United States Patent Application Publication	20250256860
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	Chatelois; Bruno et al.

HYBRID AIRCRAFT PROPULSION SYSTEM WITH ELECTRIC MOTOR ALIGNMENT

Abstract

A hybrid aircraft propulsion system includes a first motor operatively connected to a propulsor via a first motor driveshaft and is mounted to an engine static structure through engine mounts operable to adjust a position of the first motor and the first motor driveshaft. A second motor is an electric motor having a second motor driveshaft which is coaxial to the first motor driveshaft. The second motor is operatively connected to the propulsor via the second motor driveshaft to selectively drive the propulsor. A height compensation structure is operatively connected to the second motor and structured to adjust axial alignment of the second motor driveshaft relative to the first motor driveshaft to make the first motor driveshaft more coaxial to the second motor driveshaft.

Inventors: **Chatelois; Bruno (Boucherville, CA), Weaver; Paul (Chateauguay, CA)**

Applicant: **Pratt & Whitney Canada Corp.** (Longueuil, CA)

Family ID: **1000007786960**

Appl. No.: **18/440677**

Filed: **February 13, 2024**

Publication Classification

Int. Cl.: **B64D31/18** (20240101); **H02K5/00** (20060101); **H02K7/00** (20060101); **H02K7/14** (20060101)

U.S. Cl.:

CPC **B64D31/18** (20240101); **H02K5/00** (20130101); **H02K7/003** (20130101); **H02K7/14** (20130101);

Background/Summary

BACKGROUND

[0001] This applications relates to structure for maintaining aligned driveshafts between a first motor and an associated electric motor in a hybrid aircraft propulsion system.

[0002] Gas turbine engines are known, and typically include a propulsor delivering air as propulsion air. The propulsor also delivers air into a compressor where it is mixed with fuel and ignited.

[0003] Products of the combustion pass downstream across turbine rotors, driving them to rotate. A driveshaft is driven by the turbine rotors to in turn drive the propulsor and compressor rotors.

[0004] More recently, hybrid engine systems are being developed wherein an electric motor provides selective drive in addition to the drive provided by the gas turbine engine. This may allow the size of the gas turbine engine to be made smaller. As an example, at high power operation, such as takeoff of an associated aircraft, the electric motor may supplement the gas turbine engine power such that the high thrust required for takeoff can be achieved with a relatively smaller gas turbine engine.

[0005] In one type of hybrid engine system the electric motor drives a driveshaft which is coaxial with the driveshaft of the gas turbine engine.

[0006] Gas turbine engines are typically mounted to allow some adjustment in relative height and attitude such as through elastomeric engine mounts to static structure. As the height and attitude of the gas turbine engine adjusts, the height and attitude of its driveshaft may also change. When this occurs, it may raise challenges.

SUMMARY

[0007] A hybrid aircraft propulsion system includes a first motor operatively connected to a propulsor via a first motor driveshaft and is mounted to an engine static structure through engine mounts operable to adjust a position of the first motor and the first motor driveshaft. A second motor is an electric motor having a second motor driveshaft which is coaxial to the first motor driveshaft. The second motor is operatively connected to the propulsor via the second motor driveshaft to selectively drive the propulsor. A height compensation structure is operatively connected to the second motor and structured to adjust axial alignment of the second motor driveshaft relative to the first motor driveshaft to make the first motor driveshaft more coaxial to the second motor driveshaft.

[0008] These and other features will be best understood from the following drawings and specification, the following is a brief description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** schematically shows a gas turbine engine and associate electric motor.

[0010] FIG. **2** shows a height compensation system for an electric motor and gas turbine engine.

[0011] FIG. **3** shows a detail of the FIG. **2** system.

[0012] FIG. **4**A shows hydraulic connections within the FIG. **2** engine.

[0013] FIG. **4**B shows a drive connection for the FIG. **3** embodiment.

[0014] FIG. **5** shows an alternative electric motor mount.

[0015] FIG. **6** shows yet another alternative electric motor mount.

[0016] FIG. **7** shows yet another alternative electric motor mount.

[0017] FIG. **8**A shows an alternative hydraulic system.

[0018] FIG. **8**B shows a drive connection for the FIGS. **5-7** embodiments.

