# 論文の内容の要旨

# Dissertation Abstract

論文題目 Title: Internal Flow Dynamics and Performance Loss Mechanisms in Shear Force Pump

(層流摩擦ポンプの内部流動と性能損失に関する研究)

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Shear force pump consisting of multiple co-rotating disks is considered to be one of the suitable candidates for micro compression devices, which are greatly demanded in power generation, chemical and medical application fields. In this device, the fluid viscosity does not only cause loss, but also works as compression power, so that it is expected to have advantages in small scale, such as millimeter size.

In the previous studies, shear force pump in the experimental works could achieve low efficiencies, even though the analytical and numerical works showed very high efficiencies for the co-rotating disks as a compression unit. Present work aims to clarify the loss mechanisms in shear force pump system and discuss the ideas that could reduce the losses.

Two typical shear force pump systems are designed in the present work. Also, the internal flow fields in

these two systems are investigated numerically to understand the flow dynamics and clarify the loss mechanisms. The results show that the flow which is quite close to peripheral direction of rotating disks at the rotor outlet is the main loss factor in shear force pump system. Due to this flow structure, the long flow path of primary flow and strong secondary flow are yielded in the diffuser or scroll part. Therefore, the friction loss is highly increased. Also, the reverse flow between co-rotating disks appears in the working condition with low flow rate, so that disk package can not work appropriately with high performance as predicted by analytical or numerical works on flow field in rotor part.

The diffuser design is also discussed in the present study to deal with strong tangential flow direction at the disk outlet. Numerical investigation on the internal flow field for co-rotating disks working with new diffuser designs are conducted. Also, the flow field and performance are compared with conventional design. It is concluded that the reverse flow between co-rotating disks in the low flow rate can be improved by introducing the rotating convergent diffuser after the disk packages, so that rotor part can work with higher efficiency in the lower flow rate than conventional design. The peak efficiency of rotor is improved from 65% to 78% in the present design. The performance of whole pump can be enhanced with peak efficiency increased from 37% to 42%. Also, for rotating diffuser, small convergent angle is beneficial to enhance this effect and reduce the loss in diffuser itself.

In the present study, the grooved disks effect is also investigated numerically and experimentally. The numerical work concentrates on the flow field between co-rotating disks with grooved surfaces. The

groove effects on the flow field are clarified. The experimental test-rig is designed and built, and the results are compared with numerical results. The results show that the pressure coefficient at the disk outlet and diffuser measurement point can be enhanced for the same flow coefficient by introducing the groove structure. In other words, more flow rate can be acquired for the same total pressure gain from co-rotating disks, so that the flow angle at the disk outlet can be improved to reduce the loss in the rotating convergent diffuser part. Several tens of percent efficiency improvement of rotating diffuser can be expected by introducing the groove with depth 0.2 and 0.4 in the present design.