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GEARBOX ASSEMBLY HAVING A GEAR BRAKE SYSTEM

Abstract

A gearbox assembly including a gear assembly, an input shaft, an output shaft, and a gear brake system. The input shaft is coupled to the gear assembly. The output shaft is drivingly coupled to the input shaft through the gear assembly. The gear brake system is disposed within the gear assembly, and includes one or more brake devices. The gear brake system actuates the one or more brake devices to brake the gear assembly during a reverse torque condition of the gearbox assembly.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS
[0001] The present application claims the benefit of Italian Patent Application No. 102024000002647, filed on Feb. 8, 2024, which is hereby incorporated by reference herein in its entirety.
TECHNICAL FIELD
[0002] The present disclosure relates generally to gearbox assemblies, and, particularly, to gear brake systems for gearbox assemblies.
BACKGROUND
[0003] Gearbox assemblies, such as gearbox assemblies for vehicles, transfer torque from an input shaft to an output shaft. Such vehicles can include turbine engines that generally include a propulsor (e.g., a fan or a propeller) and a turbo-engine (e.g., a compressor section, a combustion section, and a turbine section) arranged in flow communication with one another. The gearbox assembly in a turbine engine transfers torque and power from the turbo-engine to the propulsor.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0004] The foregoing and other features and advantages will be apparent from the following, more particular, description of various exemplary embodiments, as illustrated in the accompanying drawings, wherein like reference numbers generally indicate identical, functionally similar, or structurally similar elements.
[0005] FIG. **1** is a schematic cross-sectional diagram of a turbine engine, taken along a longitudinal centerline axis of the turbine engine, according to the present disclosure.
[0006] FIG. **2**A is a schematic partial cross-sectional view of a gearbox assembly of the turbine engine of FIG. **1**, taken along section line **2**A-**2**A, and having a gear brake system in an unactuated state, according to the present disclosure.
[0007] FIG. **2**B is a schematic partial cross-sectional view of the gearbox assembly with the gear brake system in an actuated state, according to the present disclosure.
[0008] FIG. **2**C is a schematic cross-sectional view of the gearbox assembly, taken at detail **2**C in FIG. **1**, and having the gear brake system in the actuated state, according to the present disclosure.
[0009] FIG. **3** is a schematic cross-sectional view of the gearbox assembly having a gear brake system in an actuated state, according to another embodiment.
DETAILED DESCRIPTION
[0010] Features, advantages, and embodiments of the present disclosure are set forth or apparent from a consideration of the following detailed description, drawings, and claims. Moreover, the following detailed description is exemplary and intended to provide further explanation without limiting the scope of the disclosure as claimed.
[0011] Various embodiments of the present disclosure are discussed in detail below. While specific embodiments are discussed, this is done for illustration purposes only. A person skilled in the relevant art will recognize that other components and configurations may be used without departing from the spirit and the scope of the present disclosure.
[0012] As used herein, the terms “first,” “second,” “third,” and “fourth” may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components.
[0013] The terms “upstream” and “downstream” refer to the relative direction with respect to fluid flow in a fluid pathway. For example, “upstream” refers to the direction from which the fluid flows, and “downstream” refers to the direction to which the fluid flows.
[0014] The terms “forward” and “aft” refer to relative positions within a turbine engine or vehicle,

and refer to the normal operational attitude of the turbine engine or vehicle. For example, with regard to a high-bypass turbine engine, forward refers to a position closer to an engine inlet and aft refers to a position closer to an engine nozzle or exhaust. In one example, in a reverse flow turbine engine, forward refers to a position closer to the engine nozzle or exhaust and aft refers to a position closer to an engine inlet.

[0015] The terms “coupled,” “fixed,” “attached,” “connected,” and the like, refer to both direct coupling, fixing, attaching, or connecting, as well as indirect coupling, fixing, attaching, or connecting through one or more intermediate components or features, unless otherwise specified herein.

[0016] The singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise.

[0017] As used herein, the terms “axial” and “axially” refer to directions and orientations that extend substantially parallel to a centerline of the turbine engine. Moreover, the terms “radial” and “radially” refer to directions and orientations that extend substantially perpendicular to the centerline of the turbine engine. In addition, as used herein, the terms “circumferential” and “circumferentially” refer to directions and orientations that extend arcuately about the centerline of the turbine engine.

[0018] As used herein, a “propulsor” is a component of the turbine engine that is drivingly coupled to the turbo-engine such that rotation of the components of the turbo-engine causes the propulsor to rotate and to generate thrust. A propulsor can include a fan or a propeller. In turbofan engines (ducted fan engines or unducted fan engines), the propulsor is a fan. In turboprop engines, the propulsor is a propeller.

[0019] As used herein, “stiff” or “stiffness” is the extent that an object resists deformation in response to an applied force on the object. The more stiff an object is (e.g., greater stiffness), the less flexible the object is and the more the object resists deformation in response to the applied force on the object (e.g., the object does not bend or deform under the applied force). Likewise, the less stiff an object is (e.g., lesser stiffness), the more flexible the object is and the less the object resists deformation in response to the applied force on the object (e.g., the object bends or deforms under the applied force).

[0020] As used herein, “normal operation” of a gearbox assembly, a turbine engine, or a vehicle is intended to mean when the gearbox assembly, the turbine engine, or the vehicle is operating, and torque is transferred from an input shaft to an output shaft through a gear assembly of the gearbox assembly in an operational torque direction. This causes the output shaft to rotate in an operational rotational direction. In the case of a turbine engine, the torque is transferred from the turbo-engine (e.g., via a low-pressure shaft) to the propulsor (e.g., via a propulsor shaft) through the gear assembly during the normal operation of the turbine engine.

[0021] As used herein, a “reverse torque condition” is when the torque through the gear assembly changes from the operational torque direction. In one example, the reverse torque condition occurs when torque is transferred from the output shaft to the input shaft through the gear assembly in a reverse torque direction that is opposite the operational torque direction. In another example, the reverse torque condition occurs when the output shaft is operating in the operational rotational direction, and the torque is transferred from the output shaft through the gear assembly causing the output shaft to decelerate. The reverse torque condition can occur when the gearbox assembly, the turbine engine, or the vehicle is operating or is shut down. In the case of a turbine engine, the reverse torque condition can occur when the propulsor is windmilling and causing the propulsor shaft to rotate, thereby rotating the gears of the gearbox assembly.

[0022] As used herein, “windmill” or “windmilling” is a condition when the propulsor and the low-pressure shaft of the turbine engine continue to rotate at low speeds, while the high-pressure shaft rotates slowly or even stops. Windmilling can occur when the turbine engine is shut down, but air still flows across the propulsor, such as during an in-flight engine shutdown or when the turbine engine is on the ground and the propulsor is rotating in the presence of wind when the turbine engine is shut down. During windmilling, torque is transferred from the propulsor (e.g., via the propulsor shaft) to the turbo-engine (e.g., via the low-pressure shaft) through the gear assembly, therefore the forces (e.g., the torques) are oriented in a direction that is opposite to the operational torque direction.

[0023] Approximating language, as used herein throughout the specification and claims, is applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as “about,” “approximately,” “generally,” and “substantially” is not to be limited to the precise value specified. In at least some instances, the approximating language may correspond to the precision of an instrument for measuring the value, or the precision of the methods or the machines for constructing the components or the systems or manufacturing the components or the systems. For example, the approximating language may refer to being within a one, a two, a four, a ten, a fifteen, or a twenty percent margin in either individual values, range(s) of values or endpoints defining range(s) of values.