DETAILED DESCRIPTION

[0019] FIG. **1** schematically illustrates a hybrid aircraft propulsion system including gas turbine engine **20**. The example gas turbine engine **20** is a turboprop that generally incorporates a propulsor **22**, a compressor section **24**, a combustor section **26** and a turbine section **28**. The propulsor **22** drives air for propulsion. The turbine engine **20** intakes air along a core flow path C into the compressor section **24** for compression and communication into the combustor section **26**. In the combustor section **26**, the compressed air is mixed with fuel and ignited to generate an exhaust gas flow that expands through the turbine section **28** and is exhausted through exhaust nozzle **37**. The turbine section has a high pressure turbine **30** that drives shaft **32** to drive the high pressure compressor **34**. The turbine section **28** also has a low pressure turbine **36** driving a shaft **38** to drive a low pressure compressor **40**, and the propulsor **22**. An exhaust nozzle **37** bends for packaging reasons. A bore allows shaft **104** to extend through it and be protected. Although not shown, there would be a gear connection between the shaft **38** and the propulsor **22**.

[0020] A driveshaft **104** is shown being driven by electric motor **102** to drive the shaft **38**. The electric motor **102** is controlled as described below along with the gas turbine engine **20**. The gas turbine engine **20** of FIG. **1** is shown as part of a hybrid aircraft propulsion system **100** in FIG. **2**, with the inclusion of an electric motor **102** driving a shaft **104**. Shaft **104** is connected directly to the propulsor low pressure turbine **36** of the gas turbine engine **20**.

[0021] As shown, there are elastomeric mounts **105** and **106** on the gas turbine engine **20**. Mounts **105**/**106** connect gas turbine engine **20** to static structure S, shown schematically. In practice there may be many more mounts.

[0022] As known, the elastomeric engine mounts **105** and **106** allow the height and attitude of the gas turbine engine **20** to change.

[0023] FIG. **2** shows a hydraulic actuator **110** communicates hydraulic fluid to an electric motor actuator, or height compensation structure **115** include a mount plate **112** for the electric motor **102**. Embodiments of height compensation structure **115** include hydraulic structure described in more detail with regard to FIGS. **4**A and **8**A. Also electric motor mount embodiments as shown in FIG. **3** or **5-7** are also part of height compensation structure **115**. A spring mechanism and sliding joint **114** is illustrated as one example electric motor mount.

[0024] A control **99** is shown schematically, and selectively controls gas turbine engine **20**, and electric motor **102**. The electric motor **102** is selectively driven to provide drive through driveshaft **104** to supplement rotation of the driveshaft **29** in gas turbine engine **20** under certain conditions. As one example, at high power conditions, such as takeoff, control **99** will provide supplemental electric motor power.

[0025] As another example, under certain conditions the electric motor **102** may provide sole power in place of the gas turbine engine **20**.

[0026] The control could be incorporated into a full authority digital electronic controller ("FADEC") such as are known for current hybrid engine systems.

[0027] While a gas turbine engine **20** is disclosed, broadly speaking, this application discloses a hybrid aircraft propulsion system. The gas turbine engine could be replaced by a rotary engine, a piston engine, an electric motor, or other sources of drive. Thus, for purposes of the scope of this application these could be thought of collectively as a first motor, with the electric motor being thought of as a second motor.

[0028] As shown in FIG. **3**, an electric motor mount includes spring mechanism and sliding joint **114** that includes a spring **120** biasing a plate **116** away from a static mount **122** for the electric motor **102**. A guide **121** receives a tongue **118** from the electric motor **102** such that the electric motor can adjust vertically.

[0029] FIG. **4**A shows a hydraulic system **110** associated with the gas turbine engine **20** and for providing feedback to the height compensation structure **115** as the engine **20** has its height changed.

