

# Development of a Thick Plate Folding Mechanism as a Cover for a Manufacturing System

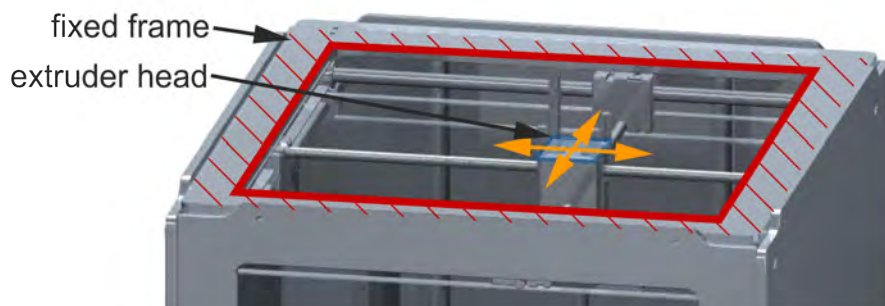
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## Abstract

Folding mechanisms as a construction principle hold a key advantage in the inclusion of both transformability and rigidity. Nevertheless, existing rigid folding applications throughout all technical disciplines are individually designed solutions. For the widespread use of folding mechanisms in different engineering fields, a systematic transfer of knowledge across traditional disciplinary boundaries needs to be established. This coherence between requirements, properties and applications can be consolidated in a specific design methodology for rigid folding mechanisms. The analysis of various products and their development processes leads to a universal accepted methodology. This contribution therefore presents the development of a deployable rigid folding mechanism as a cover for a manufacturing system, focusing on the steps taken in the design process. Furthermore, problems in the state of the art design process induced by the folding mechanism are highlighted and solutions given.

The application in this case is a moveable cover for a manufacturing system, represented by a 3d printer. The goal is a folding mechanism, which allows the connection to the rigid frame and the moving extruder head, while closing the open workspace. To follow the extruder head, a folding with two degrees of freedom (DOF) is required. Based on the structure of the 3d printer no further supporting points are possible. The named restrictions are shown in figure 1.



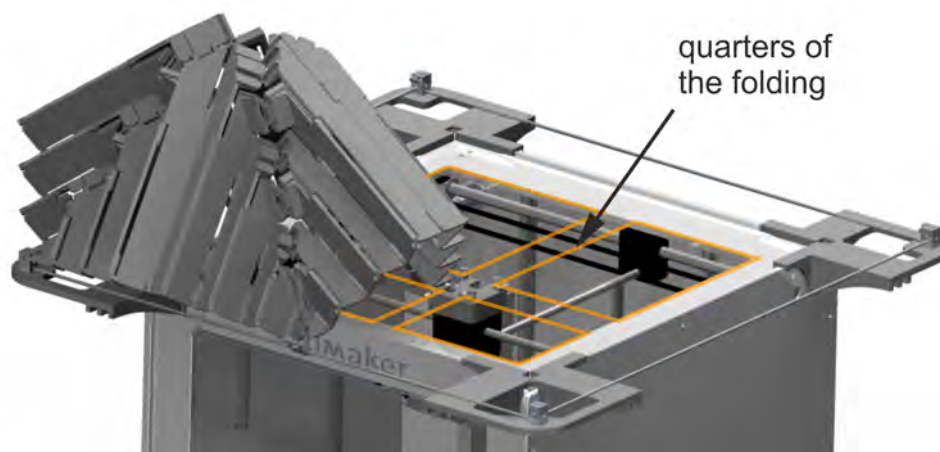
**Figure 1:** Basic restrictions for the application

While developing the rigid folding mechanism, a range of scenarios are analysed. Based on

problems that occur during the design process, the steps leading to the principle solution and the geometric definition are focused. For a folding mechanism, this represents the steps in which to systematically choose the optimal folding mechanism and the introduction of a plate thickness.

In order to break down the problem, a subdivision of the geometric restrictions is done based on symmetry and DOF. Subdividing the available space leads to several different combinations and quantities of folding mechanisms. Possible solutions combine various motional areas with one or two DOF, while still keeping an overall motion with two DOF.

The selection of folding mechanisms through crease patterns leads, as a starting point for thick plate application, to problems in the design process. This is shown by the developed prototypes. The moveable cover therefore combines concepts from the offset panel technique by Morgan et al. (2016) for the conversion from a zero-thickness rigid-foldable mechanism into a thick rigid origami application. It further proposes a way to offset the axes out of the plates while still regaining the kinematic properties of two DOF. Finally a critical evaluation of the projected requirements and the final cover, shown in figure 2 is carried out.



**Figure 2:** 2 DOF foldable mechanism covering the manufacturing system (only first quarter of the folding shown)

## References

Michael R. Morgan, Robert J. Lang, Spencer P. Magleby, and Larry L. Howell. Towards developing product applications of thick origami using the offset panel technique. *Mechanical Sciences*, 7(1):69–77, 2016. ISSN 2191-916X. doi: 10.5194/ms-7-69-2016.