Chapter 12
Dies, Pressure Heads, Strainer Plates and More

Harald Berger

12.1 Outline/Introduction

In any ceramic production plant, shaping plays a central role: it forms the basis for high-quality products.

Modern ceramic production processes are expected to produce flawless surfaces and crack-free filigree structures, but that depends to a large extent on the quality of the shaping process. In this respect, stress-relieved extrusion is the main precondition for column-drawn products. During the entire shaping process the extrusion body must be kept uniformly shaped, guided and ultimately moulded into the geometry of the end-product while excessive shear stress must be avoided. All this takes place mainly in the pressure head and die, which are attached to the end of the extruder. Even “invisible” differences in the speed of the body at various depths of the extruded column in the pressure head and die can cause defects with quality-impairing impact on the final product. For successful production, the pressure head and die must be designed in such a way that the body maintains an optimal speed-and-stress profile as it flows through the extrusion tool; uniform, constant speed over the cross-section of the column must be assured.

The following article deals mainly with pressure heads and dies in the shaping of ceramic bodies by means of extrusion. The state-of-the-art regarding the accomplishment of extrusion with maximum-achievable stress relief is described for the various fields: heavy clay ceramics, whitewares, and technical ceramics. In addition to pressure head and die, the extruder itself also has a major influence on shaping. Extruder, pressure head and die must not be viewed individually; they should be regarded as a “full & complete shaping assembly”. However, for the purposes of the following article, the extruder itself is not dealt with in detail.

H. Berger
Braun GmbH, D-88048 Friedrichshafen, Markdorfer Strasse 1, Friedrichshafen, Germany
e-mail: harald.berger@zmb-braun.de
12.2 Specific Characteristics of Ceramic Extrusion Body with Regard to Shaping

The extrusion body used in the production of continuous-column ceramic products is, by nature, highly kneadable and workable. Permanent deformation takes place due to the effects of external forces that induce states of stress within the material as soon as a certain boundary stress is exceeded. This kind of behaviour is summarized under the heading “plasticity”. The body’s intrinsic dimensional stability, i.e. its resistance to creep induced by its own weight, stems from the presence of the aforementioned boundary (or minimum) stress, which in the case of pure shear flow is termed “yield point” or “flow limit”. The flow limit indicates at which applied pressure the body begins to flow.

Consequently, due to the flow limit of the ceramic body – the stresses resulting from the shaping process cannot be completely relieved. The same applies to subsequent relaxation of the body: some amount of residual pressure will always remain behind. This phenomenon is also called the “ceramic memory” of the extrusion body. Nevertheless, it is very likely that the induced stresses will ease later on during drying and firing.

Wall slip is another characteristic of ceramic body for extrusion. Wall slip depends both on the nature of the extrusion body and on the characteristics of the surface over which it has to slide.

Irrespective thereof, each and every extrusion compound has its own set of material properties, all of which have to be considered in detail.

12.3 Factors of Influence to be Considered for the Design of Extrusion Tools

- Rheological properties of extrusion body: the aforementioned rheological properties of ceramic body must be kept in mind for designing and building extrusion tools. These properties constitute the sum total of numerous determining parameters – factors to which the raw material is exposed from preparation through extrusion.
- Influence of the extruder: size and design of the auger and extruder barrel, vacuum, position and geometry of the end-auger, clearance between auger and barrel.
- Subsequent treatment of the extruded green bodies: drying, firing, transport and handling systems.
- End-product requirements and characteristics: ultimate shape, requirements regarding precision, surface quality, standards, approvals.
- Efficiency: structural materials and tribomaterials in relation to production quantities.