[0030] A rear port mount **106**P and a rear starboard mount **106**S on the gas turbine engine move as the engine moves and adjusts the position of a piston **128** in hydraulic cylinders **124** and **126**. As shown, the port and starboard hydraulic cylinders are combined together with lines **130** and **132**, to average the hydraulic pressure and volume and minimize the effect of the engine rotation on the height compensation. For example, when the engine rotates due to torque, the port mount moves downward and the starboard mounts moves upward, the net hydraulic fluid to the electric actuator will be zero. However if both port and starboard mounts move in the same direction, the net hydraulic fluid will cause a piston **136** in cylinder **134** of an electric motor actuator to move, compensating for the height change. This system is utilized with system **114** of FIG. **3**.
[0031] Thus, as the gas turbine engine **20** changes its height, or adjusts its orientation between port and starboard, hydraulic fluid moves between the two cylinders **124** and **126**. However, the fluid is also delivered into opposed chambers within cylinder **134** driving a piston **136** for the height compensation system **115**. As can be appreciated, as the piston **136** moves it moves the mount plate **112** such that the location of the electric motor **102** also adjusts and responds to adjustment of the engine **20**. In this manner, the orientation of the driveshafts **104** and **27** on the electric motor **102** and the gas turbine engine **20** are brought closer to being coaxial. Again, the height compensation system **115** includes chamber **134**, piston **136**, spring **120**, plate **112** and the mount of FIG. **3**.
[0032] Since the FIG. **3** embodiment will provide height adjustment, but will not provide any ability to pivot, the FIG. **3** system is preferably used with a drive connection for shaft **104** as shown in FIG. **4**B. Flexible diaphragms **50** connect the shaft **104** to both the electric motor **102** and the low pressure turbine **36**, allowing for pivoting compensation between the engine **20** and the electric motor **102**.
[0033] FIG. **5** shows an alternative electric motor mount embodiment **139** still having the guide **144** and tongue **146** which is movable within the guide. A spring **148** biases the tongue **146** relative to a static mount **142**. The mount plate **140** is moving with the electric motor **102**. However, there is also a pivot connection **150** allowing the electric motor **102** to pivot relative to the static mount **142** as the engine adjusts its position.
[0034] FIG. **6** shows yet another electric motor mount embodiment **201** wherein the motor **102** is connected to the static structure by mount plate **154**, and through elastomeric mounting blocks **156**. This embodiment allows vertical and rotation movement.
[0035] FIG. **7** shows yet another electric motor mount embodiment **190** wherein the electric motor **102** is connected to a gimbal frame. Here a static mount plate **181** mounts the hydraulic piston **182**, and with a spring bias **184**. A first gimbal **187** is pivotally connected at **186** to the electric motor. This allows pivoting perpendicular to the rotational axis of the electric motor **102**. However, the first gimbal mount **187** is received in a second gimbal connection **188** to the static structure **181**. This allows pivoting essentially in a vertical direction as shown in FIG. **7**, that is, top to bottom of the Figure.
[0036] FIG. **8**A shows an alternative hydraulic system **200** wherein front starboard and port mounts **177** are shown with cylinders **172**S and **172**P communicating through lines **188** and **182** to a set of rear starboard and port cylinders **178**S and **178**P, and mounts **176** that are fixed to the gas turbine engine and move with a piston. The lines **188** and **182** further communicate with a single cylinder **189** having a piston **193** as part of height compensation system **191**. The front cylinders **172**S/**172**P compensate for the engine attitude and the rear cylinders **178***s*/**178**P compensate for the height of the engine. A mount plate **192** moves with piston **193** to adjust the position of the electric motor **102**. Springs **194** assist in positioning the electric motor **102**.
[0037] FIG. **8**A may be utilized with the FIGS. **5-7** embodiments to allow height adjustment and pivoting.
[0038] A driveshaft is shown in FIG. **8**B connecting the electric motor **102** to the low pressure turbine **36**. This embodiment would be utilized with the adjustment systems of FIGS. **5-7**. Since the FIGS. **5-7** systems allow pivoting movement, two diaphragms of the FIG. **4**B embodiment are not

required.

[0039] A hybrid aircraft propulsion system under this disclosure could be said to include a first motor operatively connected to a propulsor via a first motor driveshaft and is mounted to an engine static structure through mounts operable to adjust a position of the first motor and the first motor driveshaft. A second motor is an electric motor having a second motor driveshaft which is coaxial to the first motor driveshaft. The second motor is operatively connected to the propulsor via a second motor driveshaft to selectively drive the propulsor. A height compensation structure is operatively connected to the first motor driveshaft and the second motor driveshaft and structured to adjust axial alignment of the first motor driveshaft relative to the second motor driveshaft to make the first motor driveshaft more coaxial to the second motor driveshaft.

[0040] In another embodiment according to the previous embodiment, the first motor is one or more of a gas turbine engine, a rotary engine, a reciprocating engine, and an electric motor.

[0041] In another embodiment according to any of the previous embodiments, the second motor is mounted through a second motor mount such that it can slide within a guide, and is provided with a spring bias to control the amount of movement of the second motor. The second motor mount is part of the height compensation system.

