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(54) DISPLACEMENT PUMP PRESSURE FEEDBACK CONTROL AND METHOD OF CONTROL

(57) A method of controlling an actuation pump (104) including monitoring a supply pressure of a pump (104), monitoring an outlet pressure of the pump (104), commanding a motor (102) by a motor controller, which receives the monitored pressures, to drive the pump (104) at a speed based on a comparison of the supply pressure and the outlet pressure of the pump (104).

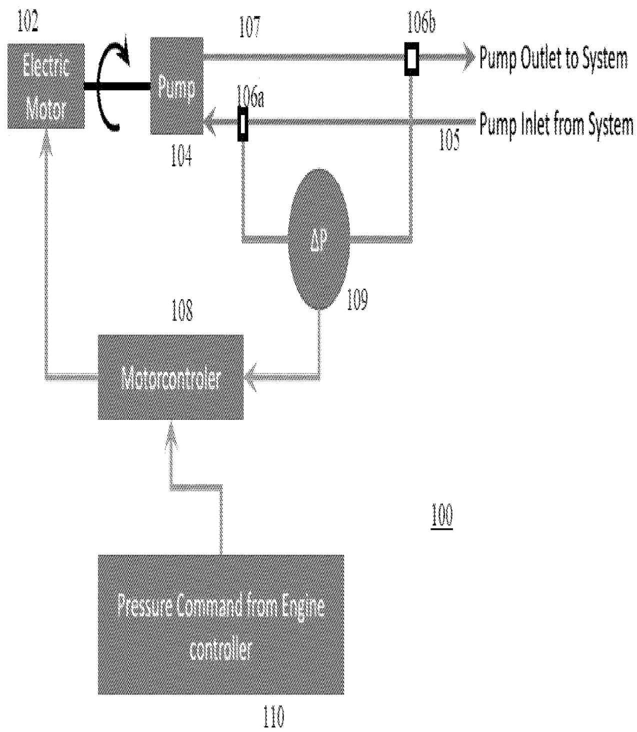

FIG. 1

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Description

Background

Technological Field

[0001] The present disclosure relates to a method of controlling a positive displacement pump, and specifically to controlling a pump using a pressure differential.

Description of Related Art

[0002] Positive displacement pumps produce large parasitic losses in air breathing engine fluid systems. Traditionally pumps are controlled based on their mechanical linkage to engine speed and are sized for to meet extreme conditions which are rarely reached or operated at. This leads to oversizing, which then requires other oversized components and unneeded flow capacity in the vast majority of operational conditions. This unneeded flow is a source of parasitic losses within an engine environment. While conventional design, operation, and sizing methods have generally been considered satisfactory for their intended purpose, there is still a need in the art for improved pump controls and sizing methods. The present disclosure provides a solution for this need.

Summary of the Invention

[0003] A method of controlling a pump is disclosed. The method includes monitoring a supply pressure of a pump, monitoring an outlet pressure of the pump, and commanding a motor to drive the pump at a speed based on a comparison of the supply pressure and the outlet pressure of the pump, where the pump is a positive displacement pump and the motor is an electric motor. The method can include receiving an initial pressure command from an engine controller. Commanding the motor can include changing a speed of the motor in response to a change from the initial pressure command from the engine controller and/or a change in differential pressure between the supply pressure and the outlet pressure.

[0004] It is also considered that the monitored pressures can be sent as electrical signals directly to a motor controller to electrical and directly sent back to the motor controller command the motor to drive the pump. The method can also include actuating a stator vane of an aircraft based on an increased or decreased pressure from the pump.

[0005] A system for operating the method described above is also disclosed. The system includes a motor, a pump operatively coupled to the motor to be driven by the motor, wherein the pump includes an input side and an output side, a pressure sensor to monitor a pressure difference between the input side and output side of the pump, and a motor controller to command the motor based on the detected pressure difference across the pump and monitor the pressure sensor. The motor controller can be operatively coupled to an engine controller, where the engine controller can be configured to provide a pressure command to the motor controller based on power required to accomplish an actuation task.

[0006] The pressure sensor can be configured to measure supply pressure and outlet pressure of the pump. The pressure sensor can include a first pressure sensing element located on a supply side of the pump, and a second pressure sensing element located on an output side of the pump. The pressure sensor can be a differential pressure sensor. It is also considered that the pressure sensor can include two independent sensors wherein each of the two independent sensors is configured to measure absolute pressure. The system can be part of an actuation system of an aircraft for actuating a stator vane or other air guiding element.

