over an extended period of time. Therefore, we chose a single-case approach with two investigations in industry.

The first investigation took place in a company producing agricultural machinery. Over the course of four weeks, the design process of a group of four designers redesigning a fruit press was observed and documented (see Figure 5.2). The second investigation was conducted in a company of the capital goods industry. In this company we observed three projects of a design team developing and redesigning several components of a particleboard production plant (see Figure 5.3) for eight weeks.

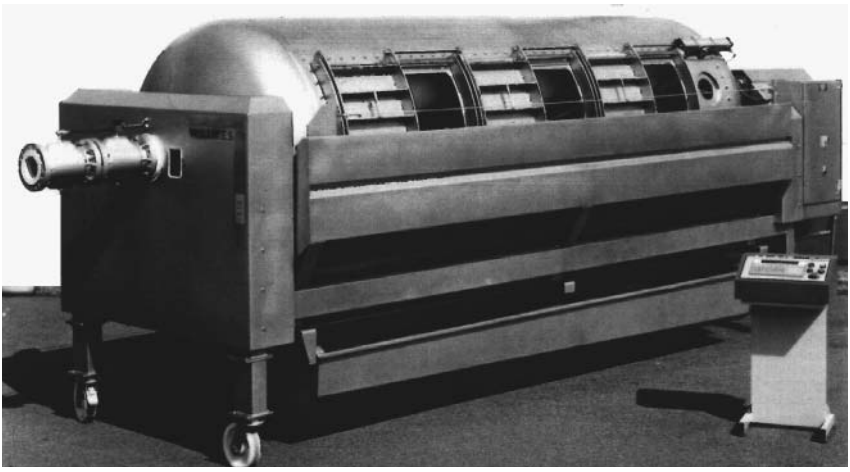

Figure 5.2 Pneumatic fruit press.

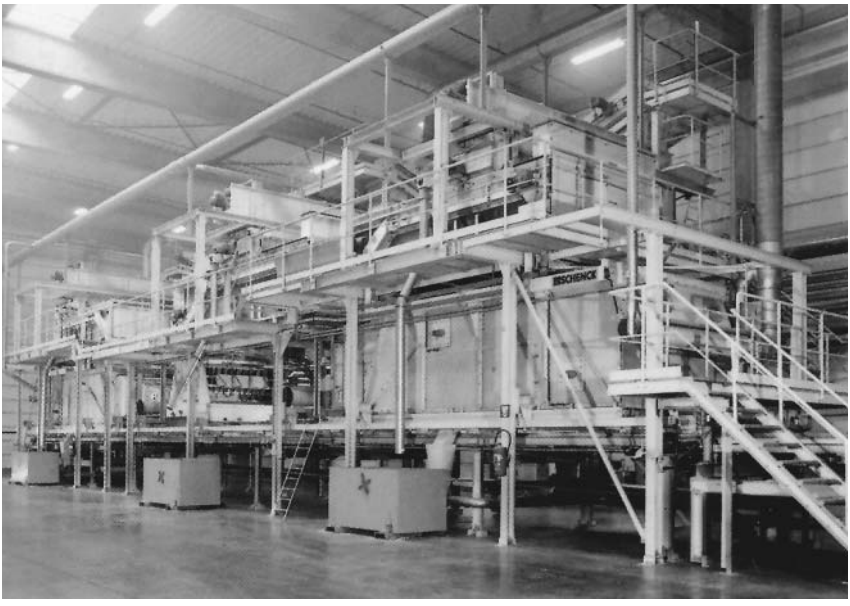

Figure 5.3 Particleboard production plant.

The large number of influencing factors requires the use of a variety of investigation methods. The following sections describe the methods used to compile information on the "external conditions," the "design process," the "individual prerequisites," and the "prerequisites of the group." For the analysis of design representations, the data concerning the designers' activities are of specific interest. The compilation of factors from the individual and the group will be important in a second step for additional analysis of the underlying mechanisms (see Figure 5.14).

External conditions and the design process

Several different aspects regarding conditions were recorded, such as branch, the economic situation of the company, its culture and organization, the flow of information and communication within the organization, and, last but not least, the direct working environment.

To compile the dynamic course of the design process, a detailed analysis of the design work at short time intervals is required. The duration of intervals was determined by the characteristics (categories) of the communication in order to describe the process. To this end a standardized approach for investigating cooperative design in industry was developed by combining direct and indirect methods.

The primary direct method was continuous non-participant observation, involving two observers – a mechanical engineer and a psychologist – sitting in the same room as the designers. The mechanical engineer observed the activities of the designers in terms of, for example, working-steps in accordance with those used in the systematic design approaches seen in Pahl and Beitz (1997), and the development of technical solutions in terms of subfunctions/components, ideas and solution variants. The psychologist focused on cognitive and social aspects such as decision-making and group interactions. A standardized laptop-based "online" protocol was used to document the observations in real time. This protocol provided a first description of the design work as a problem-solving process. Video recordings of all teamwork and the relevant phases of individual design work were used to review and obtain a detailed account of specific interesting phases of the individual and the group design process (cf. Frankenberger and Auer 1996).

The final protocol of the observed design process consisted of a word-by-word transcription of important dialogues (see Table 5.4) and a description of the entire process with an average duration of 30 seconds per protocol line. These protocols formed the material for a qualitative and quantitative analysis of the process, using special software that allows easy analysis by presenting graphic representations of each process characteristic against time. These graphs represent the development of the solution by showing the moves between the sub-problems and solution variants.

In addition to these direct methods, indirect methods, such as diary sheets, were used. Diary sheets were used as a basis for short semi-structured interviews each evening in which the designers were asked about their successes and failures of the day, how they solved problems, and when and why they contacted their colleagues. The diary sheets were designed to be filled out by the designers with minimum effort, in order to avoid loss of motivation.