

Applications

Sebastian Pech*, René Richter and Jens Lienig

Non-occlusive pumping principle for blood pump application

<https://doi.org/10.1515/auto-2021-0153>

Received October 27, 2021; accepted September 27, 2022;

Abstract: Roller pumps are used in medicine to pump blood in extracorporeal blood circuits. Blood is subjected to mechanical stress in these peristaltic pumps, due to the complete tube occlusion. This stress causes damage to red blood cells (hemolysis). We present a novel peristaltic pumping principle that addresses these issues. In contrast to conventional roller pumps, the tube is stimulated by a circulating eccentric oscillation. Therefore, this type of pump does not require complete tube occlusion. The blood is less mechanically stressed and hemolysis is reduced by 55% compared to a roller pump.

Keywords: blood pump; hemolysis; peristaltic pump; red blood cell damage; tube occlusion.

Zusammenfassung: In der Medizin werden Rollenpumpen zum Betreiben extrakorporaler Blutkreisläufe verwendet. Beim Einsatz dieser Verdrängerpumpen ist das Blut aufgrund der kompletten Schlauchquetschung (Okklusion) mechanischen Belastungen ausgesetzt. Dies führt zu einer Zerstörung der Erythrozyten (Hämolyse). Im Gegensatz zu konventionellen Rollenpumpen nutzt das vorgestellte neuartige Pumpprinzip eine umlaufene exzentrische Oszillation und verzichtet auf die vollständige Schlauchokklusion. Dadurch lässt sich die Hämolyse im Vergleich zu einer Rollenpumpe um 55% reduzieren.

Schlagwörter: Blutpumpe; Hämolyse; Schlauchpumpe; Zerstörung der roten Blutkörperchen; Schlauchquetschung.

*Corresponding author: **Sebastian Pech**, Dresden University of Technology, Institute of Electromechanical and Electronic Design (IFTE), Dresden, Germany, E-mail: sebastian.pech@outlook.com

René Richter and Jens Lienig, Dresden University of Technology, Institute of Electromechanical and Electronic Design (IFTE), Dresden, Germany, E-mail: rene.richter@tu-dresden.de (R. Richter), jens.lienig@tu-dresden.de (J. Lienig)

1 Introduction

Extracorporeal blood pumps are used to operate extracorporeal life support systems (ECLS), dialysis or organ perfusion systems. Figure 1 shows the typical structure of an organ perfusion system with blood as the perfusion medium. This circuit is used to supply blood to organs (kidney, liver, lung, heart) outside the human body for transplantation or organ conditioning [1]. Blood is oxygenated in the circulation loop in a similar manner to a heart-lung machine and an ECLS. Depending on the organ, several blood pumps are required to perfuse different vascular systems.

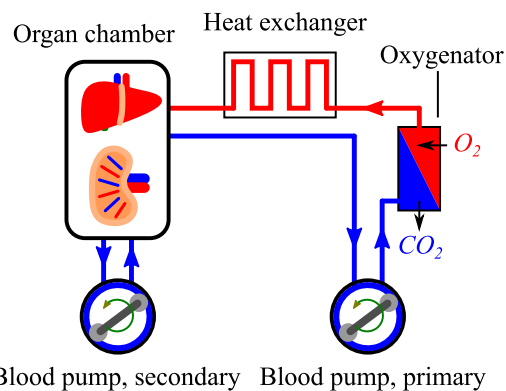


Figure 1: Typical perfusion circulation system (according to [2]) to supply blood to organs outside the human body. Two roller pumps are used to perfuse the organ in this example.

1.1 Problem: red blood cell damage

Blood and its components are damaged during extracorporeal blood circulation and associated pumping. This is very taxing for a patient's organism and restricts the maximum permissible extracorporeal blood circulation time. In addition to the harmful impact of foreign surfaces, the shear stress acting on the blood during the pumping process is the main cause of blood damage [3–5]. This shear stress leads to a deformation of the elastic cell membrane and results in mechanical destruction of the red blood