[0007] The motor controller used in the method includes non-transitory computer readable medium comprising computer executable instructions to execute the steps of the method described above. The motor controller can be configured to receive a pressure command from the engine controller to produce power required to accomplish an actuation task, wherein the engine controller can also be responsible for controlling an aircraft engine.

[0008] These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description of the preferred embodiments taken in conjunction with the drawings.

Brief Description of the Drawings

[0009] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

FIG. 1 is a schematic depiction of a pump motor controller in accordance with the disclosure.

Detailed Description

[0010] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, a schematic view of an exemplary embodiment of a system for controlling a pump based on a pressure difference between an input and output pressure on the pump in accordance with the disclosure is shown in FIG. 1 and is designated generally by reference character 100. The system and methods described herein allow for engine actuation systems to only consume power needed to accomplish an actuation task based on instant operational constraints, instead of depending on unrelated engine speed relationships, making for more efficient systems.

[0011] Referring now to FIG. 1, a schematic of system 100 is shown. The system 100 is part of an aircraft actuation system coupled to an aircraft engine, and is considered to be useful in both an actuation system and a main fuel pump application. Any system where a pressure needs to be manipulated to influence system functionality can benefit from this architecture. The system 100 includes a motor 102, a pump 104 operatively coupled to and controlled by the motor 102. The motor 102 is an electric motor, and the pump 104 is a positive displacement pump.

[0012] A pressure sensor having a pair of sensing elements 106a, 106b is used to monitor the pressure difference across pump 104. One pressure sensing element 106a is located on an input side 105 of pump 104 to sense input pressure of the pump 104. A second pressure sensing element 106b is located on an output side 107 of the pump 104 in order to sense output pressure from the pump 104. This type of pressure sensor can be a differential pressure sensor spanning a pump membrane in order to output a difference in pressures by referencing pressure with another location where pressure is also measure. It is also considered that each of the sensing elements 106a, 106b can be independent pressure sensors to measure and produce absolute pressure readings. The sensors 106a/b can be separate pressure transducers, each connected to the microcontroller 108 to monitor a pressure difference across the pump 104. Each one of the pressures sensing elements at each of the locations shown in Fig. 1 are both connected to a single differential pressure transducer 109. The differential pressure transducer 109 is itself connected to the microcontroller 108 to convey input indicative of the pressure differential between the inlet and outlet of the pump 104. A motor controller 108 is operatively coupled to the motor 102 in order to command the motor 102 to increase or decrease speeds based on targeted pressure commands received from a master engine controller 110, and based on the input from the pressure sensors 106a, 106b. The motor controller 108 is programmed to compare the target pressure readings versus the outputs, and increase or decrease the speed of the motor 102 accordingly.

[0013] The motor controller 108 includes a non-transitory computer readable medium which includes computer executable instructions to monitor a supply pressure of the pump 104, monitor an outlet pressure of the pump 104, and monitor and control the speed of the electric motor 102 based on a comparison of the supply pressure and the outlet pressure of the pump.

[0014] The methods and systems of the present disclosure, as described above and shown in the drawings, provide for a method of designing and sizing an displacement pump system that is more attuned to the specific task it is required to perform. While the apparatus and methods of the subject disclosure have been shown and described with reference to preferred embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the scope of the subject disclosure.

Claims

1. A method of controlling a pump (104) comprising:

   monitoring a supply pressure of a pump (104);
   monitoring an outlet pressure of the pump (104); and
   commanding a motor (102) to drive the pump (104) at a speed based on a comparison of the supply pressure and the outlet pressure of the pump (104).

2. The method of claim 1, further comprising receiving an initial pressure command from an engine controller.

3. The method of claim 1 or 2, wherein the motor (102) is an electric motor.

4. The method of any preceding claim, wherein the pump (104) is a positive displacement pump (104).

5. The method of any preceding claim, wherein commanding the motor (102) includes changing a speed of the motor (102) in response to a change from the initial pressure command from the engine controller and/or a change in differential pressure between the supply pressure and the outlet pressure.

