Materials Research Proceedings 34 (2023) 246-251 https://doi.org/10.21741/9781644902691-29

Static Mechanical Force Amplifier on the Example of a Fastener with an Electromagnetic Bolt

JASIŃSKI Wiesław [1 *], KRYSIAK Piotr [1] and PICHLAK Cezary [1]

[1]Military Institute of Engineer Technology, ul. Obornicka 136, 50-961 Wrocław

Key words: Strength Amplifier, Fastener, Bolt, Construction Optimization

Abstract. Modern mechanical constructions consist of purchased elements and workshop-made elements. Undoubtedly, purchased components – made in specialized factories – have a definite advantage in quality and durability. Unfortunately, sometimes the operating parameters of a component for a given application are insufficient. Then it remains to design and manufacture a given element in the workshop – losing quality and costs. This paper presents a different approach. Application requirements can be customized just include an additional (simple) element, e.g. a force amplifier, and a purchased component can be used.

Introduction

In the construction of mechanisms, fasteners are used to hold stored energy and then release it to perform the necessary work. These types of fasteners should hold the given load when fastened, and then easily unfasten under load. Therefore, the design of such mechanisms should be specific. It is particularly important that at the time of opening the clasp there are no abrasions and mechanical jerks.

The above-mentioned requirements are met by electric strikes available on the market, commonly used in door locks. Unfortunately, they are not designed to transfer too much force when closed. It is therefore necessary to limit the force to an acceptable value. This can be done with a static force amplifier which is based on the principle of equilibrium of mechanical moments.

This paper presents an exemplary construction of a mechanical force amplifier mechanism with the use of an electromagnetic lock.

Materials and Methods

Autodesk Inventor Professional 2021 parametric software version 2021.3.3 was used for the design (Fig.1 and Fig.2.). The program contains the necessary mechanical standards and a number of useful calculation modules and wizards.

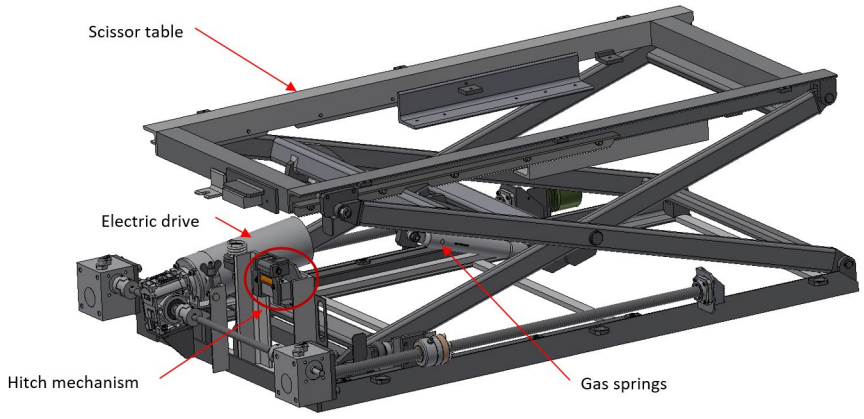

Fig.1. *View of the device containing the considered mechanism.*

Materials Research Proceedings 34 (2023) 246-251 https://doi.org/10.21741/9781644902691-29

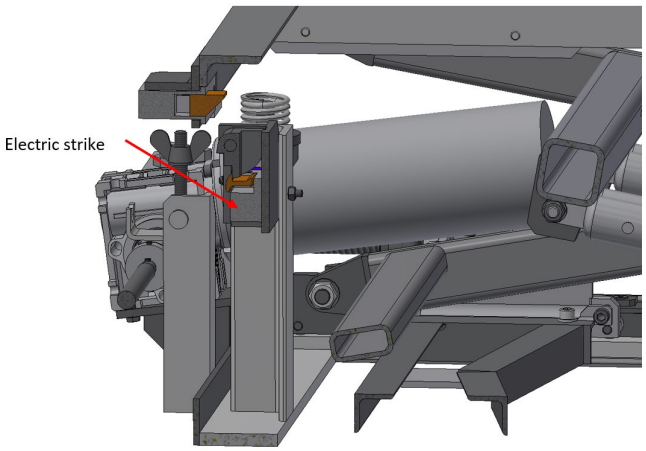

Fig.2. *Cross-section of the working fastening mechanism.*

The process of creating the mechanism required the initial preparation of pre-designed components. All the parts were then interconnected by mutual ties/connections. This procedure allowed to verify the matching of components and interconnections.

