Design of Electrohydraulic Energy Converter for Ventricular Assist System

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Introduction

Many invasive techniques have been applied for treating cardiac patients since first usage of the intra-aortic balloon pump (IABP) in 1967. Though various types of Ventricular Assist System(VAS)s have been used clinically for end-stage chronic cardiac patients during last two decades, it still remains necessary to improve their system reliability and hemocompatibility. Ventricular function of some cardiac patients can be recovered by temporal cardiac assistance. In order to enhance the clinical use of VAS, we need to develop less complex and easily applicable VASs which do not need undergoing open heart surgery.

In this paper, we designed a new electrohydraulic energy converter for LVAS which can be used as a conventional one. Feasibility of the application of this energy converter to a catheter type VAS for temporal use is also considered theoretically.

Materials and Methods

Electrohydraulic mechanism with a bellows and a ball screw unit is applied to maximize the controllability of VAS. In this system, stroke volume and heart rate can be easily changed with various control mode by a simple motor control. Necessary pump capacity for VAS is summarized in table 1. We use a brushless DC motor (Sierracin/Magnedyne 594-05, USA) to minimize the volume of the total system, . Stroke volume can be varied by changing of motor revolution number and heart rate by motor speed. PI controller is also designed for this purpose as shown in figure. 1.

A ball screw unit (THK BLK 1510G, Japan) and linear motion guide (THK RSR9W, Japan) transfer motor's circular motion to linear motion of bellows. In order to increase total system efficiency, lead of the ball screw was decided as 10 mm per 1 revolution by considering of the optimal motor operation range in motor performance curve. Since bellow is one of the weakest points in our VAS, minimum 2 million compression and distension cycles must be guaranteed for 10 day's durable operation of VAS. Therefore, specially designed bellows (Sang-a Corp, Korea) will be used for this purpose. Energy converter system is shown in figure 2.

In the catheter type VAS as shown in figure 3, the length of catheter is about 100 mm and the diameter is about 6 mm. We calculated pressure drop due to the catheter. hte calculations showed it is 200 mmHg in the worst case. Therefore, pump load will be increased to 320 mmHg when AoP is

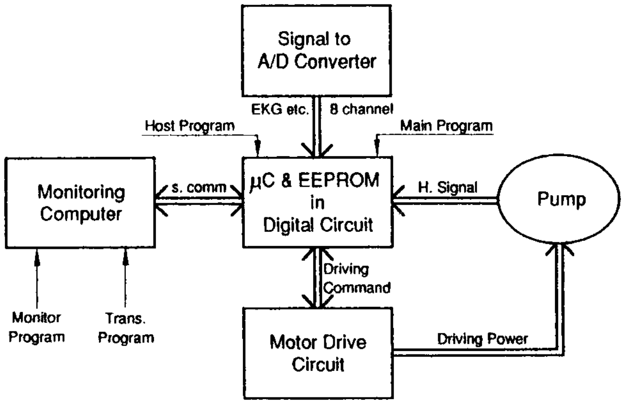
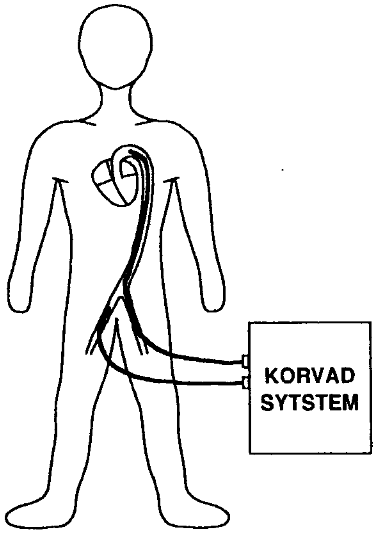


Figure 1. *PI Controller Scheme for Ventricular Assist Systems*



KORVAD for Acute Use :
FA to FV Access with Catheter

Figure 3. *KORVAD System Configurations*

Table 1. *Design specification of KORVAD*

Power	25 w
Heart.Rate	30 ~ 120 bpm
Torque	29 ~ 88 oz-in
Speed	300 ~ 1200 rpm
Efficiency	about 50 %
Output Pressure	Max. 750 mmHg
Max. Stroke Length	5 cm
Max. Stroke Volume	98 cc
Max. Cadiac Output	Max. 9.6 L/min

120 mmHg. In this case, we will change the pump operation mode to low speed and high torque state to overcome this load while pump cardiac output is maintained by 5 L/min.

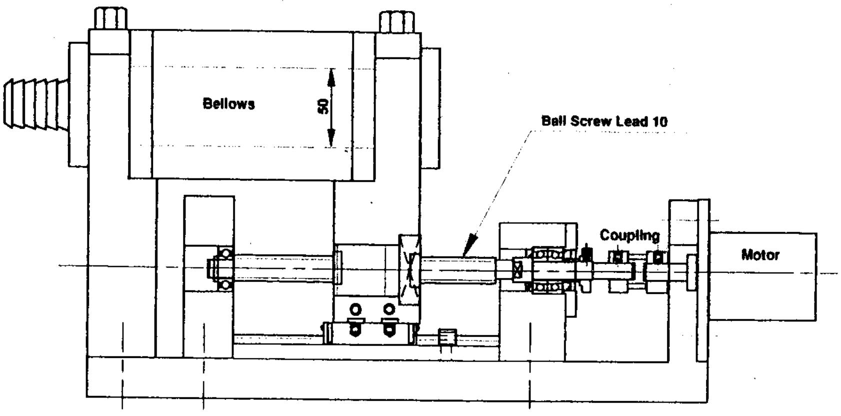


Figure 2. *Schematic Drawing of KORVAD Energy Converter System*

Results and Discussion

Since pressure variation in oil is very large, aeration is expected. Stroke volume will be reduce by this aeration. Amount of aeration is calculated theoretically to 10 % of the total oil volume when silicone oil is used in our pressure load. It depends on kinds of oil we use and flow patterns generated in oil. Therefore, experiments about aeration should be performed.

Pump operation range for both utilization (conventional & catheter type of VAS) must be well defined by considering total pump efficiency and feasibility of application as a catheter type VAS.

Acknowledgement

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