6. The method of any preceding claim, wherein the monitored pressures are sent as electrical signals directly to a motor controller to electrical and directly sent back to the motor controller command the motor (102) to drive the pump (104).

7. The method of any preceding claim, further comprising actuating a stator vane of an aircraft based on an increased or decreased pressure from the pump (104).

8. A system comprising:

   a motor (102);
   a pump (104) operatively coupled to the motor (102) to be driven by the motor (102), wherein the pump (104) includes an input side and an output side;
   a pressure sensor to monitor a pressure difference between the input side and output side of the pump (104); and
   a motor controller to command the motor (102) based on the detected pressure difference across the pump (104) and monitor the pressure sensor.

9. The system of claim 8, wherein the motor controller is operatively coupled to an engine controller, and optionally wherein the engine controller is configured to provide a pressure command to the motor controller based on power required to accomplish an actuation task.

10. The system of claim 8 or 9, wherein the pressure sensor is configured to measure supply pressure and outlet pressure of the pump (104).

11. The system of any of claims 8 to 10, wherein the pressure sensor includes a first pressure sensing element located on a supply side of the pump (104), and a second pressure sensing element located on an output side of the pump (104), or wherein the pressure sensor is a differential pressure sensor, or wherein the pressure sensor includes two independent sensors wherein each of the two independent sensors is configured to measure absolute pressure.

12. The system of any of claims 8 to 11, wherein the system is part of an actuation system of an aircraft for actuating a stator vane or other air guiding element.

13. A motor controller for controlling a pump pressure comprising:
a non-transitory computer readable medium comprising computer executable instructions to:

monitor a supply pressure of the pump (104);
monitor an outlet pressure of the pump (104); and
command a motor (102) based on a comparison of the supply pressure and the outlet pressure of the pump (104).

14. The microcontroller of claim 13, wherein the pump (104) is a positive displacement pump.

15. The microcontroller of claim 13 or 14, wherein the motor controller is configured to receive a pressure command from the engine controller to produce power required to accomplish an actuation task, and/or wherein the engine controller controls an aircraft engine.

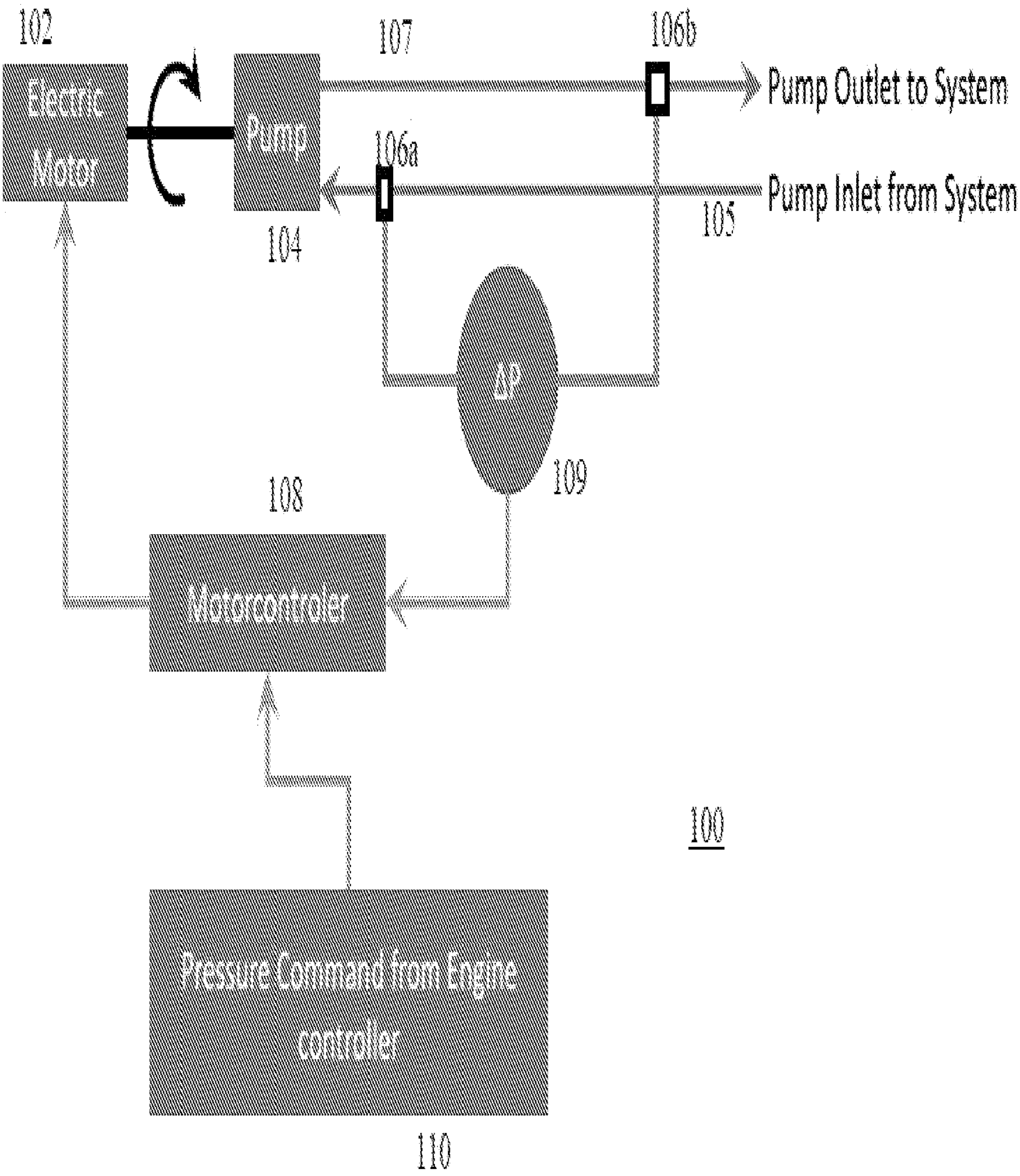
102
Electric Motor
107
106b
Pump Outlet to System
Pump
106a
Pump Inlet from System
105
104
ΔP
109
108
Motorcontroler
100
Pressure Command from Engine controller
110

