ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering

Tome XII [2014] – Fascicule 2 [May]
ISSN: 1584-2665 [print]; ISSN: 1584-2673 [online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

[1.] Juraj ONDRUŠKA, [2.] Ľubomír ŠOOŠ, [3.] Peter BIATH, [4.] Viliam ČAČKO, [5.] Juraj BENIAK

CARDAN USE APLICATION IN SPHERICAL PELLETING PRESSES

[1-5.] Faculty of Mechanical Engineering, Slovak University of Technology in Bratislava, Institute of Manufacturing Systems, Environmental Technology and Quality Management in Bratislava,
Nám. Slobody 17, 812 31 Bratislava, SLOVAKIA

Abstract: Since 1995, our department has been involved with the research and development of devices for pressing (pelleting) biomass and waste material. This article describes the current state of development in the concept of spherical pelleting, and recent results of our research. The design of the machine is patent protected. Tests of the first prototype resulted in shaft damage whose source was not clear. However, more thorough analysis and testing resulted in determining the source. In order to reduce negative effects in the PLG machine, special treatment of the shafts together with the Hooke's joint is suggested. It is assumed that such a drive solution will ensure enough torque to efficiently operate the machine and increase the energy efficiency of the system.
Keywords: Sphere pelleting press, pellets, heating equipment, kardan, Hooke's joint

1. INTRODUCTION

The current version of the machine is designated as PLG 2010 which is a modular concept. Its development has undergone computer simulations, geometric analysis by CAX systems, and kinematic analysis. Throughout the development it has been shown that the main source of damage was a result of a poorly designed Hook joint. The inconsistent operation of the Hooke's joint resulted in violation of other machine constraints which resulted in premature damage and loss of performance (Figure 1).

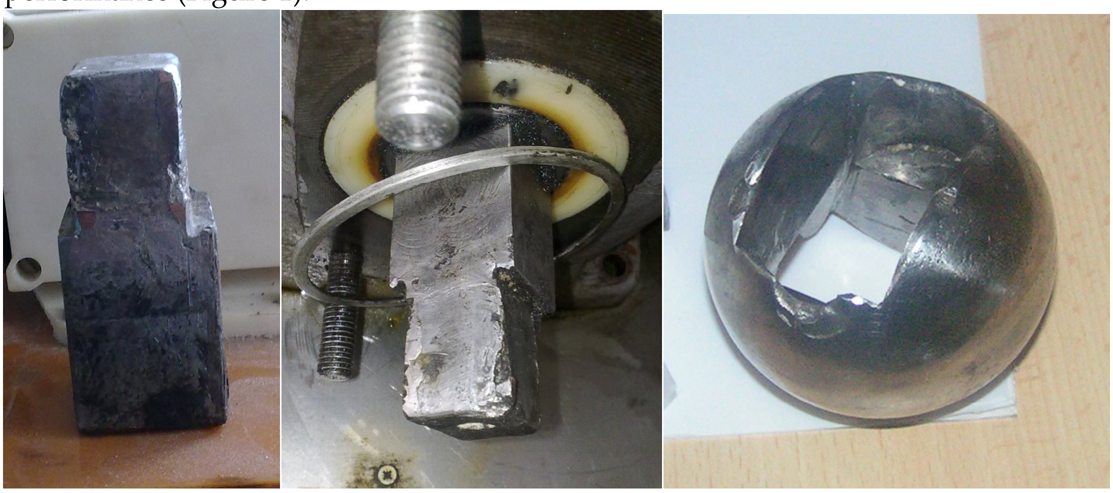

Figure 1: Important components of version 1 devices after long-term test operation

2. INNOVATION OF NEW CONSTRUCTION

The current version (PLG) can be constructed in various configurations. Each configuration is constructed with the most suitable modules. One of these configurations includes the use of Hooke's joint. This is designed for the partial transfer of moment. However, moment is also transferred through other parts of the mechanism. The combined kardan suffers from a great problem. Even though the input shaft rotates at constant velocity, the velocity of the output shaft is varying (Figure 2) [5] which results in vibration and premature wear. Changing the input velocity depends on the configuration of the joint used. Thus, the motion equation at two different angles is given in relation 1. In our configuration, the angle of the Hooke's joint is „β = 25°“. The amplitude of the angular deviation is based on relation 1 [5]. Maximum deviation as the input shaft moves from 0-180° is +-2,81°. This angle results in a relative shift of the pressing device by 4.8mm. This shift was calculated at a working diameter 98mm. (Figure 4)