[0024] The present disclosure provides for a gearbox assembly for a vehicle, having one or more bearings therein. In operation, the gearbox assembly transfers torque from an input shaft to an output shaft through the gear assembly. In one embodiment, the gearbox assembly is for a turbine engine, and the input shaft is a low-pressure shaft of a turbo-engine of the turbine engine and the output shaft is a propulsor shaft of the turbine engine. In this way, the turbo-engine transfers torque to the propulsor shaft through the gearbox assembly to rotate a propulsor of the turbine engine.

[0025] The bearings allow rotation of one or more gears of the gearbox assembly about the bearings. In one embodiment, one or more of the bearings are journal bearings. The bearings can include any type of bearings, such as, for example, roller bearings, ball bearings, or the like. The bearings, especially, journal bearings, are hydrodynamic bearings that typically require a steady supply of lubricant during all operational phases of the gearbox assembly to properly lubricate the bearings to prevent damage due to sliding contact for hydrodynamic journal bearings or even for the generic gear mesh interface. Typically, a lubrication system supplies the lubricant to the bearings during operation of the gearbox assembly (e.g., while the turbine engine or the vehicle is powered on and operating).

[0026] The input shaft or the output shaft of the gearbox assembly may experience long duration, continued rotation following a shutdown of the turbine engine. For example, torque may be transferred from the output shaft to the input shaft in a reverse torque condition when the gearbox assembly is shut down. In one embodiment, this reverse torque condition occurs when the propulsor of the turbine engine is windmilling. In such instances, the bearings can be affected by not receiving enough lubricant for lubricating the bearings. For example, during the reverse torque condition (e.g., windmilling), the rotational speed of the shafts may be too low to power a pump that pumps the lubricant to the bearings. In some instances, e.g., during operation of the vehicle (e.g., when the turbine engine of an aircraft is in-flight), the lubrication system may lose pressure (e.g., due to a failure of the pump or other components of the lubrication system), such that the lubrication system is unable to provide the lubricant to the bearings.

[0027] The criticality of the lubricant interruptions increases when the bearings are journal bearings, since the absence of lubricant at the journal bearings can lead to a journal bearing failure and subsequent gearbox failure, which may cause the input shaft (e.g., the low-pressure shaft) to lock up permanently. Such a failure of the journal bearings is referred to as a journal bearing seizure and occurs when there is contact between a pin and a bore of one of the gears of the gear assembly, thereby causing a significant increase of wear and friction that leads to bearing failure. If contact occurs between the journal bearing and the pin during high-power operation, the two components can become welded together due to the high temperature from the friction.

[0028] Some gearbox assemblies include an auxiliary lubrication system that includes an auxiliary pump to supply lubricant to the bearings to prevent damage to the bearings due to inadequate lubricant supply during the reverse torque condition. Such auxiliary lubrication systems, however, require added complexity for driving the auxiliary pump. Further, the auxiliary pump requires added complexity to provide the lubricant during high speeds, such as during operation of the gearbox assembly (e.g., of the turbine engine or the vehicle), and during low speeds, such as during the reverse torque condition (e.g., during windmilling). During the reverse torque condition, the propulsor can rotate in a reverse torque rotational direction that is opposite an operational rotational direction of the gearbox assembly. This adds significant complexity to the auxiliary pump as the auxiliary pump needs to operate over a large speed range, and provide a flow of the lubricant regardless of the rotational direction of the output shaft (e.g., of the propulsor).

[0029] Accordingly, the present disclosure provides a gear brake system that brakes one or more of the gears of the gear assembly to prevent the gears from rotating, thereby preventing the output shaft (e.g., and the propulsor) from rotating. The gear brake system actuates to brake (e.g., to lock) the gears in response to the reverse torque condition (e.g., the output shaft transfers torque to the input shaft). The gear brake system includes one or more brake devices, such as brake pads, or the like, and a brake fluid reservoir that stores brake fluid therein. The brake fluid reservoir is disposed within at least one of the gears, and, in particular, is disposed within the pin of the gears. The pin includes a variable stiffness such that a first side of the pin has a greater stiffness than a second side of the pin. For example, the first side of the pin is a side that an operational load is applied on the pin (e.g., a load from the gears while the gearbox assembly is operating during normal operation). Thus, the brake fluid reservoir is disposed within the pin on the second side of the pin.

[0030] The gear brake system passively actuates the brake devices during the reverse torque condition. For example, the reverse torque condition causes the gears to apply a reverse torque condition load on the second side (rather than the first side). This reverse torque condition load causes the pin to deform at the second side such that the pin squeezes the brake fluid reservoir and forces the brake fluid out of the brake fluid reservoir. The brake fluid actuates the brake devices such that the brake devices contact, and apply friction on, one or more of the gears to brake the gears and to prevent the gears from rotating. During the reverse torque condition, the output shaft transfers torque and power at a lower magnitude (e.g., about 150 horsepower) than the torque and the power during the normal operation. Thus, the torque is relatively low during the reverse torque condition relative to the torque during the normal operation, and the brake devices are able to brake the gears during the reverse torque condition. The gear brake system is a closed brake fluid circuit such that the brake fluid is recycled back to the brake fluid reservoir when the brake devices are unactuated.

[0031] Accordingly, the gear brake system of the present disclosure brakes or locks the gears to prevent rotation of the gears. With no rotation of the gears, the bearings do not require the lubricant. Thus, the gear brake system prevents bearing seizure during the reverse torque condition without having to supply lubricant to the bearings during the reverse torque condition. Therefore, the gear brake system of the present disclosure eliminates the need for an auxiliary lubrication system and reduces complexity of the lubrication system as compared to gearbox assemblies without the benefit of the present disclosure. Further, the closed brake fluid circuit placed within a single component (e.g., within the pin) reduces the possibility of a leak as compared to brake systems without the benefit of the present disclosure.

[0032] Referring now to the drawings, FIG. **1** is a schematic cross-sectional diagram of a turbine engine **10**, taken along a longitudinal centerline axis **12** of the turbine engine **10**, according to an embodiment of the present disclosure. As shown in FIG. **1**, the turbine engine **10** defines an axial direction A extending parallel to the longitudinal centerline axis **12**, a radial direction R that is normal to the axial direction A, and a circumferential direction C that extends arcuately about the longitudinal centerline axis **12**.

[0033] In general, the turbine engine **10** includes a propulsor section **14** and a turbo-engine **16** disposed downstream from the propulsor section **14**. The turbo-engine **16** includes, in serial flow relationship, a compressor section **21**, a combustor **26**, and a turbine section **27**. The turbo-engine **16** is substantially enclosed within an outer casing **18** that is substantially tubular and defines a core inlet **20** that is annular about the longitudinal centerline axis **12**. As schematically shown in FIG. **1**, the compressor section **21** includes a booster or a low-pressure (LP) compressor **22** followed downstream by a high-pressure (HP) compressor **24**. The combustor **26** is downstream of the compressor section **21**. The turbine section **27** is downstream of the combustor **26** and includes a high-pressure (HP) turbine **28** followed downstream by a low-pressure (LP) turbine **30**. The turbo-engine **16** further includes a jet exhaust nozzle section **32** that is downstream of the turbine section **27**, a high-pressure (HP) shaft **34**, and a low-pressure (LP) shaft **36**. The HP shaft **34** drivingly connects the HP turbine **28** to the HP compressor **24**, and the HP compressor **24**, the HP turbine **28**, and the HP shaft **34** are together referred to as an HP spool. The HP turbine **28** and the HP compressor **24** rotate in unison through the HP shaft **34**. The LP shaft **36** drivingly connects the LP turbine **30** to the LP compressor **22**, and the LP compressor **22**, the LP turbine **30**, and the LP shaft **36** are together referred to as an LP spool. The LP turbine **30** and the LP compressor **22** rotate in unison through the LP shaft **36**. The compressor section **21**, the combustor **26**, the turbine section **27**, and the jet exhaust nozzle section **32** together define a core air flow path.