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 6434

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 10 364 816 B2 (LINCUS INC [US]) 30 July 2019 (2019-07-30) * paragraphs [0012] - [0018] *	1,3-6,8, 10,11, 13,14 7,9,12, 15	INV. F04B17/03 F04B49/065
X A	US 10 815 987 B2 (FMC KONGSBERG SUBSEA AS [NO]) 27 October 2020 (2020-10-27) * page 1, lines 25-29 * * page 4, line 22 - page 6, line 5 *	1-6,8, 10,11, 13,15 7,9,12	
X	US 2017/314282 A1 (NIX AXEL [US]) 2 November 2017 (2017-11-02) * paragraphs [0044], [0051], [0052], [0107]; figures 1-4 *	1,3,5, 10,11,13	
Y	US 2020/141331 A1 (TRAMONTIN TIMOTHY [GB]) 7 May 2020 (2020-05-07) * paragraphs [0011], [0012], [0044], [0076] *	7,9,12, 15	TECHNICAL FIELDS SEARCHED (IPC)
X	US 2013/048114 A1 (ROTHMAN NATHAN F [US] ET AL) 28 February 2013 (2013-02-28) * paragraphs [0013] - [0017]; figures 1,4a *	1-3,8, 10,11,13	F04B
X	CN 111 412 132 A (HUNAN SMART FLOW TECH CO LTD) 14 July 2020 (2020-07-14) * the whole document *	1,8,13	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	13 December 2022	Ziegler, Hans-Jürgen

CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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13-12-2022

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 10364816	B2	30-07-2019	NONE		
US 10815987	B2	27-10-2020	AU 2016348649	A1	10-05-2018
			BR 112018009151	A2	06-11-2018
			EP 3371453	A1	12-09-2018
			NO 340793	B1	19-06-2017
			US 2018313349	A1	01-11-2018
			WO 2017076939	A1	11-05-2017
US 2017314282	A1	02-11-2017	NONE		
US 2020141331	A1	07-05-2020	CN 111140288	A	12-05-2020
			EP 3650659	A1	13-05-2020
			US 2020141331	A1	07-05-2020
US 2013048114	A1	28-02-2013	US 2013048114	A1	28-02-2013
			US 2016054009	A1	25-02-2016
			US 2018156472	A1	07-06-2018
			US 2020217520	A1	09-07-2020
			US 2022042687	A1	10-02-2022
CN 111412132	A	14-07-2020	NONE		

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82