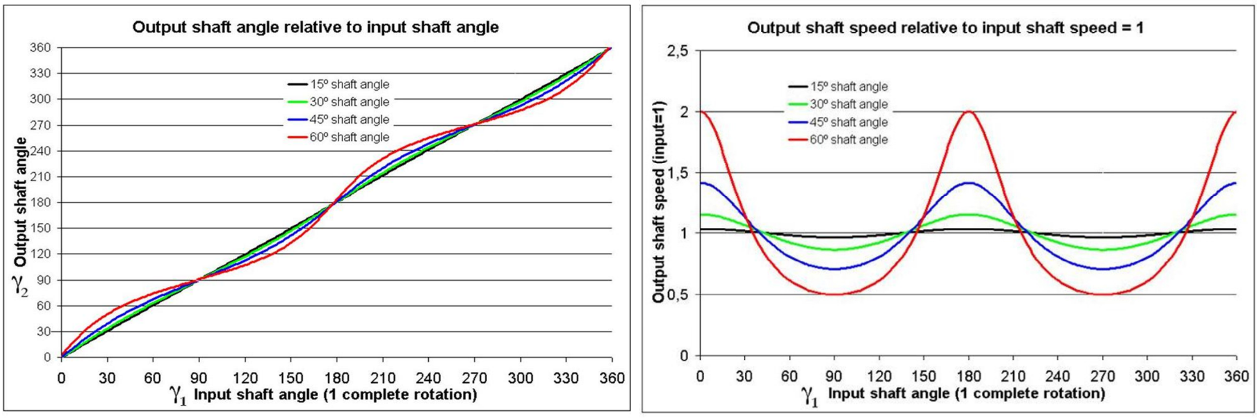

Figure 2: Graphical representation of the physical properties of Hooke's joint [5]

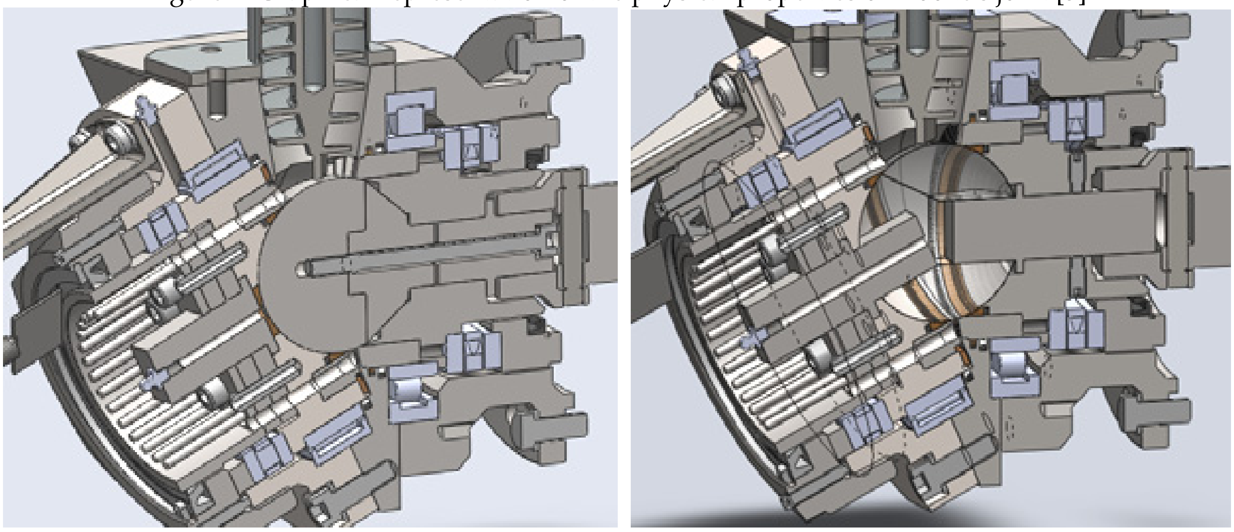

Figure 3: Two variants of the modular structure of the device PLG2010

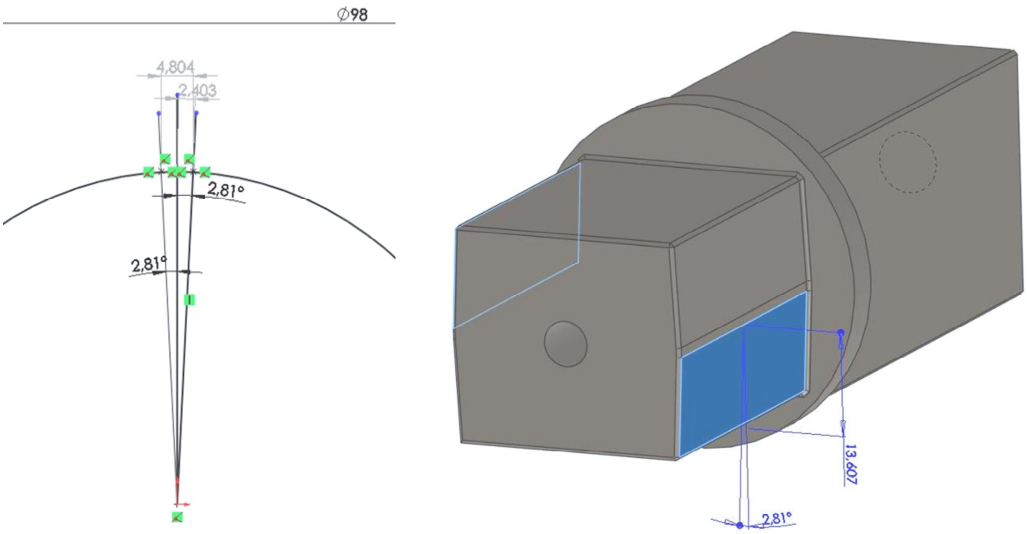

Figure 4: Proportional range displacement during operation, necessary adjustment shaft on left

$$\tan \gamma_1 = \cos\beta \sin \gamma_2 \quad (1)$$

$$\gamma_2 = \tan^{-1}\left(\frac{\tan\gamma_1}{\cos\beta}\right)$$

where: γ_1 - The angle of rotation for axle 1, γ_2 - The angle of rotation for axle 2, β - The bend angle of the joint, or angle of the axles with respect to each other, with zero being parallel or straight through.