[0034] For the embodiment depicted in FIG. **1**, the propulsor section **14** includes a propulsor **38** (e.g., a variable pitch propulsor) having a plurality of propulsor blades **40** coupled to a disk **42** in a spaced apart manner. In the embodiment of FIG. **1**, the propulsor **38** is a fan that is driven by the turbo-engine **16**. In some embodiments, the propulsor **38** is a propeller that is driven by the turbo-engine **16**. The propulsor blades **40** extend outwardly from the disk **42** generally along the radial direction R. In the case of a variable pitch propulsor, the plurality of propulsor blades **40** is rotatable relative to the disk **42** about a pitch axis P by virtue of the propulsor blades **40** being operatively coupled to an actuation member **44** configured to collectively vary the pitch of the propulsor blades **40** in unison. The propulsor blades **40**, the disk **42**, and the actuation member **44** are together rotatable about the longitudinal centerline axis **12** via a propulsor shaft **45** that is powered by the LP shaft **36** across a power gearbox, also referred to as a gearbox assembly **46** (e.g., the turbine engine **10** is an indirect drive engine). In this way, the propulsor **38** is drivingly coupled to, and powered by, the turbo-engine **16**. The gearbox assembly **46** is shown schematically in FIG. **1**. The gearbox assembly **46** is a reduction gearbox assembly for adjusting the rotational speed of the propulsor shaft **45** and, thus, the propulsor **38** relative to the LP shaft **36** when power is transferred from the LP shaft **36** to the propulsor shaft **45**.

[0035] Referring still to the exemplary embodiment of FIG. **1**, the disk **42** is covered by a propulsor hub **48** that is aerodynamically contoured to promote an airflow through the plurality of propulsor blades **40**. In addition, the propulsor section **14** includes an annular casing or a nacelle **50** that circumferentially surrounds the propulsor **38** and at least a portion of the turbo-engine **16**. The nacelle **50** is supported relative to the turbo-engine **16** by a plurality of outlet guide vanes **52** that are circumferentially spaced about the nacelle **50** and the turbo-engine **16**. Moreover, a downstream section **54** of the nacelle **50** extends over an outer portion of the turbo-engine **16**, and, with the outer casing **18**, defines a bypass airflow passage **56** therebetween.

[0036] During operation of the turbine engine **10**, a volume of air **58** enters the turbine engine **10** through an inlet **60** of the nacelle **50** or the propulsor section **14**. As the volume of air **58** passes across the propulsor blades **40**, a first portion of air, also referred to as bypass air **62**, is directed into the bypass airflow passage **56**. At the same time, a second portion of air, also referred to as core air **64**, is directed into the upstream section of the core air flow path through the core inlet **20** of the LP compressor **22**. The ratio between the bypass air **62** and the core air **64** is commonly known as a bypass ratio. The pressure of the core air **64** is then increased through the LP compressor **22**, generating compressed air **65**. The compressed air **65** is directed through the HP compressor **24**, where the pressure of the compressed air **65** is further increased. The compressed air **65** is then directed into the combustor **26**, where the compressed air **65** is mixed with fuel and ignited to generate combustion gases **66**.

[0037] The combustion gases **66** are directed into the HP turbine **28** and expanded through the HP turbine **28** where a portion of thermal energy or kinetic energy from the combustion gases **66** is extracted via one or more stages of HP turbine stator vanes **68** and HP turbine rotor blades **70** that are coupled to the HP shaft **34**. This causes the HP shaft **34** to rotate, thereby supporting operation of the HP compressor **24** through the HP shaft **34** (self-sustaining cycle). In this way, the combustion gases **66** do work on the HP turbine **28**. The combustion gases **66** are then directed into the LP turbine **30** and expanded through the LP turbine **30**. Here, a second portion of the thermal energy or the kinetic energy is extracted from the combustion gases **66** via one or more stages of LP turbine stator vanes **72** and LP turbine rotor blades **74** that are coupled to the LP shaft **36**. This causes the LP shaft **36** to rotate, thereby supporting operation of the LP compressor **22** (self-sustaining cycle) and rotation of the propulsor **38** through the LP shaft **36** via the gearbox assembly **46**. In this way, the combustion gases **66** do work on the LP turbine **30**.

[0038] The combustion gases **66** are subsequently directed through the jet exhaust nozzle section **32** of the turbo-engine **16** to provide propulsive thrust. Simultaneously, the bypass air **62** is routed through the bypass airflow passage **56** before being exhausted from a propulsor nozzle exhaust section **76** of the turbine engine **10**, also providing propulsive thrust. The HP turbine **28**, the LP turbine **30**, and the jet exhaust nozzle section **32** at least partially define a hot gas path **78** for routing the combustion gases **66** through the turbo-engine **16**.

[0039] The turbine engine **10** depicted in FIG. **1** is by way of example only. In other exemplary embodiments, the turbine engine **10** may have any other suitable configuration. For example, in other exemplary embodiments, the propulsor **38** may be configured in any other suitable manner (e.g., as a fixed pitch propulsor) and further may be supported using any other suitable propulsor frame configuration. Moreover, in other exemplary embodiments, any other suitable number or configuration of compressors, turbines, shafts, or a combination thereof may be provided. In still other exemplary embodiments, aspects of the present disclosure may be incorporated into any other suitable turbine engine, such as, for example, turbofan engines, propfan engines, turbojet engines, turboprop, or turboshaft engines.

[0040] FIG. **2**A is a schematic partial cross-sectional view of the gearbox assembly **46**, taken along section line **2**A-**2**A of FIG. **1**, and having a gear brake system **200** in an unactuated state, according to the present disclosure. FIG. **2**B is a schematic partial cross-sectional view of the gearbox assembly **46** with the gear brake system **200** in an actuated state, according to the present disclosure. FIG. **2**C is a schematic cross-sectional view of the gearbox assembly **46**, taken at detail **2**C in FIG. **1**, and having the gear brake system **200** in the actuated state, according to the present disclosure.

[0041] The gearbox assembly **46** includes a gear assembly **100**, an input shaft **101** (FIG. **2**C), and an output shaft **103** (FIG. **2**C). The output shaft **103** is drivingly coupled to the input shaft **101** through the gear assembly **100**. In the embodiment of FIGS. **1** to **2**C, the input shaft **101** is the LP shaft **36** (FIG. **1**) and the output shaft **103** is the propulsor shaft **45** (FIG. **1**) such that the turbo-engine **16** (FIG. **1**) drives the propulsor **38** (FIG. **1**) through the gearbox assembly **46**, as detailed above. In some embodiments, the gearbox assembly **46** can be utilized in applications other than turbine engines, such as, for example in automobiles, or the like. In such applications, the input shaft **101** can be coupled to a crankshaft of the automobile (e.g., via a flywheel therebetween) and the output shaft **103** can be a shaft of the automobile's transmission for providing power to the wheels of the automobile through the gearbox assembly.

[0042] The gear assembly **100** includes a plurality of gears **102**, **104**, and **106**. The plurality of gears **102**, **104**, and **106** include a first gear **102**, a second gear **104**, and a third gear **106**. In FIGS. **2**A to **2**C, the first gear **102** is a sun gear, the second gear **104** is a planet gear, and the third gear **106** is a ring gear. While one first gear **102**, one second gear **104**, and one third gear **106** are shown in FIGS. **2**A to **2**C, the gear assembly **100** can include one or more first gears **102**, one or more second gears **104**, and one or more third gears **106**. The second gear **104** is constrained by a second gear carrier **105** (FIG. **2**C).

[0043] The gear assembly **100** can be arranged as an epicyclic gear assembly. When the gear assembly **100** is an epicyclic gear assembly, the gear assembly **100** includes a plurality of second gears **104** (e.g., two or more second gears **104**). In the epicyclic gear assembly, the gear assembly **100** can be in a star arrangement or a rotating ring gear type gear assembly (e.g., the third gear **106** is rotating about the longitudinal centerline axis **12** and the second gear carrier **105** is fixed and stationary). In such an arrangement, the output shaft **103** is driven by the third gear **106**. For example, the third gear **106** is coupled to the propulsor shaft **45** (FIG. **1**) such that rotation of the third gear **106** causes the propulsor shaft **45**, and, thus, the propulsor **38**, to rotate. In this way, the third gear **106** is an output of the gear assembly **100**. However, other suitable types of gear assemblies may be employed. In one non-limiting embodiment, the gear assembly **100** is a planetary arrangement, in which the third gear **106** is held fixed, with the second gear carrier **105** (FIG. **2**C) allowed to rotate. In such an arrangement, the output shaft **103** is driven by the second gear carrier **105**. For example, the second gear carrier **105** is coupled to the propulsor shaft **45** such that rotation of the second gear carrier **105** causes the propulsor shaft **45**, and, thus, the propulsor **38**, to rotate. In this way, the second gear **104** (e.g., via the second gear carrier **105**) is the output of the gear assembly **100**. In another non-limiting embodiment, the gear assembly **100** may be a differential gear assembly in which the third gear **106** and the second gear carrier **105** are both allowed to rotate. While an epicyclic gear assembly is detailed herein, the gear assembly **100** can include any type of gear assembly including, for example, a compound gear assembly, a multiple stage gear assembly, or the like.

[0044] The first gear **102** includes a plurality of first gear teeth **108** (only one shown in FIGS. **2**A and **2**B). The plurality of first gear teeth **108** are disposed on an external surface of the first gear **102**. The second gear **104** includes a plurality of second gear teeth **110** (only two shown in FIGS. **2**A and **2**B). The plurality of second gear teeth **110** are disposed on an external surface of the second gear **104**. The third gear **106** includes a plurality of third gear teeth **112** (only one shown in FIGS. **2**A and **2**B). The plurality of third gear teeth **112** are disposed on an internal surface of the third gear **106**. The plurality of first gear teeth **108**, the plurality of second gear teeth **110**, and the plurality of third gear teeth **112** can include spur gear teeth (e.g., gear teeth extending substantially parallel with a gear longitudinal centerline axis of the respective gear), helical gear teeth (e.g., gear teeth extending at a non-zero angle with respect to the gear longitudinal centerline axis), or the like.

[0045] The first gear **102** is coupled to the input shaft **101** (FIG. **2**C) of the gearbox assembly **46** such that rotation of the input shaft **101** causes the first gear **102** to rotate. In particular, the first gear **102** is coupled to the LP shaft **36** (FIG. **1**) such that rotation of the LP shaft **36** causes the first gear **102** to rotate. Radially outward of the first gear **102**, and intermeshing therewith, is the second gear **104** that is supported by the second gear carrier **105**. In particular, the plurality of second gear teeth **110** intermesh with the plurality of first gear teeth **108**. The second gear carrier **105** supports and constrains the second gear **104** such that the second gear **104** is enabled to rotate about a second gear longitudinal centerline axis **107** (FIG. **2**C) of the second gear **104** without rotating about the periphery of the first gear **102**. Radially outwardly of the second gear **104**, and intermeshing therewith, is the third gear **106**, which is an annular ring gear. In particular, the plurality of third gear teeth **112** intermesh with the plurality of second gear teeth **110**. The third gear **106** is coupled via the output shaft **103** (FIG. **2**C) and rotates to drive rotation of the output shaft **103** about the longitudinal centerline axis **12**. In particular, the third gear **106** is coupled via the propulsor shaft **45** (FIG. **1**) to the propulsor **38** (FIG. **1**) and rotates to drive rotation of the propulsor **38** about the longitudinal centerline axis **12**.

[0046] The second gear **104** includes a second gear pin **120**, about which the second gear **104** rotates. In particular, the second gear pin **120** is disposed within the second gear **104** and the second gear **104** rotates with respect to the second gear pin **120**. The second gear pin **120** is hollow and defines a hollow interior **122**. The second gear pin **120** is coupled with the second gear carrier **105** (FIG. **2**C) such that the second gear pin **120** is a static component and is prevented from rotating about the second gear longitudinal centerline axis **107** (FIG. **2**C). In this way, the second gear **104** is constrained by the second gear carrier **105**.

[0047] The second gear **104** includes one or more second gear bearings **130** disposed therein. The one or more second gear bearings **130** enable the second gear **104** to rotate about the one or more second gear bearings **130** such that the second gear **104** rotates about the second gear longitudinal centerline axis **107** (FIG. **2**C). The one or more second gear bearings **130** can include any type of bearing for a gear, such as, for example, journal bearings, roller bearings, or the like. In the embodiment of FIGS. **2**A to **2**C, the one or more second gear bearings **130** include a journal bearing defined between the second gear pin **120** and the second gear **104**. For example, a lubricant (e.g., oil) is provided between the second gear pin **120** and the second gear **104** such that a lubricant film is formed between an outer surface of the second gear pin **120** and an inner surface of the second gear **104**. The lubricant film maintains a space or a gap between the second gear **104** and the second gear pin **120** such that the second gear **104** rotates with respect to the second gear pin **120**.

[0048] The second gear **104** and the second gear pin **120** may be viewed with respect to a “clock” orientation having a twelve o'clock position, a three o'clock position, a six o'clock position, and a nine o'clock position when viewed in the orientation of FIGS. **2**A and **2**B. Although not provided with reference numerals, the clock orientation is understood to include all clock positions therebetween. The twelve o'clock position is positioned at a top of the second gear **104** and the second gear pin **120**, the three o'clock position is positioned ninety degrees (90°) from the twelve o'clock position, the six o'clock position is positioned at a bottom of the second gear **104** and the second gear pin **120** and is one hundred eighty degrees (180°) from the twelve o'clock position, and the nine o'clock position is positioned ninety degrees (90°) from the six o'clock position.

[0049] The second gear pin **120** includes a stiff portion **124** and a deformable portion **126**. The stiff portion **124** has a greater stiffness than the deformable portion, and resists deformation when an operational load is applied on the second gear pin **120** during the normal operation of the gearbox assembly **46** (e.g., during the normal operation of the turbine engine **10**), as detailed further below. The deformable portion **126** has a lesser stiffness than the stiff portion **124**, and deforms when a reverse torque load is applied on the second gear pin **120** during the reverse torque condition of the gearbox assembly **46**, as detailed further below. For example, the deformable portion **126** can have a lesser thickness than the stiff portion **124**. In some embodiments, the deformable portion **126** is made of a material that has a lesser stiffness than a material of the stiff portion **124**. For example, the deformable portion **126** can be made of a material having a lesser modulus of elasticity than the material of the stiff portion **124** of the second gear pin **120**.

[0050] The stiff portion **124** is defined on a first side of the second gear pin **120** and the deformable portion **126** is defined on a second side of the second gear pin **120** that is opposite the first side. In particular, the stiff portion **124** is defined between the six o'clock position and the twelve o'clock position of the second gear pin **120** in a clockwise direction. The deformable portion **126** is defined between the twelve o'clock position and the six o'clock position of the second gear pin **120** in the clockwise direction. In this way, the stiff portion **124** is positioned generally at the nine o'clock position, and the deformable portion **126** is positioned generally at the three o'clock position. In some embodiments, the deformable portion **126** can include a gradient stiffness such that the stiffness of the second gear pin **120** decreases from the stiff portion **124** to the deformable portion **126**. For example, the stiffness decreases from the twelve o'clock position and the six o'clock position to the three o'clock position of the second gear pin **120**.

[0051] The gear brake system **200** includes one or more brake devices **202**, a brake fluid reservoir **204**, and one or more brake fluid lines **206**. In FIGS. **2**A to **2**C, the one or more brake devices **202** are brake pads that apply friction against the second gear **104** when actuated to brake (e.g., to lock) the second gear **104** to prevent the second gear **104** from rotating, as detailed further below. The one or more brake devices **202** include a friction material that applies friction on the second gear **104** to brake the second gear **104**. The friction material can include, for example, a rubber material, a ceramic material, composite materials, metallic materials, or the like. In the embodiment of FIGS. **2**A to **2**C, the one or more brake devices **202** include a first brake device **202***a* and a second brake device **202***b*. The first brake device **202***a* is positioned generally at a radially top portion of the second gear pin **120** (e.g., generally at the twelve o'clock position of the second gear pin **120**). The second brake device **202***b* is positioned generally at a radially bottom portion of the second gear pin **120** (e.g., generally at the six o'clock position of the second gear pin **120**). The gear brake system **200** actuates the one or more brake devices **202** to contact the second gear **104** and to prevent the second gear **104** from rotating, as detailed further below.

[0052] The brake fluid reservoir **204** stores a brake fluid **208** therein. The brake fluid is a hydraulic fluid, such as, for example, water, oil, mineral oil, a glycol-ether fluid, a silicone-based fluid, or the like. The brake fluid reservoir **204** is disposed within the second gear **104**. In particular, the brake fluid reservoir **204** is disposed within the hollow interior **122** of the second gear pin **120**. The brake fluid reservoir **204** is positioned within the second gear pin **120** generally at the deformable portion **126** of the second gear pin **120**. In particular, the brake fluid reservoir **204** is positioned between the twelve o'clock position and the six o'clock position (e.g., generally at the three o'clock position) in the clockwise direction. The brake fluid reservoir **204** is positioned in the second gear pin **120** such that the second gear pin **120** (the deformable portion **126**) contacts the brake fluid reservoir **204** during the reverse torque condition, as detailed further below. The brake fluid reservoir **204** is made of a deformable material and can include a thin wall such that the brake fluid is directed out of the brake fluid reservoir when the brake fluid reservoir deforms. The thin wall of the brake fluid reservoir **204** is in fluid communication with the one or more brake fluid lines **206**. In some embodiments, the gear brake system **200** includes one or more valves (e.g., check valves, or the like) in fluid communication with the brake fluid reservoir **204** and the one or more brake fluid lines **206** such that the brake fluid is directed into the one or more brake fluid lines **206** through the one or more valves when the brake fluid reservoir **204** is deformed.

[0053] The one or more brake fluid lines **206** are in fluid communication with the one or more brake devices **202** and the brake fluid reservoir **204**. In this way, the one or more brake fluid lines **206** direct the brake fluid from the brake fluid reservoir **204** to the one or more brake devices **202** to actuate the one or more brake devices **202**, as detailed further below. The one or more brake fluid lines **206** include a first brake fluid line **206***a* and a second brake fluid line **206***b*. The first brake fluid line **206***a* is in fluid communication with the first brake device **202***a*. The second brake fluid line **206***b* is in fluid communication with the second brake device **202***b*.

[0054] During the normal operation of the gearbox assembly **46** (e.g., of the turbine engine **10** of FIG. **1**), the input shaft **101** (FIG. **2**C) rotates and transfers power to the output shaft **103** (FIG. **2**C) through the gearbox assembly **46**. In particular, the LP shaft **36** (FIG. **1**) rotates and transfers power to the propulsor shaft **45** (FIG. **1**) through the gearbox assembly **46** to rotate the propulsor **38** (FIG. **1**), as detailed above with respect to FIG. **1**. With reference to FIG. **2**A, during the normal operation, the gear brake system **200** is unactuated such that the one or more brake devices **202** are spaced from the second gear **104** and are prevented from contacting the second gear **104** (e.g., the gear assembly **100** is unlocked). This allows the plurality of gears **102**, **104**, and **106** of the gear assembly **100** to rotate during the normal operation. The first gear **102** rotates in a first gear operational rotational direction **150**. As the first gear **102** rotates, the plurality of first gear teeth **108** intermesh with the plurality of second gear teeth **110**, thereby reacting against the plurality of first gear teeth **108**. This causes torque to be transferred from the first gear **102** to the second gear **104**, thereby rotating the second gear **104** in a second gear operational rotational direction **152**. The second gear operational rotational direction **152** is opposite the first gear operational rotational direction **150**. At the same time, the plurality of second gear teeth **110** intermesh with the plurality of third gear teeth **112**, thereby reacting against the plurality of third gear teeth **112**.

[0055] In the star arrangement of the gear assembly **100**, this causes the torque to be transferred from the second gear **104** to the third gear **106**, thereby rotating the third gear **106** and the output shaft **103** (FIG. **2**C). For example, the third gear **106** rotates the propulsor shaft **45** (FIG. **1**), thereby causing the propulsor **38** (FIG. **1**) to rotate. In the planetary arrangement of the gear assembly **100**, the second gear **104** rotates about the longitudinal centerline axis **12** and the third gear **106** is stationary such that the third gear **106** applies a reaction torque against the second gear **104**. In this way, the second gear **104** rotates the output shaft **103** via the second gear carrier **105** (FIG. **2**C). For example, the second gear **104** (via the second gear carrier **105**) rotates the propulsor shaft **45**, thereby causing the propulsor **38** to rotate.

[0056] The intermeshing of the plurality of second gear teeth **110** with the plurality of first gear teeth **108** and the plurality of third gear teeth **112** applies a gear teeth operational load **154** on the plurality of second gear teeth **110** in a first gear teeth load direction. As the second gear **104** rotates, the second gear **104** applies a second gear operational load **156** on the second gear pin **120**. The second gear **104** applies the second gear operational load **156** on the stiff portion **124** of the second gear pin **120**. The stiff portion **124** prevents the second gear pin **120** from deforming under the second gear operational load **156**. Accordingly, the second gear pin **120** is prevented from contacting the brake fluid reservoir **204** during the normal operation. In this way, the gear brake system **200** is prevented from actuating the one or more brake devices **202** and braking the second gear **104**, and, thus, the output shaft **103**, during the normal operation. For example, the LP shaft **36** rotates the propulsor shaft **45** through the gearbox assembly **46** and torque is transferred from the LP shaft **36** to the propulsor shaft **45** to rotate the propulsor **38** during the normal operation.

[0057] With reference to FIGS. **2**B and **2**C, during a reverse torque condition (e.g., during windmilling), the torque is transferred from the output shaft **103** (FIG. **2**C) to the input shaft **101** (FIG. **2**C) through the gearbox assembly **46**. For example, the windmilling causes the propulsor **38** (FIG. **1**) to rotate, thereby rotating the output shaft **103** (e.g., the propulsor shaft **45**). In this way, the torque transfer through the gearbox assembly **46** is in an opposite direction as to the torque transfer during the normal operation. To prevent the plurality of gears **102**, **104**, and **106** from rotating, the present disclosure provides for a method of braking the gear assembly **100** by actuating the one or more brake devices **202** to brake the gear assembly **100** during the reverse torque condition, as detailed further below. During the reverse torque condition, the second gear **104** tends to rotate in a second gear reverse torque rotational direction **162** that is opposite the second gear operational rotational direction **152** (FIG. **2**A).

[0058] The intermeshing of the plurality of second gear teeth **110** with the plurality of first gear teeth **108** and the plurality of third gear teeth **112** applies a gear teeth reverse torque load **164** on the plurality of second gear teeth **110** in a second gear teeth load direction that is opposite the first gear teeth load direction. As the second gear **104** tends to rotate, the second gear **104** applies a second gear reverse torque load **166** on the second gear pin **120**. The second gear **104** applies the second gear reverse torque load **166** on the deformable portion **126** of the second gear pin **120**. In this way, the second gear pin **120** deforms under the second gear reverse torque load **166**. In other words, the second gear **104** squeezes the second gear pin **120** during the reverse torque condition. Accordingly, the second gear pin **120** contacts and applies a force on the brake fluid reservoir **204** during the reverse torque condition. The force causes the brake fluid reservoir **204** to deform such that the brake fluid is directed out of the brake fluid reservoir **204** and into the one or more brake fluid lines **206**. The one or more brake fluid lines **206** direct the brake fluid to the one or more brake devices **202** to actuate the one or more brake devices **202** to contact the second gear **104**. In this way, the gear brake system **200** actuates the one or more brake devices **202** and brakes the second gear **104**, and, thus, the output shaft **103**, during the reverse torque condition to prevent the output shaft **103** from rotating during the reverse torque condition. Thus, the gear assembly **100** is braked and locked during the reverse torque condition. In particular, the torque is transferred from the propulsor **38** to the gear assembly **100** (e.g., the second gear **104**) through the propulsor shaft **45** during the reverse torque condition (e.g., as the propulsor **38** is windmilling), and the gear brake system **200** actuates the one or more brake devices **202** to prevent the propulsor shaft **45** from rotating (e.g., the plurality of gears **102**, **104**, and **106** of the gear assembly **100** are prevented from rotating).

[0059] In embodiments that include a plurality of second gears **104**, one or more of the plurality of second gears **104** can include a respective gear brake system **200** disposed therein based on the braking force needed for a particular gear assembly. In the embodiment of FIGS. **2**B to **2**C, the one or more brake devices **202** move generally radially to contact an inner surface of the second gear **104** to brake (lock) the second gear **104** and prevent the second gear **104** from rotating. In some embodiments, the one or more brake devices **202** can move axially to brake (lock) the second gear **104**, as detailed further below with respect to FIG. **3**.

[0060] FIG. **3** is a schematic cross-sectional view of the gearbox assembly **46** having a gear brake system **300** in an actuated state, according to another embodiment. The gear brake system **300** includes one or more brake devices **302**, a brake fluid reservoir **304**, and one or more brake fluid lines **306**. The one or more brake devices **302**, the brake fluid reservoir **304**, and the one or more brake fluid lines **306** are substantially similar to the one or more brake devices **202**, the brake fluid reservoir **204**, and the one or more brake fluid lines **206**, respectively, of FIGS. **2**A to **2**C. The one or more brake devices **302** include a first brake device **302***a* and a second brake device **302***b*. The first brake device **302***a* and the second brake device **302***b* are positioned to actuate substantially axially when the gear brake system **300** is actuated. In FIG. **3**, the first brake device **302***a* and the second brake device **302***b* are positioned on a top portion of the second gear pin **120**. The first brake device **302***a* is positioned at an axially forward surface of the second gear **104**. The second brake device **302***b* is positioned at an axially aft surface of the second gear **104**. The one or more brake fluid lines **306** include a first brake fluid line **306***a* and a second brake fluid line **306***b*. The first brake fluid line **306***a* is in fluid communication with the brake fluid reservoir **304** and the first brake device **302***a*. The second brake fluid line **306***b* is in fluid communication with the brake fluid reservoir **304** and the second brake device **302***b*.

[0061] The one or more brake devices **302** can also include a third brake device **302***c* and a fourth brake device **302***d*. The third brake device **302***c* and the fourth brake device **302***d* are positioned to actuate substantially axially when the gear brake system **300** is actuated. In FIG. **3**, the third brake device **302***c* and the fourth brake device **302***d* are positioned on a bottom portion of the second gear pin **120**. The third brake device **302***c* is positioned at the axially forward surface of the second gear **104**. The fourth brake device **302***d* is positioned at the axially aft surface of the second gear **104**. The one or more brake fluid lines **306** also include a third brake fluid line **306***c* and a fourth brake fluid line **306***d*. The third brake fluid line **306***c* is in fluid communication with the brake fluid reservoir **304** and the third brake device **302***c*. The fourth brake fluid line **306***d* is in fluid communication with the brake fluid reservoir and the fourth brake device **302***d*.

[0062] The gear brake system **300** operates substantially similarly as does the gear brake system **200** of FIG. **2**. However, when the gear brake system **300** is actuated (as in FIG. **3**), the one or more brake devices **302** move substantially axially, rather than substantially radially (as in FIG. **2**C). In particular, the first brake device **302***a* moves axially aftward to contact the second gear **104**, and the second brake device **302***b* moves axially forward to contact the second gear **104**. Likewise, the third brake device **302***c* moves axially aftward to contact the second gear **104**, and the fourth brake device **302***d* moves axially forward to contact the second gear **104**. In this way, the one or more brake devices **302** are actuated to brake the second gear **104**, and, thus, the output shaft **103** to prevent the output shaft **103** from rotating during the reverse torque condition. During the normal operation, the one or more brake devices **302** are spaced axially from the second gear **104** such that the second gear **104**, and, thus, the output shaft **103**, is allowed to rotate.

[0063] Accordingly, the gear brake systems **200** and **300** brake or lock the gears **102**, **104**, and **106** to prevent rotation of the gears **102**, **104**, and **106** during the reverse torque condition. With no rotation of the gears **102**, **104**, and **106**, the second gear bearings **130**, and the gears **102**, **104**, and **106**, do not require lubricant. Thus, the gear brake systems **200** and **300** prevent bearing seizure of the second gear bearings **130** during the reverse torque condition without having to supply lubricant to the second gear bearings **130** during the reverse torque condition. Therefore, the gear brake systems **200** and **300** eliminate the need for an auxiliary lubrication system and reduce complexity of the lubrication system as compared to gearbox assemblies without the benefit of the present disclosure. Further, the closed brake fluid circuit placed within a single component (e.g., within second gear **104**) reduces the possibility of a leak as compared to brake systems without the benefit of the present disclosure due to not having to have brake fluid lines from outside of the gear assembly.

[0064] Further aspects of the present disclosure are provided by the subject matter of the following clauses.

[0065] A gearbox assembly comprises a gear assembly, an input shaft coupled to the gear assembly, an output shaft drivingly coupled to the input shaft through the gear assembly, and a gear brake system disposed within the gear assembly and comprising one or more brake devices, the gear brake system actuating the one or more brake devices to brake the gear assembly during a reverse torque condition of the gearbox assembly.

[0066] The gearbox assembly of the preceding clause, the reverse torque condition being when torque is transferred from the output shaft to the input shaft through the gear assembly.

[0067] The gearbox assembly of any preceding clause, the gear brake system comprising a brake fluid reservoir that stores brake fluid therein, and the gear brake system supplies the brake fluid from the brake fluid reservoir to the one or more brake devices to actuate the one or more brake devices during the reverse torque condition.

