

Guide to the use of ESDU Data Items on cam design

Endorsed by
The Institution of Mechanical Engineers

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We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Mechanisms Committee, which has the following membership:

Chairman

Dr M.R. Smith — University of Newcastle upon Tyne

Members

Mr P.J. Carden — Ricardo Consulting Engineers, Shoreham-by-Sea

Mr T.H. Davies — University of Technology, Loughborough

Dr G. Druce — University of Surrey

Mr A.A. Fogarasy — Independent

Prof. F. Freudenstein* — Columbia University, NY, USA

Dr M.J. Gilmartin — Liverpool John Moores University

Dr A. Samuel* — University of Melbourne, Victoria, Australia

Prof. D.J. Sanger — University of Salford

Dr C.W. Stammers — University of Bath

Mr M. Webb — Quin Systems Ltd, Wokingham.

* Corresponding Member

The technical work involved in the assessment of the available information and the initial construction of the Data Item was undertaken by

Mr P.J. Carden — Ricardo Consulting Engineers

Subsequent development of the Data Item was undertaken by Mr C.J. Loughton, Head of the Mechanical Motion and System Dynamics Group, who has overall responsibility for the work in this subject area.

The Mechanisms Committee, which first met in 1975, is continuing the work that previously was the responsibility of the former Gearing and Mechanisms Committee, which first met in November 1964. Like the earlier Committee it has the cooperation of many engineers and scientists in industry, research establishments and universities from whom much assistance and information is being received.

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1. INTRODUCTION

A cam is a mechanical member that, by direct contact, transmits a desired motion to another mechanical member, known as a follower, by virtue of its profile shape. Cams are used in a wide range of machinery to generate and control non-uniform motion and so the design of cams is a common activity undertaken repeatedly by engineers in many different industries. In the most common arrangement the cam rotates and the follower moves backwards and forwards in a straight line (translating motion) or in an arc (swinging motion).

ESDU publishes a range of Data Items that are useful during the design of cam mechanisms and the purpose of this Guide is to help users of those Data Items to employ them to their best advantage.

An outline of the typical phases of cam design is given in Section 2 and the relevant Data Items that may be useful at each stage are identified. A list of typical causes of failure of cam and follower systems is given in Section 3.

2. A BRIEF OUTLINE OF CAM DESIGN

2.1 The Sequence of Design

The design of cams is undertaken by a diverse group of people with widely varying skills and experience. Some typical cam design situations are:

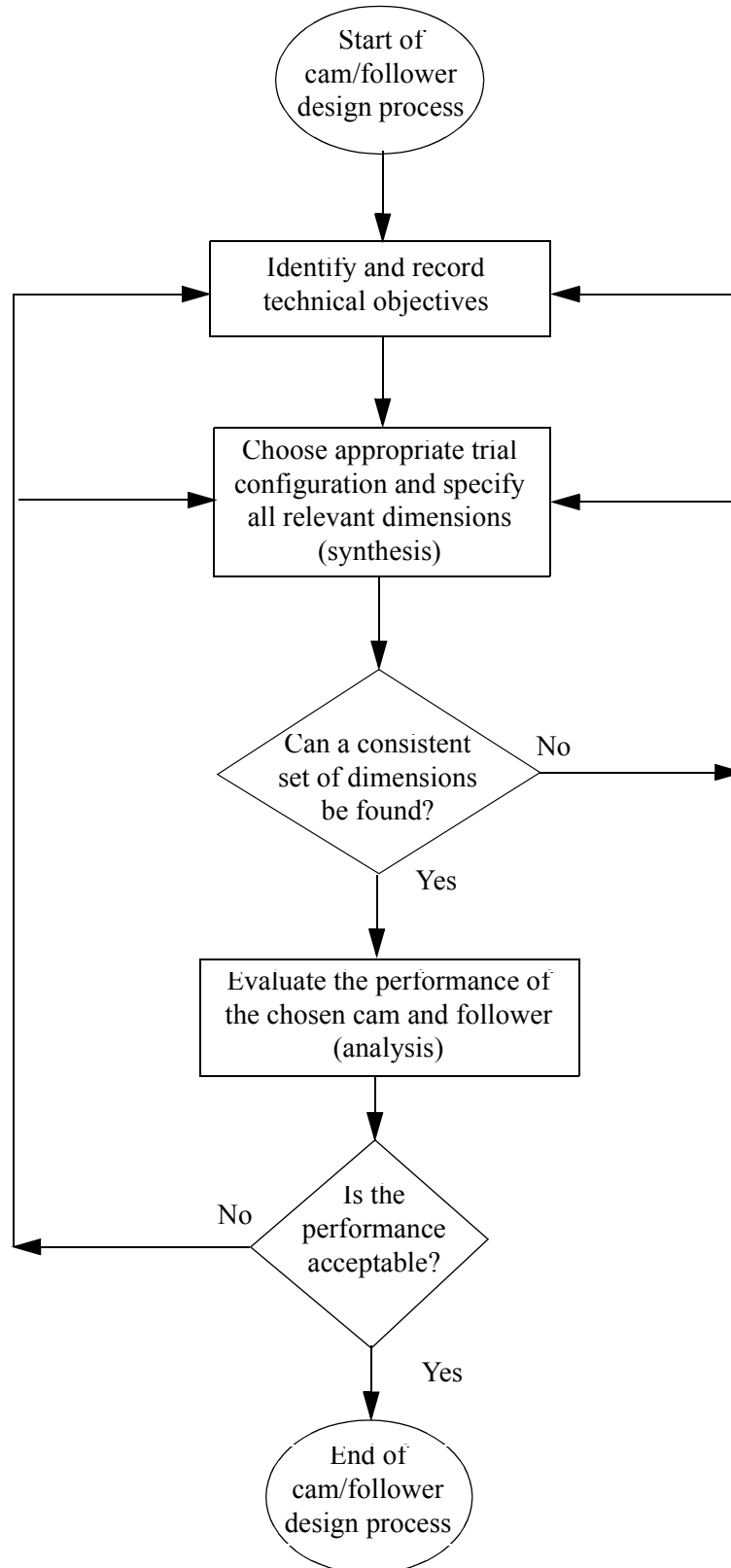
- (a) the design of a novel mechanism to generate and control the motion of a particular component (such as a valve) in a machine,
 - (b) the design of a new cam to fit in an existing machine to improve machine performance or to alter the output motion,
 - (c) the modification of an existing cam/follower system to tailor its performance for a novel application
- or
- (d) the modification of an existing cam/follower system to avoid particular recurring failures in service.

In each of these situations a different set of constraints applies. For instance, during the design of a new mechanism a number of different cam/follower types may be feasible whereas during the modification of an existing design it may only be possible to alter one or two dimensions.

In each design situation the recommended method for finding a satisfactory solution is to follow through four distinct design activities. These can be summarised as:

- (i) state the technical objectives,
 - (ii) specify relevant component dimensions and materials types (synthesis),
 - (iii) determine the performance of the specified mechanism (analysis)
- and
- (iv) decide whether the performance is acceptable.

These four activities are further described in the following sections and the design process is illustrated in Sketch 2.1. Note the numerous return paths on the schematic which indicate the iterative nature of successful cam design.



Sketch 2.1 Schematic of cam/follower design process

2.2 Technical Objectives

2.2.1 General advice

In general, during the specification of the technical objectives of a design activity, it is important not to presuppose the use of a particular mechanism type. In this particular case an initial selection procedure presupposes the use of a cam/follower system. Where possible, the technical objectives should be recorded in quantitative terms as part of the machine design specification and careful consideration should be given to the allowable tolerance on each value. It may be necessary to revise the technical objectives in the light of information obtained during the design process (see Sketch 2.1).

2.2.2 Motion

During the design of almost every cam system, the most important objective is to ensure that the follower moves in a prescribed manner. The first task, therefore, is to define those aspects of the follower motion that are vital to the correct functioning of the device. These requirements are most conveniently recorded on a

timing diagram (Data Item 01003^[25])[†],

especially if the motion of the follower must be synchronised with other motions in the machine. Usually the correct functioning of the machine involves precise positioning of the follower at certain points during the cycle (especially during the dwell periods but sometimes at intermediate points during motion periods). It may be necessary to match the velocity of the follower to that of some other moving component in the machine. Since inertia force is proportional to acceleration it is often important to minimise the peak value of this quantity, especially if the system is to operate at high speed.

2.2.3 Secondary objectives

In many cases control of the follower motion is not the only objective of the cam design. It may be necessary for the mechanism to fit in a predetermined space and it may be very important that the mechanism performs adequately for a specified minimum lifetime without significant wear. If the externally applied load is high this may influence the design considerably and if this load is known (or can be estimated, even roughly) it should be recorded on a *load diagram* or as part of the *timing diagram* as a function of time (or cam angle).

It is not possible to give an exhaustive list of possible technical objectives as many will be particular to the application. However the design and development process can be significantly shortened if the majority of relevant failure modes are identified at the outset (see Section 3).

ESDU Data Items contain many examples in which typical technical objectives are stated. In particular two full

worked examples (Data Item 85013^[10]),

of complete cam designs are provided in which the primary objectives are reported at the outset.

2.3 Synthesis

When the technical objectives have been identified, the next step is to specify fully a trial mechanism that meets the requirements. Broadly speaking, this is known as synthesis.

[†] Superscripted numbers within square brackets indicate the reference numbers used within Section 4.