OVERRUNNING ALTERNATOR DECOUPLER PULLEY WITH BARE WIRE SPRING AND GREASE LUBRICATION

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ABSTRACT

A decoupler assembly is provided for a system that employs an endless power transmitting element. The decoupler includes a one-way clutch with a wrap spring and a torsion spring that are disposed between a pulley, which is engaged to the endless power transmitting element, and a hub. The one-way clutch permits overrunning of a driven or output one of the pulley and the hub, whereas the torsion spring stores and releases energy to attenuate the response of the one-way clutch in a manner that provides improved durability of an interface between the wrap spring and the pulley.
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FIELD OF THE INVENTION

[0001] The invention relates to a belt drive assembly for driving belt driven accessories in an engine of an automotive vehicle, and more particularly, to a decoupling mechanism for allowing the belt driven accessories to operate temporarily at a speed other than the belt drive assembly.

DESCRIPTION OF THE PRIOR ART

[0002] It is widely known in an automotive vehicle engine to transfer a portion of the engine output to a plurality of belt driven accessories utilizing an endless serpentine belt. Typically, each component includes an input drive shaft and a pulley coupled to a distal end of the drive shaft for driving engagement with the belt. An example of such a belt driven accessory is an alternator.

[0003] It is also known to provide a decoupler operatively coupled between the pulley and the alternator to allow the alternator drive shaft to “overrun” or rotate at a faster speed than the pulley and to allow the speed of the pulley to oscillate with respect to the alternator drive shaft due to oscillations in the engine speed.

[0004] Examples of decouplers are disclosed in the U.S. Pat. No. 6,083,130, issued to Mewissen et al. on Jul. 4, 2000 and the U.S. Pat. No. 5,139,463, issued to Bytzek et al. on Aug. 18, 1992.

[0005] It remains desirable to provide a decoupler that is easier to manufacture and has better durability over conventional decoupler designs.

SUMMARY OF THE INVENTION

[0006] According to one aspect of the invention, a decoupler assembly is provided for transferring torque between a shaft and a drive belt. The decoupler assembly includes a hub configured to be fixedly secured to the shaft. The hub includes a helical first slot formed therein. A carrier is rotatably mounted on the hub. The carrier includes a helical second slot formed therein. A torsion spring extends between a hub end and a carrier end for transferring torque between the hub and carrier, wherein the hub end is retained in the helical first slot to prevent relative movement between the hub end of the torsion spring and the hub and the carrier end is retained in the helical second slot to prevent relative movement between the carrier end of the torsion spring and the carrier. A pulley is rotatably coupled to the hub. The pulley includes an outer surface configured to frictionally engage with the drive belt. The pulley has an inner surface formed therein. A clutch spring is fixedly secured to the carrier and has a plurality of helical coils frictionally engaging with the inner surface of the pulley to selectively couple the hub and pulley. The torsion spring and the clutch spring are wound in opposite senses enabling the clutch spring to expand into gripping engagement with the inner surface of the pulley relative to the hub and to contract out of gripping engagement with the inner surface during deceleration of the pulley relative to the hub.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0008] FIG. 1 is a front view of an engine of an automotive vehicle incorporating a decoupler assembly according to one aspect of the invention;

[0009] FIG. 2 is an enlarged fragmentary sectional view of the decoupler assembly;

[0010] FIG. 3 is a perspective view of a clutch spring in the decoupler assembly;

[0011] FIG. 4 is a perspective view of a carrier for carrying one end of the clutch spring in the decoupler assembly;

[0012] FIG. 5 is a perspective view of the clutch spring assembled to the carrier;

[0013] FIG. 6 is an exploded perspective view of the decoupler assembly according to a second embodiment of the invention;

[0014] FIG. 7 is a cross sectional view of the decoupler assembly according to the second embodiment of the invention;

[0015] FIG. 8 is a cross sectional view of the decoupler assembly according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] Referring to the figures, an engine for an automotive vehicle is generally indicated at 10 in FIG. 1. The engine 10 includes a crankshaft 12 driving an endless serpentine belt 14, as commonly known by those having ordinary skill in the art. The engine 10 also includes a belt driven accessory 16 driven by the belt 14. Described in greater detail below, a decoupler assembly 20 is operatively assembled between the belt 14 and the belt driven accessory 16 for automatically decoupling the belt driven accessory 16 from the belt 14 when the belt 14 decelerates relative to the belt driven accessory 16 and allowing the speed of the belt 14 to oscillate relative to the belt driven accessory 16. Additionally, a detailed description of the structure and function of a decoupler assembly can be found in applicant’s U.S. Pat. No. 6,083,130, which issued on Jul. 4, 2000 and is incorporated herein by reference in its entirety.