[0068] The gearbox assembly of any preceding clause, the gear brake system comprising one or more brake fluid lines in fluid communication with the brake fluid reservoir and the one or more brake devices, and the brake fluid lines direct the brake fluid from the brake fluid reservoir to the one or more brake devices during the reverse torque condition.

[0069] The gearbox assembly of any preceding clause, the gear assembly comprising a first gear and a second gear that intermeshes with the first gear, and the brake fluid reservoir is disposed within the second gear.

[0070] The gearbox assembly of any preceding clause, the one or more brake devices being spaced from the second gear during normal operation of the gearbox assembly, and the gear brake system actuates the one or more brake devices such that the one or more brake devices contact the second gear to brake the gear assembly during the reverse torque condition.

[0071] The gearbox assembly of any preceding clause, the second gear including a second gear pin about which the second gear rotates, and the brake fluid reservoir is disposed within the second gear pin.

[0072] The gearbox assembly of any preceding clause, the second gear pin being deformable and deforms during the reverse torque condition such that the second gear pin squeezes the brake fluid reservoir and forces the brake fluid out of the brake fluid reservoir to supply the brake fluid to the one or more brake devices.

[0073] The gearbox assembly of any preceding clause, the second gear pin including a deformable portion, and the brake fluid reservoir is positioned within the second gear pin at the deformable portion.

[0074] The gearbox assembly of any preceding clause, the second gear pin including a stiff portion, and the deformable portion has a lesser stiffness than the stiff portion.

[0075] The gearbox assembly of any preceding clause, the gear assembly including a plurality of gears including the first gear and the second gear.

[0076] The gearbox assembly of any preceding clause, the gear assembly including a third gear.
[0077] The gearbox assembly of the preceding clause, the first gear being a sun gear, the second gear is a planet gear, and the third gear is a ring gear.
[0078] The gearbox assembly of any preceding clause, the second gear being constrained by a second gear carrier.
[0079] The gearbox assembly of any preceding clause, the gear assembly including a plurality of second gears.
[0080] The gearbox assembly of any preceding clause, the first gear including a plurality of first gear teeth.
[0081] The gearbox assembly of any preceding clause, the second gear including a plurality of second gear teeth.
[0082] The gearbox assembly of any preceding clause, the third gear including a plurality of third gear teeth.
[0083] The gearbox assembly of any preceding clause, the plurality of second gear teeth intermeshing with the plurality of first gear teeth.
[0084] The gearbox assembly of any preceding clause, the plurality of third gear teeth intermeshing with the plurality of third gear teeth.
[0085] The gearbox assembly of any preceding clause, the input shaft being coupled to the first gear.
[0086] The gearbox assembly of any preceding clause, the output shaft being coupled to third gear.
[0087] The gearbox assembly of any preceding clause, the output shaft being coupled to the second gear carrier.
[0088] The gearbox assembly of any preceding clause, the input shaft being a low-pressure shaft of a turbo-engine of a turbine engine.
[0089] The gearbox assembly of any preceding clause, the output shaft being a propulsor shaft of a propulsor of the turbine engine.
[0090] The gearbox assembly of any preceding clause, the second gear including one or more second gear bearings disposed therein, the one or more second bearings allowing the second gear to rotate about a second gear longitudinal centerline axis.
[0091] The gearbox assembly of any preceding clause, the one or more bearings being journal bearings.
[0092] The gearbox assembly of any preceding clause, the journal bearings being defined between the second gear pin and the second gear.
[0093] The gearbox assembly of any preceding clause, the second gear deforming and applying a reverse torque load during the reverse torque condition.
[0094] The gearbox assembly of any preceding clause, the stiff portion being defined on a first side of the second gear pin.
[0095] The gearbox assembly of any preceding clause, the deformable portion being defined on a second side of the second gear pin that is opposite the first side.
[0096] The gearbox assembly of any preceding clause, the first side being a side of the second gear pin on which the second gear applies an operational load during the normal operation of the gearbox assembly.
[0097] The gearbox assembly of any preceding clause, the second side being a side of the second gear pin on which the second gear applies the reverse torque load during the reverse torque condition.
[0098] The gearbox assembly of any preceding clause, the one or more brake devices being brake pads.
[0099] The gearbox assembly of any preceding clause, the one or more brake devices applying friction against the second gear to brake the second gear.
[0100] The gearbox assembly of any preceding clause, the one or more brake devices including a

first brake device and a second brake device.
[0101] The gearbox assembly of any preceding clause, the first brake device being positioned at a radially top portion of the second gear pin.
[0102] The gearbox assembly of any preceding clause, the second brake device being positioned at a radially bottom portion of the second gear pin.
[0103] The gearbox assembly of any preceding clause, the one or more brake devices moving generally radially outward to contact the second gear during the reverse torque condition.
[0104] The gearbox assembly of any preceding clause, the one or more brake devices moving generally axially to contact the second gear during the reverse torque condition.
[0105] The gearbox assembly of any preceding clause, the first brake device moving axially forward and the second brake device moves axially aftward to contact the second gear.
[0106] The gearbox assembly of any preceding clause, the one or more brake devices including a third brake device and a fourth brake device, the first brake device and the second brake device are positioned at a top portion of the second gear pin, and the third brake device and the fourth brake device are positioned at a bottom portion of the second gear pin.
[0107] A method of braking a gear assembly of a gearbox assembly, the gearbox assembly comprising an input shaft, an output shaft drivingly coupled to the input shaft through the gear assembly, and a gear brake system disposed within the gear assembly and including one or more brake devices, the method comprising actuating the one or more brake devices to brake the gear assembly during a reverse torque condition of the gearbox assembly.
[0108] The method of any preceding clause, the reverse torque condition being when torque is transferred from the output shaft to the input shaft through the gear assembly.
[0109] The method of any preceding clause, the gear brake system comprising a brake fluid reservoir that stores brake fluid therein, and the method further comprises supplying the brake fluid from the brake fluid reservoir to the one or more brake devices to actuate the one or more brake devices during the reverse torque condition.
[0110] The method of any preceding clause, the gear brake system comprising one or more brake fluid lines in fluid communication with the brake fluid reservoir and the one or more brake devices, and the method further comprises directing the brake fluid from the brake fluid reservoir to the one or more brake devices through the one or more brake fluid lines during the reverse torque condition.
[0111] The method of any preceding clause, the gear assembly comprising a first gear and a second gear that intermeshes with the first gear, and the brake fluid reservoir is disposed within the second gear.
[0112] The method of any preceding clause, the one or more brake devices being spaced from the second gear during normal operation of the gearbox assembly, and the method further comprises actuating the one or more brake devices such that the one or more brake devices contact the second gear to brake the gear assembly during the reverse torque condition.
[0113] The method of any preceding clause, the second gear including a second gear pin about which the second gear rotates, and the brake fluid reservoir is disposed within the second gear pin.
[0114] The method of any preceding clause, the second gear pin being deformable, and the method further comprises deforming the second gear pin during the reverse torque condition such that the second gear pin squeezes the brake fluid reservoir and forces the brake fluid out of the brake fluid reservoir to supply the brake fluid to the one or more brake devices.
[0115] The method of any preceding clause, the second gear pin including a deformable portion, and the brake fluid reservoir is positioned within the second gear pin at the deformable portion.
[0116] The method of any preceding clause, the second gear pin including a stiff portion, and the deformable portion has a lesser stiffness than the stiff portion.
[0117] The method of any preceding clause, the gearbox assembly including the gearbox assembly of any preceding clause.