[0042] In another embodiment according to any of the previous embodiments, a hydraulic connection between the first motor and the height compensation structure communicates movement of the first motor to the height compensation to provide adjustment of the height of the second motor in response to adjustment of the height of the first motor.

[0043] In another embodiment according to any of the previous embodiments, the hydraulic connection provides feedback of both an attitude change and a height change of the first motor to the height compensation structure.

[0044] In another embodiment according to any of the previous embodiments, there is the second motor mount having a pivot connection between the second motor and second motor static structure such that the second motor can pivot and move vertically with the first motor.

[0045] In another embodiment according to any of the previous embodiments, the second motor mount includes a gimbal member which is pivotally mounted to the second motor to allow pivoting movement about a first axis, and the gimbal structure is pivotally mounted to the second motor static structure such that second motor may also pivot about a second axis.

[0046] In another embodiment according to any of the previous embodiments, there are elastomeric mounting blocks as part of the second motor mount and the second motor static structure that allow the adjustment of the second motor in response to movement of the first motor.

[0047] In another embodiment according to any of the previous embodiments, there are a pair of front mount hydraulic cylinders associated with port and starboard sides of the first motor, and a pair of rear port and starboard mounts associated with the first motor, cach having fluid cylinders and fluid pistons, and communicating hydraulic fluid between opposed chambers on each side of the respective fluid pistons to each of the front starboard and port mounts and rear starboard and port mounts, and to a second motor adjustment cylinder having a second motor piston that is part of the height compensation structure.

[0048] In another embodiment according to any of the previous embodiments, the second motor driveshaft is connected to the first motor driveshaft and to the second motor through flexible diaphragms.

[0049] In another embodiment according to any of the previous embodiments, a hydraulic connection between the first motor and the height compensation structure communicates movement of the first motor to the height compensation structure to provide adjustment of the height of the second motor in response to adjustment of the height of the first motor.

[0050] In another embodiment according to any of the previous embodiments, there is a second motor mount as part of the height compensation system, with an element on the second motor is guided within a guide on the second motor mount to allow height adjustment.

[0051] In another embodiment according to any of the previous embodiments, the hydraulic connection provides feedback of both an attitude change and a height change of the first motor to the height compensation structure.
[0052] In another embodiment according to any of the previous embodiments, the second motor mount also includes a pivot connection between the second motor and second motor static structure such that the second motor can pivot and move vertically with the first motor.
[0053] In another embodiment according to any of the previous embodiments, a control for the first motor and the second motor operates the second motor selectively under high power conditions to supplement the drive from the first motor.
[0054] In another embodiment according to any of the previous embodiments, there are a pair of front mount hydraulic cylinders associated with port and starboard sides of the first motor, and a pair of rear port and starboard mounts associated with the first motor, each having fluid cylinders and fluid pistons, and communicating hydraulic fluid between opposed chambers on each side of the respective fluid pistons to each of the front starboard and port mounts and rear starboard and port mounts, and to a first second motor adjustment cylinder having a second motor piston that is part of the height compensation structure.
[0055] In another embodiment according to any of the previous embodiments, the second motor mount includes a gimbal member which is pivotally mounted to the second motor to allow pivoting movement about a first axis, and the gimbal structure is pivotally mounted to the second motor static structure such that second motor may also pivot about a second axis.
[0056] In another embodiment according to any of the previous embodiments, there are elastomeric mounting blocks as part of a second motor mount that is part of the height compensation structure and second motor static structure that allow adjustment of the second motor in response to movement of the first motor.
[0057] In another embodiment according to any of the previous embodiments, the second motor driveshaft is connected to the first motor driveshaft and to the second motor through flexible diaphragms.
[0058] In another embodiment according to any of the previous embodiments, a control for the second motor and the first motor operates the second motor selectively under high power conditions to supplement the drive from the first motor.
[0059] Although embodiments have been disclosed, a worker of skill in this art would recognize that modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the true scope and content.