Results and Discussion

The purpose of this work was to present a specific approach to purchasing components commonly used in the industry, taking into account the permissible nominal parameters. If the permissible values are exceeded in a specific application, it is possible to use an additional mechanism, e.g. a static mechanical force amplifier, which will adjust these values.

Design of the hitch mechanism. The ASSA ABLOY shopping component Electric strike 143.U Cat. No. 143.Q34 was used to construct the fastening mechanism. The cam with eccentrically made teeth is an element that strengthens the force of the impact on the electric strike. One of the teeth is supported on the latch of the electric strike and the other of the teeth is used to fasten the lock (door) tongue carrying the payload. The diagram of the mechanism's operation is shown in Fig.3.

Materials Research Proceedings 34 (2023) 246-251 https://doi.org/10.21741/9781644902691-29

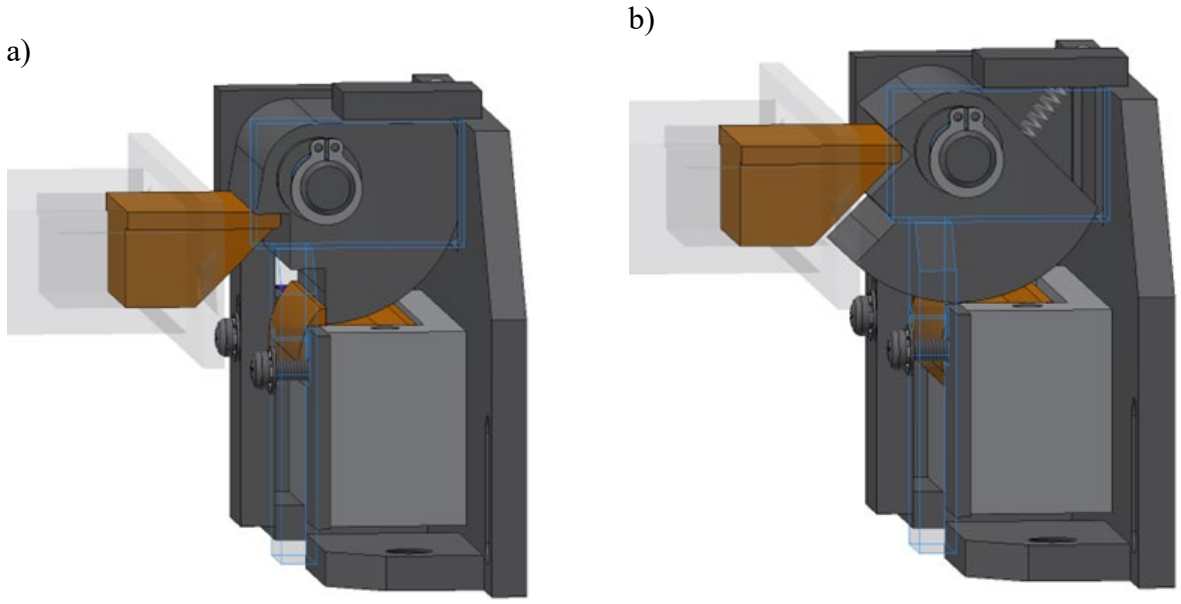

Fig.3. *The essence of the operation of the hitch mechanism: a) locked, b) unlocked*

Such a mechanism should effectively enhance the ability of the catch to transfer static forces. This means that the load may exceed the ratings specified by the manufacturer of the electric strike. At the same time, the catch can be opened and the load placed on it can be released without using much force and almost instantaneously. The instantaneous operation of such a mechanism is sometimes a particularly important feature.

Calculations for the hitch mechanism. Calculation of the fastening mechanism was done in a classic way. Fig.4 shows the load diagram of the fastener.