[0118] The method of any preceding clause, further comprising transferring torque from the input shaft to the output shaft through the gear assembly during normal operation of the gearbox assembly such that the input shaft causes the output shaft to rotate.
[0119] The method of any preceding clause, further comprising preventing the one or more brake devices from contacting the gear assembly during the normal operation of the gearbox assembly.
[0120] The method of any preceding clause, further comprising transferring torque from the output shaft to the input shaft through the gearbox assembly during the reverse torque condition.
[0121] The method of any preceding clause, the reverse torque condition occurring when a propulsor of the turbine engine is windmilling.
[0122] The method of any preceding clause, the torque transfer during the reverse torque condition being in an opposite direction as to the torque transfer during the normal operation of the gearbox assembly.
[0123] The method of any preceding clause, further comprising applying, with the plurality of first gear teeth or the plurality of third gear teeth, a gear teeth reverse torque load on the plurality of second gear teeth during the reverse torque condition.
[0124] The method of any preceding clause, further comprising applying, by the second gear, a second gear reverse torque load on the second gear pin during the reverse torque condition.
[0125] The method of any preceding clause, further comprising deforming the second gear pin by the second gear reverse torque load.
[0126] The method of any preceding clause, further comprising deforming the brake fluid reservoir by the second gear pin during the reverse torque condition.
[0127] The method of any preceding clause, the one or more brake devices being brake pads.
[0128] The method of any preceding clause, further comprising supplying the brake fluid from the brake fluid reservoir to the one or more brake devices when the second gear pin deforms during the reverse torque condition.
[0129] The method of any preceding clause, further comprising moving the one or more brake devices generally radially to contact the second gear to brake the gear assembly during the reverse torque condition.
[0130] The method of any preceding clause, further comprising moving the one or more brake devices generally axially to contact the second gear to brake the gear assembly during the reverse torque condition.
[0131] The method of any preceding clause, further comprising moving the first brake device axially forward and moving the second brake device axially aftward to brake the second gear during the reverse torque condition.
[0132] A turbine engine comprising a turbo-engine having a low-pressure shaft, a propulsor having a propulsor shaft, and a gearbox assembly. The gearbox assembly comprises a gear assembly, the propulsor shaft being coupled to the low-pressure shaft through the gear assembly, and a gear brake system disposed within the gear assembly and comprising one or more brake devices, the gear brake system actuating the one or more brake devices to brake the gear assembly during a reverse torque condition of the gearbox assembly.
[0133] The turbine engine of the preceding clause, the gearbox assembly being the gearbox assembly of any preceding clause.
[0134] A method of operating the turbine engine of any preceding clause, the method comprising transferring torque from the propulsor shaft to the gear assembly during a reverse torque condition, and actuating, via the torque, the one or more brake devices to brake the gear assembly during the reverse torque condition of the gearbox assembly.
[0135] The method of the preceding clause, the method including the method of braking the gear assembly of the gearbox assembly of any preceding clause.
[0136] Although the foregoing description is directed to the preferred embodiments of the present disclosure, other variations and modifications will be apparent to those skilled in the art and may be

made without departing from the disclosure. Moreover, features described in connection with one embodiment of the present disclosure may be used in conjunction with other embodiments, even if not explicitly stated above.

Claims

1. A gearbox assembly comprising: a gear assembly; an input shaft coupled to the gear assembly; an output shaft drivingly coupled to the input shaft through the gear assembly; and a gear brake system disposed within the gear assembly and comprising one or more brake devices, the gear brake system actuating the one or more brake devices to brake the gear assembly during a reverse torque condition of the gearbox assembly.
2. The gearbox assembly of claim 1, wherein the reverse torque condition is when torque is transferred from the output shaft to the input shaft through the gear assembly.
3. The gearbox assembly of claim 1, wherein the gear brake system comprises a brake fluid reservoir that stores a brake fluid therein, and the gear brake system supplies the brake fluid from the brake fluid reservoir to the one or more brake devices to actuate the one or more brake devices during the reverse torque condition.
4. The gearbox assembly of claim 3, wherein the gear brake system comprises one or more brake fluid lines in fluid communication with the brake fluid reservoir and the one or more brake devices, and the brake fluid lines direct the brake fluid from the brake fluid reservoir to the one or more brake devices during the reverse torque condition.
5. The gearbox assembly of claim 3, wherein the gear assembly comprises a first gear and a second gear that intermeshes with the first gear, and the brake fluid reservoir is disposed within the second gear.
6. The gearbox assembly of claim 5, wherein the one or more brake devices are spaced from the second gear during normal operation of the gearbox assembly, and the gear brake system actuates the one or more brake devices such that the one or more brake devices contact the second gear to brake the gear assembly during the reverse torque condition.
7. The gearbox assembly of claim 5, wherein the second gear includes a second gear pin about which the second gear rotates, and the brake fluid reservoir is disposed within the second gear pin.
8. The gearbox assembly of claim 7, wherein the second gear pin is deformable and deforms during the reverse torque condition such that the second gear pin squeezes the brake fluid reservoir and forces the brake fluid out of the brake fluid reservoir to supply the brake fluid to the one or more brake devices.
9. The gearbox assembly of claim 8, wherein the second gear pin includes a deformable portion, and the brake fluid reservoir is positioned within the second gear pin at the deformable portion.
10. The gearbox assembly of claim 9, wherein the second gear pin includes a stiff portion, and the deformable portion has a lesser stiffness than the stiff portion.
11. A method of braking a gear assembly of a gearbox assembly, the gearbox assembly comprising an input shaft, an output shaft drivingly coupled to the input shaft through the gear assembly, and a gear brake system disposed within the gear assembly and including one or more brake devices, the method comprising: actuating the one or more brake devices to brake the gear assembly during a reverse torque condition of the gearbox assembly.
12. The method of claim 11, wherein the reverse torque condition is when torque is transferred from the output shaft to the input shaft through the gear assembly.
13. The method of claim 11, wherein the gear brake system comprises a brake fluid reservoir that stores brake fluid therein, and the method further comprises supplying the brake fluid from the brake fluid reservoir to the one or more brake devices to actuate the one or more brake devices during the reverse torque condition.
14. The method of claim 13, wherein the gear brake system comprises one or more brake fluid lines

in fluid communication with the brake fluid reservoir and the one or more brake devices, and the method further comprises directing the brake fluid from the brake fluid reservoir to the one or more brake devices through the one or more brake fluid lines during the reverse torque condition.

15. The method of claim 13, wherein the gear assembly comprises a first gear and a second gear that intermeshes with the first gear, and the brake fluid reservoir is disposed within the second gear.

16. The method of claim 15, wherein the one or more brake devices are spaced from the second gear during normal operation of the gearbox assembly, and the method further comprises actuating the one or more brake devices such that the one or more brake devices contact the second gear to brake the gear assembly during the reverse torque condition.

17. The method of claim 15, wherein the second gear includes a second gear pin about which the second gear rotates, and the brake fluid reservoir is disposed within the second gear pin.

18. The method of claim 17, wherein the second gear pin is deformable, and the method further comprises deforming the second gear pin during the reverse torque condition such that the second gear pin squeezes the brake fluid reservoir and forces the brake fluid out of the brake fluid reservoir to supply the brake fluid to the one or more brake devices.

19. The method of claim 18, wherein the second gear pin includes a deformable portion, and the brake fluid reservoir is positioned within the second gear pin at the deformable portion.

20. The method of claim 19, wherein the second gear pin includes a stiff portion, and the deformable portion has a lesser stiffness than the stiff portion.