The angles γ_1 and γ_2 in a rotating joint will be functions of time. Differentiating the equation of motion with respect to time and using the equation of motion itself to eliminate a variable yields the relationship between the angular velocities (relation 2) [5].

$$\omega_1 = \frac{d\gamma_1}{dt} \text{ and } \omega_2 = \frac{d\gamma_2}{dt} \Rightarrow \omega = \frac{\omega_1 \cos\beta}{1 - \sin^2\beta \cos^2\gamma_1} \quad (2)$$

ω_1 - angular velocities for axle 1, ω_2 - angular velocities for axle 2

As shown in the plots, the angular velocities are not linearly related, but rather are periodic with a period twice that of the rotating shafts. The angular velocity equation can again be differentiated to get the relation between the angular accelerations a_1 and a_2 (relation 3) [5].

$$a_2 = \frac{a_1 \cos\beta}{1 - \sin^2\beta\cos^2\gamma_1} - \frac{\omega_1^2 \cos\beta \sin^2\beta \sin 2\gamma_2}{(1 - \sin^2\beta \cos^2\gamma_1)^2} \quad (3)$$

where: a_1 - angular accelerations for axle 1, a_2 - angular accelerations for axle 2

In operation, the pressing chamber has relatively compact material, which under ideal conditions, creates a rigid constraint between the tools. This rigid constraint results in a ratio of 1:1, but the ratio of the Hooke's joint changes. Thus the ratio differs to the one in the Hooke's joint, which results in undesirable loading. In extreme cases, collisions in the tool occur which plastically deforms the material. If the material in the chamber is relatively plastic, then collision of the machines tools will not result. If the material in the chamber is compactable and relatively strong, damage to the machine can result. The shafts can twist, bend or even break. The effects of this damage can be seen in „Figure 1 ". The secondary issue as a result of this problem is the loss in performance, since the shift between the tools operates inconsistently and inefficiently. In some cases, such an effect can be considered a good thing, for example, the need to partially mix the pressed material to homogenize its plasticization. An example and graphic representation of this effect can be seen in (Figure 2).

CONCLUSION

In order to reduce negative effects in the PLG machine, special treatment of the shafts together with the Hooke's joint is suggested (Figure 4). It is assumed that such a drive solution will ensure enough torque to efficiently operate the machine and increase the energy efficiency of the system.

ACKNOWLEDGMENT

This paper reports on work done in the project "Developing of progressive technology of biomass compaction and production of prototypes and highly productive tools" (ITMS code of the project: 26240220017), supported by the Research and Development Operating Programme funded by the European Regional Development Fund.

REFERENCES

[1.] Šooš, Ľ.- Grman, M: Compactor on pellets.-,2006.- Number of utility model: SK 4554.- Date of acquirement: 19.6. 2006.
[2.] Grman, M.: Diploma work 2002- Progressive construction of compacting machine
[3.] Šooš, Ľ.- Grman, M.: Way to compact pellets from cornloft organic and/or anorganic raw stock or raw commixture and compactor on pellets.- 2009.- Number of patent: SK 286877.- Date of conferment: 4.5.2009.
[4.] Šooš, Ľ.: Suggestion, development and study of new constructions of pelletizing machines. Pro-Energy magazine n. 4, p. 56-60. ISSN 1802-4599.
[5.] [8.5.2012], [http://en.wikipedia.org/wiki/Universal_joint]

[6.] Šooš, Ľ., Ondruška, J., Matúš, M., Križan, P.: Guľový peletovací lis - nový princíp zhutňovania. In Vykurovanie 2011. Energetické a environmentálne hodnotenie systémov výroby, distribúcie a odovzdávania tepla: Zborník prednášok z 19. medzinárodnej konferencie. Ľubovnianske kúpele, SR, 28.2.-4.3. 2011. Bratislava: Slovenská spoločnosť pre techniku prostredia ZSVTS, 2011, s. 281--286. ISBN 978-80-89216-38-3

[7.] Ondruška, J., Šooš, Ľ., Križan, P., Matúš, M.: Peletovací lis progresívnej konštrukcie PLG 2010. In Energie z biomasy XI : Sborník příspěvků ze semináře. Brno, 1.-2.12. 2010. Brno: VUT v Brně, 2010, s. 101--107. ISBN 978-80-214-4243-6.

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering