Preface

In the engineering community the handling of powders and bulk solids is called bulk solids technology being, at least in Germany, part of mechanical process engineering. Process engineering involves study of the change and transformation of material properties. If mechanical processes are used for this transformation, the engineering discipline is called mechanical process engineering. The best known unit operations of mechanical process engineering are grinding, agglomeration, mixing, and separation. Due to the mechanical treatment, the particles – either single particles or a collection of particles – increase in value. To profit from this value increase industry and academia perform research and development. When handling bulk solids, e.g. storing, dosing and conveying, no value increase can be achieved, because the material properties are not changed. What can be achieved is "at most" the elimination of problems which is less interesting research and development compared to the development of new products or processes with the chance to obtain a patent.

A silo for the intermediate storage of bulk solids often seems to be only a single, unimportant element for the realization of a larger process. Bulk solid is filled into the silo continuously or discontinuously and discharged later at predetermined points of time in desired quantities. That is not always unproblematic. The known problems of arching and ratholing can lead to irregular discharge or complete blockage. The hammer often found close to a silo is a known auxiliary means which often is subsequently resorted to due to incorrect silo design. Nearly forty years ago the author of this preface wrote a monograph on bulk solids storage, called this discipline as belonging to the "stepchildren" of technology, and summarised that it often happens that a problem is accepted as given due to its frequent appearance. Has that changed much up to today?

Today the characterization and handling of bulk solids is taught at many (in Germany, nearly all) universities and technical schools in faculties of mechanical and chemical engineering. For more than twenty years seminars and short courses have been offered which cover the basics and application potential of modern bulk solids technology. The most important theoretical fundamentals are known, from which reliable silo design is possible. The necessary information is available, but it is often not consid-

ered or understood. Avoidable failures, unnecessary overtime and production shortages or stoppages have to occur before those who have lived with the mentioned problems become willing to adopt the available design method in which the silo geometry is fitted to measurable bulk solid properties.

When designing silos for flow a procedure has to be followed that is similar to the one used when designing a heat exchanger. The material properties of the concerned fluids have to be known to design the heat exchanger. This procedure is state-of-the-art. The necessary data can be found in equivalent text books (e.g., "Heat Exchanger Design Handbook", "VDI-Wärmeatlas") or have to be measured following standardized test methods. The procedure to design a silo is similar. Unfortunately there are no equivalent text books (no "Silo Design Handbook" containing material parameters). So the experimental determination of relevant bulk solid properties is much more important. If these properties are known the silo geometry can be fitted to the measured values and trouble-free operation can be achieved. A prerequisite is that the bulk solid properties measured with laboratory equipment are representative. But this prerequisite also holds regarding a heat exchanger. If, for example, "fouling" takes place on the heat exchanger surfaces the material parameters have changed, and the heat exchanger can no longer fulfil the demanded requirements. In a similar way a silo might not provide trouble-free operation when bulk solids with different properties are stored.

A text book ("Silo Design Handbook") containing reliable quantitative data concerning silo design for flow will never exist. A fluid for which the composition is known always has identical material properties. This only very seldom holds for bulk solids. Besides chemical composition, which is sufficient for characterizing a fluid, further parameters based on the disperse nature of bulk solids have an influence on their properties. Of influence are particle size, particle size distribution, particle shape, porosity, humidity and many more. If one would determine the influence of all these parameters on the relevant properties for silo design, many experiments would be necessary. Thus it is more practical to measure relevant bulk solid properties directly on representative samples. To obtain these properties shear testers are used. But only when those shear tests are performed correctly can data be obtained which enable reliable silo design for flow. Experience indicates that the prerequisite of correct performance of a shear test is often not realized, due to which it is often concluded – usually too quickly – that shear tests only have limited usefulness.

Today I would not judge bulk solid storage anymore as belonging to the "stepchildren" of technology. The most important theoretical fundamentals are known, and there are sufficiently many examples available which

prove that silos fulfil the demanded requirements when they have been designed according to the present state-of-the-art on the basis of properties measured in shear testers. What still can be called shabby and therefore could be improved is the broad application, confidence in the method and the necessity to apply it. This is all the more remarkable when considering that the percentage of bulk solids used in process industry is enormous. A few years ago the president of the EFCE (European Federation of Chemical Engineering) judged that about 60% of all products produced in the chemical industries in Europe are bulk solids. An additional 20% of products use bulk solids in the processes.

This book by Dietmar Schulze certainly will help to improve the understanding of bulk solids behavior, especially for people who only occasionally deal with bulk solids. After having obtained his diploma at the Technical University of Braunschweig he has been continuously concerned with all aspects of the characterization of bulk solids, application of measured bulk solids properties for silo design, and theoretical fundamentals of bulk solids technology. He has written important contributions to nearly all aspects of bulk solids technology which are documented in many publications. His effort in the determination of relevant bulk solid properties has been very intensive. He developed a special ring shear tester that is today known worldwide as the “Schulze Ring Shear Tester”. It is often erroneously asserted when mentioning shear testers that they are too complicated or too time consuming for many applications. Neither statement is correct. Depending on the task and on the problem, only a few experiments with a ring shear tester which has been adapted to the problem yield results that are more reliable than those which follow from empirical tests or from the application of so-called “simple testers”.

This book was published in German in autumn 2006. One of the main merits of the book is the fact that all chapters have been written by the same person who is an expert in all of the mentioned topics. The wording, nomenclature and mode of presenting graphs and sketches are identical throughout the book. This helps in understanding and searching for special questions. This has been missing in the English literature. Indeed there are some good books on bulk solids technology in English that are worth reading. But the single chapters of these books were mostly written by different authors using different nomenclature, etc. Thus, Dietmar Schulze was pressed by many of us to prepare an English version of his book, which is now available.

It is my hope this book will help to improve the understanding of bulk solids and the problems caused by them. This book treats nearly all problems which can arise in the technical application of storage and flow of bulk solids. The broad understanding and know how are based on the au-

thor's own experience in the measurement of bulk solids properties, planning and performing investigations of large silos and laboratory equipment, consulting with companies in solving problems or planning new silo facilities, and on a continuous and broad literature study.

Jörg Schwedes Braunschweig, in July 2007

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