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## ILLUSTRATIVE COURSE OF COMPACTION PROCESS OF THE PELLET PRESS PLG 2010

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**Abstract:** The article is aimed to clarify issues of calculation and illustrate the course of compaction process of pellet press PLG 2010. Construction of machine and its main parts are described in introduction to form image of the issue. Introduction also describes the basic principle of machine functioning. Next chapters are devoted to the principle of the finding out course of compaction ratio of the press. At the first 3D model of pressing space was created to find out of compression ratio. Next step was to divide the pressing space to smaller precisely defined parts, and measure its volume. The measured values were used to calculate exact values of compression ratio. And finally the calculated values were added to diagram, which describes illustrative course of compaction ratio the pellet press. Finally we must mention that the determined compaction ratio is not real but only idealized.

**Keywords:** pellet press PLG 2010, compaction process, 3D model, compaction ratio, illustrative course

### INTRODUCTION

Institute of manufacturing systems, environmental technology and quality management on STU in Bratislava are interested in biomass compaction research since 1995. The pellet press PLG 2010 is machine with progressive construction to compaction biomass, which was designed within the scientific research in our institute. There was produced three prototypes of this type of machine, each with new innovation or construction modification. The latest prototype was produced in 2010 and first test were made that time. We made the experiments to find out course of compaction ratio to get better idea about compaction processes during compacting on this machine.

### PRINCIPLE OF COMPACTION

The spherical pellet press principle of compaction is based on dragging and compacting material between the two axially misaligned discs where the first is pressing tool and second is die. Pressing tool and die are rotary components and they are rotated relative to each of the wedge angle. Together with sphere and main machine body define pressing space. Pressing tool is driven by

electromotor through a gearbox and to die torque is transferred by the friction or by contact form according to the type of pressing tools. Position of the sphere center is in the intersection of the tools axes. Sphere is rigidly connected and drifted by the press tool. Sphere, pressing tool and die define rotary part of pressing space. Static part of pressing space is defined by the body of the press. We can change pressing space geometry by changing set of tools and thus easy change conditions of compaction. Most of the pellet press parts are designed modular to reach easy and quick tools replacement.

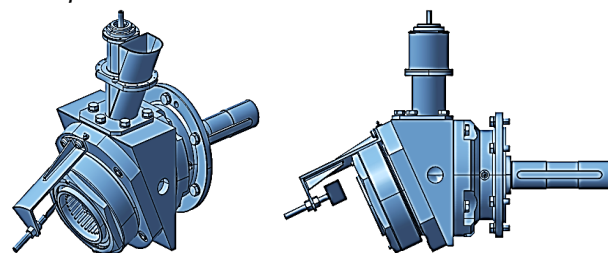


Figure 1. Pellet press PLG 2010

Insert of die and insert of pressing tool has important role in dragging, moving and compacting of pressed material. Material is

dragged to pressing space and then into pressing chamber of the die. The tools and sphere towards the press body creates movable pressing space with relative movable surfaces (figure 5). Angle of conical part is fix and it was determined with respect to reach good dragging, moving and compacting ability of the compacted material. During compaction with the drift system of torque transfer must be ensured sufficient friction between the tools. Friction depends on compacted material, its properties, shape of tools and the size of the minimal distance between them.

### CREATION OF PRESSING SPACE MODEL

We used CATIA V5 and original 3D model of machine to find out course of compaction ratio. The First step was to create pressing space of machine. Pressing space is defined by die, pressing tool, sphere and by body of machine as we can see on figure 2.

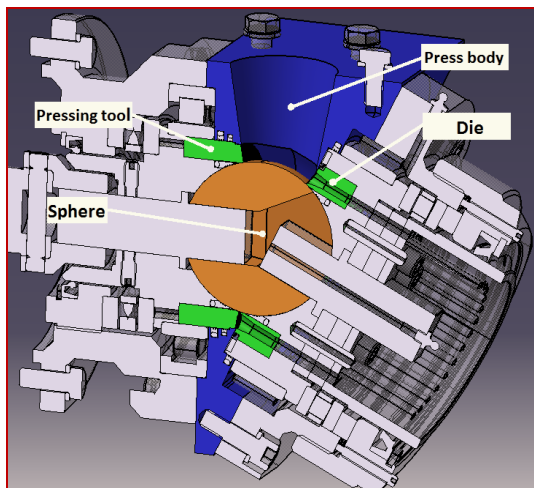


Figure 2. The pellet press section

Between the mentioned mating components arose pressing space, which is limited by two surfaces which projection is annulus. Its cut of conical surfaces with mild spatial conicity. Theoretical outside border surface is composed of two surfaces composed by intersection of two cut cylinders. Intersection is determined by outside edge of mentioned conical surfaces. At real is that theoretical surface adjusted, as the result of manually grinded edge created by intersection of cylinders. This adjustment wasn't taken into account during pressing space creation. Outside surface was simplified to spherical surface. Inner surface of the space is defined by cut of spherical surface of sphere. Plane of intersection of sphere are

defined by superficial curves of mentioned inner conical surfaces. Angle between die and pressing tool is 25°. We simplify 3D model of die and pressing tool to create model of pressing space (Figure 3). Pressing chamber of die was filled up, because it isn't considered the working part of pressing space. It leads to simplification of subtraction of volumes in 3D software. Compaction in pressing chamber is disregard because of different processes inside. Model of pressing tool was simplified by adding material into the gaps of milling. It simulate real state where gaps are filled by pressed material.

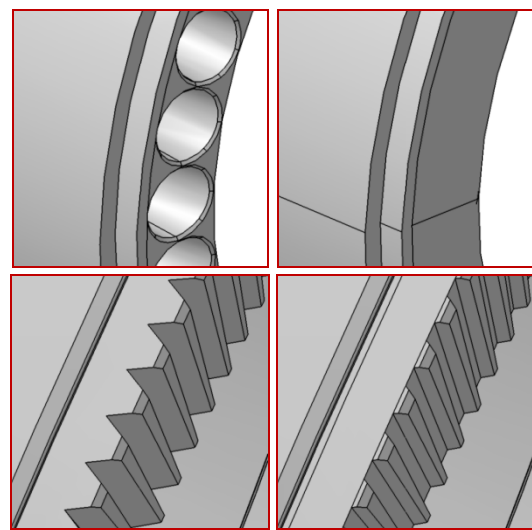


Figure 3. Pressing tool and die after editing

We added a layer of material on the outside surface of sphere, which will form base of the pressing space. That layer fill space between sphere, body and tools. Last step to create pressing space is to subtract individual part from sphere with added layer. Added layer on sphere intersects other parts, and that is the point of creating model of pressing space. On figure 4 we can see volume subtracting.

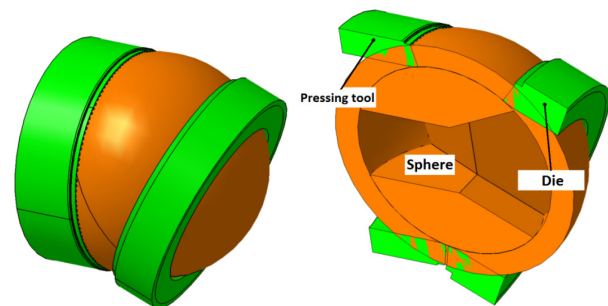


Figure 4. Volumes subtracting

After volumes subtracting was created following shape of pressing space:

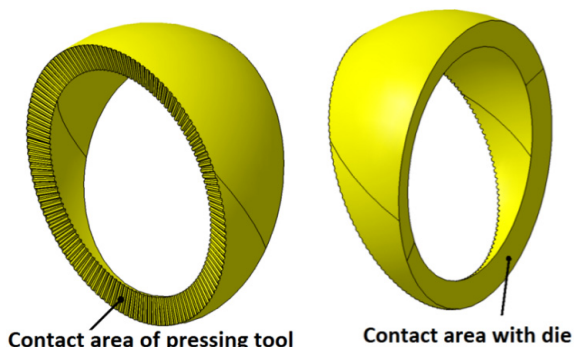


Figure 5. Pressing space

At the first model of pressing space must be divided to pieces with equal angle cut. We determine angle cut of one piece as  $360^\circ$  divided by number of output pressing chambers on the die. We were based on the assumption that the material will be equally pressed into each chamber of the die. Number of the chambers on the die is 30, thus angle cut is  $12^\circ$ . And finally volume of the first piece, is theoretically volume that will be extruded through one chamber of the die in the end.

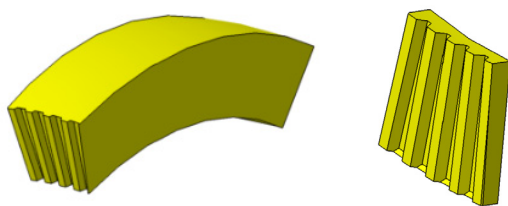


Figure 6. Input and output piece of pressing space

Whereas all moving parts have same direction of rotation, theoretically all compacted material will be extruded through chambers in only one half of whole created pressing space. Therefore we consider with the half of the pressing space model to calculate the course of compaction ratio. Angle of cut is same -  $12^\circ$ .

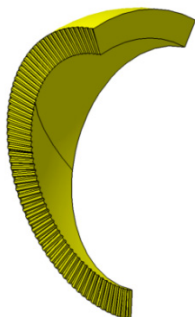


Figure 7. One half of pressing space

### IDEALIZED COURSE

Compaction ratio is ratio of compacted material volume after compacting to material volume before compacting. In case of spherical press we can say

that compaction ratio is ratio between inner volume of angle cut of pressing space and output volume of angle cut of pressing space. It means that we find out reduction (compaction) of one piece of pressing space. At the first we must find out volumes of pressing space pieces, that pressing space was divided. Total number of pieces is 15. Then for compaction ratio in specified place is valid relation:

$$zp_i = \frac{V_{Dmax}}{V_{Di}} \quad (1)$$

where:  $zp_i$  - compaction ratio in specified place [-]  
 $V_{Dmax}$  - maximal volume of piece - inner volume [ $cm^3$ ]

$V_{Di}$  - volume of piece in specified place [ $cm^3$ ]

We found compaction course after volumes measuring of specified pressing space pieces and substituting into formula. At figure 8 is shown course and measured volumes values of the specified pieces. Maximal volume of (input) piece is  $4,749 cm^3$ . Minimal volume of (output) piece is  $0,155 cm^3$ . Maximal value of compaction ratio is 30,64.

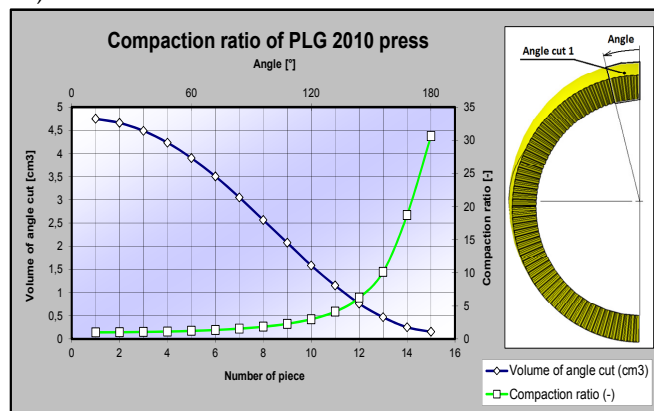


Figure 8. Idealized compaction ratio of PLG 2010 pellet press

### CONCLUSIONS

Value of found out compaction ratio is only ideal. Theoretical - ideal pressing ratio should be only input for next thought and analysis of whole system. In real processes we cant consider conclusions as relevant to find out real compaction ratio, because processes inside pressing space are really difficult to describe exactly. There are much more other input variables that influence the process of compaction. How material is behaving during compaction process is influenced by mechanism of compacting, shape of pressing space,



technological parameters of compaction and material parameters (temperature, humidity, chemical composition, split) and that is the main subject of our workplace research. Conclusions of this research can be efficiently connected to conclusions of real experiments. On basis of further analysis and comparative tests we can predict theoretical density of pellets, only by defining inner conditions of compaction.

Now this conclusions are suitable create base imagination about compaction processes inside the machine. Next research of compaction conditions leads to find out real compaction ratio and other parameters relevant with process of compaction on the PLG 2010 compaction machine.

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