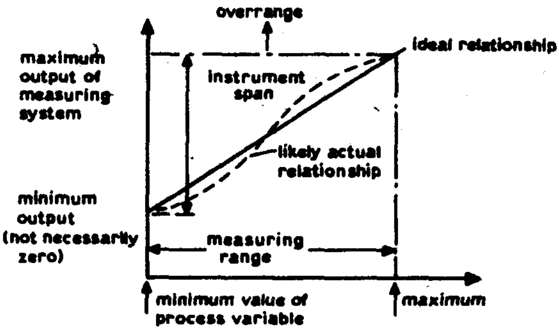

Fig. 1.1.

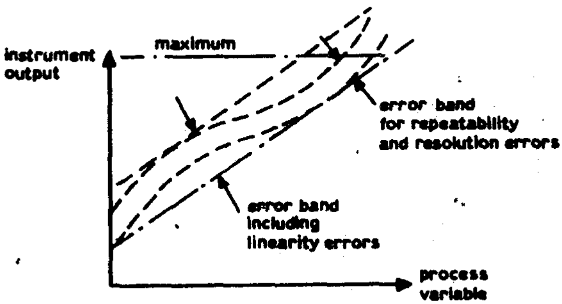

Fig. 1.2.

be placed in a measurement, taking all the factors into account (Fig. 1.2).

1.3 RANGEABILITY

Any industrial measurement system should give information of sufficient accuracy to facilitate control of the process operations over a *range* of operating conditions. It is often forgotten, however, that many of the causes of error are related to the maximum of the measuring range. Manufacturers usually quote errors in terms of FSD (full scale deflection). If a process variable is to be measured it is implied that it varies in the course of normal process operation; to allow for such variation the range of the measurement system will normally be selected so that the normal operating value of the variable represents about 70%

of FSD. Thus, if typically, a range of process variable of 3 to 1 is to be measured and the system accuracy is ±1% FSD, then the errors to be expected at the lower end of the range will be

$$\left(1 \times \frac{1}{0{\cdot}70} \times \frac{1}{3}\right) = \pm 5\%$$

1.4 ASSESSMENT OF ERRORS

It is easier to say how the performance of a measurement system is determined, than to determine it in practice. Whilst the instrument technician at a refinery or chemical plant will rarely, if ever, be asked to carry out such an evaluation experimentally, it is, nevertheless, essential that he should understand how this is done. Sometimes the errors caused in the different ways outlined above will cancel one another out; sometimes they will add up and so reinforce each other. Thus the actual error which occurs in any particular measurement is *randomly* determined; only the *probability* that the error will be greater or less than a certain size can be determined. The efore the accuracy of a measurement system is always quoted in statistical terms, that is the size of error which has, say, a 9[illegible]% probability of occurring; it cannot be quoted in any other way.

To establish this statistical data, experiments must be made repeatedly with the measuring system under test, so that the error is found on a sufficient number of occasions to allow the data to be reliably grouped; the probability of the occurrence of errors of different sizes can then be evaluated. This is obviously a very time-consuming method.

1.5 CALIBRATION

Industrial measuring devices and systems must be robust and easily maintainable, and to some extent accuracy is sacrificed to these ends. Any experiment to assess the error of measurement requires that there exists some other means of establishing the true value of the process variable being measured. Since such experiments are carried out under laboratory conditions, a more accurate instrument is often available so that the measurements can be made simultaneously on this and the industrial instrument under test. Such high accuracy instruments are