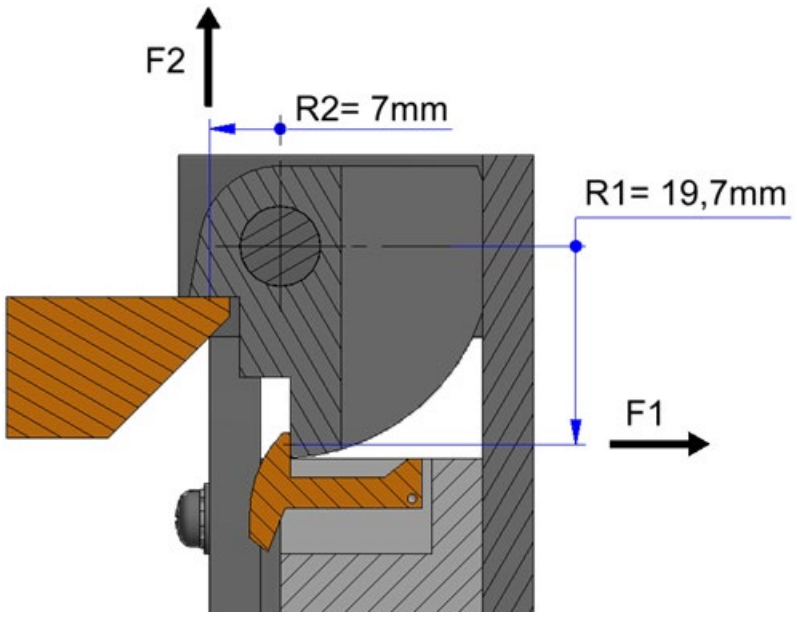

Fig.4. *Clasp load diagram*

Calculation formula from the equation of moments:

$$F2 = \frac{F1 \cdot R1}{R2}$$

where F1 acc. manufacturer's data is 8,000 N

$$F2 = \frac{8\,000\ \text{N} \cdot 19.7\ \text{mm}}{7\ \text{mm}} = 22\,514.3\ \text{N}$$

so the mechanism can carry 22,514.3 N. Reinforcement of mechanism strength:

$$w = \frac{F2}{F1}$$

totals:

$$w = \frac{22\,514.3}{8\,000} = 2.8$$

Thus, the design of the mechanism can be considered correct.

Conclusions

Contemporary designed mechanical structures should consist of as many purchased components as possible, rather than workshop-made components. These principal results from the fact that purchased components – made in specialized factories – have a definite advantage in quality and durability. In a situation where it is difficult to select a component with the right parameters, the problem can be solved by reversing the situation – lowering the requirements for the component by using, for example, a static force amplifier that will reduce these requirements.

The presented approach, which compensates for parametric or functional deficiencies of a factory-prepared component by adding an additional mechanical or structural adapter, can be successfully applied in analogous situations in other industries to reduce costs for unit or small-batch productions. Such adapters can be used in construction, particularly in the field of “smart” building information modeling (BIM), where effectors need to be widely utilized [11], sometimes based on composite materials [12]. Another example could be the deposition of additional special coatings [13, 14] to enhance wear resistance. However, in each of these cases, a thorough analysis of capabilities [15] is necessary beforehand to ensure that the desired modifications will be achieved. Stereology methods [16] and industrial statistics, both in classical [17-19] and nonparametric approaches [20-22], even supported by an expert system [23], can be helpful in this regard.

References

[1] A. Arian et al. Kinematic and dynamic analysis of the Gantry-Tau, a 3-DoF translational parallel manipulator. Appl. Math. Model. 51 (2017) 217-231. https://doi.org/10.1016/j.apm.2017.06.012

[2] J. Frączek, M. Wojtyra. Kinematyka układów wieloczłonowych – metody obliczeniowe. WNT, Warszawa, 2008.

[3] M. Gawrysiak. Mechatronika i projektowanie mechatroniczne. Wyd. Politechniki Białostockiej, Białystok, 1997.