Claims

1. A hybrid aircraft propulsion system, comprising: a first motor operatively connected to a propulsor via a first motor driveshaft and being mounted to an engine static structure through engine mounts operable to adjust a position of the first motor and the first motor driveshaft; a second motor, being an electric motor having a second motor driveshaft which is coaxial to the first motor driveshaft, the second motor being operatively connected to the propulsor via the second motor driveshaft to selectively drive the propulsor; and a height compensation structure operatively connected to the second motor and structured to adjust axial alignment of the second motor driveshaft relative to the first motor driveshaft to make the first motor driveshaft more coaxial to the second motor driveshaft.
2. The hybrid system as set forth in claim 1, wherein the first motor is one or more of a gas turbine engine, a rotary engine, a reciprocating engine, and an electric motor.
3. The hybrid system as set forth in claim 2, wherein the second motor is mounted through a second motor mount such that it can slide within a guide, and is provided with a spring bias to control the amount of movement of the second motor, the second motor mount being part of the height

compensation system.
4. The hybrid system as set forth in claim 3, wherein a hydraulic connection between the first motor and the height compensation structure communicates movement of the first motor to the height compensation to provide adjustment of the height of the second motor in response to adjustment of the height of the first motor.
5. The hybrid system as set forth in claim 4, wherein the hydraulic connection provides feedback of both an attitude change and a height change of the first motor to the height compensation structure.
6. The hybrid system as set forth in claim 5, wherein there is the second motor mount has a pivot connection between the second motor and second motor static structure such that the second motor can pivot and move vertically with the first motor.
7. The hybrid system as set forth in claim 6, wherein the second motor mount includes a gimbal member which is pivotally mounted to the second motor to allow pivoting movement about a first axis, and the gimbal structure is pivotally mounted to the second motor static structure such that second motor may also pivot about a second axis.
8. The hybrid system as set forth in claim 5, wherein there are elastomeric mounting blocks as part of the second motor mount and the second motor static structure that allow the adjustment of the second motor in response to movement of the first motor.
9. The hybrid system as set forth in claim 5, wherein there are a pair of front mount hydraulic cylinders associated with port and starboard sides of the first motor, and a pair of rear port and starboard mounts associated with the first motor, each having fluid cylinders and fluid pistons, and communicating hydraulic fluid between opposed chambers on each side of the respective fluid pistons to each of the front starboard and port mounts and rear starboard and port mounts, and to a second motor adjustment cylinder having a second motor piston that is part of the height compensation structure.
10. The hybrid system as set forth in claim 2, wherein the second motor driveshaft is connected to the first motor driveshaft and to the second motor through flexible diaphragms.
11. The hybrid system as set forth in claim 1, wherein a hydraulic connection between the first motor and the height compensation structure communicates movement of the first motor to the height compensation structure to provide adjustment of the height of the second motor in response to adjustment of the height of the first motor.
12. The hybrid system as set forth in claim 11, wherein there is a second motor mount as part of the height compensation system, with an element on the second motor is guided within a guide on the second motor mount to allow height adjustment.
13. The hybrid system as set forth in claim 12, wherein the hydraulic connection provides feedback of both an attitude change and a height change of the first motor to the height compensation structure.
14. The hybrid system as set forth in claim 3, wherein the second motor mount also includes a pivot connection between the second motor and second motor static structure such that the second motor can pivot and move vertically with the first motor.
15. The hybrid system as set forth in claim 14, wherein a control for the first motor and the second motor operates the second motor selectively under high power conditions to supplement the drive from the first motor.
16. The hybrid system as set forth in claim 14, wherein there are a pair of front mount hydraulic cylinders associated with port and starboard sides of the first motor, and a pair of rear port and starboard mounts associated with the first motor, each having fluid cylinders and fluid pistons, and communicating hydraulic fluid between opposed chambers on each side of the respective fluid pistons to each of the front starboard and port mounts and rear starboard and port mounts, and to a first second motor adjustment cylinder having a second motor piston that is part of the height compensation structure.
17. The hybrid system as set forth in claim 14, wherein the second motor mount includes a gimbal

member which is pivotally mounted to the second motor to allow pivoting movement about a first axis, and the gimbal structure is pivotally mounted to the second motor static structure such that second motor may also pivot about a second axis.

18. The hybrid system as set forth in claim 1, wherein there are elastomeric mounting blocks as part of a second motor mount that is part of the height compensation structure and second motor static structure that allow adjustment of the second motor in response to movement of the first motor.

19. The hybrid system as set forth in claim 1, wherein the second motor driveshaft is connected to the first motor driveshaft and to the second motor through flexible diaphragms.

20. The hybrid system as set forth in claim 1, wherein a control for the second motor and the first motor operates the second motor selectively under high power conditions to supplement the drive from the first motor.