[4] A. Gronowicz. Podstawy analizy układów kinematycznych. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2003.

[5] P. Hejma et al. Analytic Analysis of a Cam Mechanism. Procedia Eng. 177 (2017) 3-10. https://doi.org/10.1016/j.proeng.2017.02.175

[6] S. Miller. Teoria maszyn i mechanizmów – analiza układów kinematycznych. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 1996.

[7] J. Ormezowski. Analiza dynamiczna mechanizmu hamującego. Archiwum Motoryzacji 1 (2010) 27-34.

[8] A. Sapietova et al. Analysis and Implementation of Input Load Effects on an Air Compressor Piston in MSC.ADAMS. Procedia Eng. 177 (2017) 554-561. https://doi.org/10.1016/j.proeng.2017.02.260

[9] P. Sperzyński, J. Szrek, A. Gronowicz. Synthesis of a mechanism for generating straight line indexing trajectory. Acta Mechanica et Automatica 4 (2010) 124-129.

[10] J. Vavro Jr. et al. Kinematic and dynamic analysis of planar mechanisms by means of the SolidWorks software. Procedia Eng. 177 (2017) 476-481. https://doi.org/10.1016/j.proeng.2017.02.248

[11] J.M. Djoković et al. Selection of the Optimal Window Type and Orientation for the Two Cities in Serbia and One in Slovakia, Energies 15 (2022) art.323. https://doi.org/10.3390/en15010323

[12] J. Korzekwa et al. Tribological behaviour of Al_2O_3/inorganic fullerene-like WS_2 composite layer sliding against plastic, Int. J. Surf. Sci. Eng. 10 (2016) 570-584. https://doi.org/10.1504/IJSURFSE.2016.081035

[13] N. Radek et al. Microstructure and tribological properties of DLC coatings, Mater. Res. Proc. 17 (2020) 171-176. https://doi.org/10.21741/9781644901038-26

[14] N. Radek et al. Influence of laser texturing on tribological properties of DLC coatings, Prod. Eng. Arch. 27 (2021) 119-123. https://doi.org/10.30657/pea.2021.27.15

[15] B. Jasiewicz et al. Inter-observer and intra-observer reliability in the radiographic measurements of paediatric forefoot alignment, Foot Ankle Surg. 27 (2021) 371-376. https://doi.org/10.1016/j.fas.2020.04.015

[16] J. Pietraszek, A. Szczotok, N. Radek. The fixed-effects analysis of the relation between SDAS and carbides for the airfoil blade traces. Arch. Metall. Mater. 62 (2017) 235-239. https://doi.org/10.1515/amm-2017-0035

[17] J. Pietraszek et al. Factorial approach to assessment of GPU computational efficiency in surrogate models, Adv. Mater. Res. 874 (2014) 157-162. https://doi.org/10.4028/www.scientific.net/AMR.874.157

[18] J. Pietraszek et al. The parametric RSM model with higher order terms for the meat tumbler machine process, Solid State Phenom. 235 (2015) 37-44. https://doi.org/10.4028/www.scientific.net/SSP.235.37

[19] J. Pietraszek et al. Challenges for the DOE methodology related to the introduction of Industry 4.0. Prod. Eng. Arch. 26 (2020) 190-194. https://doi.org/10.30657/pea.2020.26.33

[20] J. Pietraszek. Fuzzy regression compared to classical experimental design in the case of flywheel assembly, LNAI 7267 LNAI (2012) 310-317. https://doi.org/10.1007/978-3-642-29347-4_36

[21] J. Pietraszek. The modified sequential-binary approach for fuzzy operations on correlated assessments, LNAI 7894 (2013) 353-364. https://doi.org/10.1007/978-3-642-38658-9_32

[22] J. Pietraszek et al. The fuzzy approach to assessment of ANOVA results, LNAI 9875 (2016) 260-268. https://doi.org/10.1007/978-3-319-45243-2_24

[23] R. Dwornicka, J. Pietraszek. The outline of the expert system for the design of experiment, Prod. Eng. Arch. 20 (2018) 43-48. https://doi.org/10.30657/pea.2018.20.09