[0017] Referring to FIG. 2, the decoupler assembly 20 includes a hub 22 having opposite first 24 and second 26 ends and a generally cylindrical body 28 extending axially therewith. The body 28 includes opposite inner 30 and outer 32 surfaces extending between the first 24 and second 26 ends of the hub 22. The inner surface 30 includes a plurality of inner threads 33 adjacent the first end 24 for fixedly securing the hub 22 to a drive shaft 15 from the belt driven accessory 16. A reduced diameter portion 34 is formed in the first end 24. The reduced diameter portion 34 includes an outer mounting surface 36 having a smaller outer diameter than the body 28. An abutment surface 38 opposite the second end 26 extends generally radially between the outer mounting surface 36 and the body 28. An annular thrust washer 39 is seated on the outer mounting surface 36 adjacent the abutment surface 38.

[0018] A socket 40 is formed in the second end 26 for receiving a suitable tool therein for rotatably threading the hub 22 onto the drive shaft 15. An annular first flange 41 extends radially outwardly from the body 28 adjacent the second end 26. The first flange 41 includes an outer flange surface 42 having a larger outer diameter than the body 28. An annular surface 44 extends generally radially between the body 28 and the outer flange surface 42 opposite the second
end 26. A generally helical first slot 46 is formed in the annular surface 44 defining a first locating surface 48 therein.

[0019] A generally cylindrical pulley 50 is rotatably journaled to the hub 22. More specifically, the pulley 50 extends between opposite first 52 and second 54 ends. The pulley 50 includes an inner surface 56 extending between the first 52 and second 54 ends. A ball bearing member 57 is coupled between the pulley 50 and the hub 22. The bearing member 57 includes an inner race 58 fixedly secured to a portion of the outer mounting surface 36 and an outer race 59 fixedly secured to a portion of the inner surface 56 adjacent the first end 52 of the pulley 50. A plurality of ball bearings 55 is rollingly engaged between the inner 58 and outer 59 races of the bearing member 57. A cylindrical bushing 60 is journaled between the pulley 50 and the first flange 41. The bushing 60 includes a sleeve wall 62 extending between a portion of the inner surface 56 adjacent the second end 54 and the outer flange surface 42 of the first flange 41. A bushing bushing flange 64 extends radially inwardly from the sleeve wall 62 and abuts the annular surface 44 in the first flange 41.

[0020] The pulley 50 includes an outer periphery 66 with a plurality of V-shaped grooves 68 formed therein for rollingly engaging and guiding the belt 14.

[0021] Referring to FIGS. 2-5, a one-way clutch assembly 70 is operatively coupled between the hub 22 and the pulley 50. The clutch assembly 70 includes a clutch spring 71 and a carrier 75. The clutch spring 71 includes a plurality of helical coils 72 extending between a bent or hooked proximal end 73, and an opposed distal end 74. Preferably, the clutch spring 71 is formed from an uncoated, spring steel material and has a non-circular cross-section to improve frictional contact. Most preferably, the cross-section of clutch spring 71 is rectangular or square. The clutch spring 71 is press fitted into frictional engagement with the inner surface 56 of the pulley 50. Preferably, a lubricant similar or compatible with grease used in the ball bearing member 57 is applied to minimize wear between the clutch spring 71 and the inner surface 56 of the pulley 50.

[0022] The carrier 75 is rotatably mounted on the hub 22. The carrier 75 is generally ring shaped and extends axially between opposite first and second sides 76, 78. A hooked slot 84 is formed in the second side 78 of the carrier 75 and is configured to retain the hooked proximal end 73 of the clutch spring 71. A generally helical second slot 86 is formed in the second side 78 of the carrier 75 defining a second locating surface 88 generally opposing the first locating surface 48 formed in the annular surface 44.

[0023] Referring to FIG. 2, a helical torsion spring 90 extends between hub 92 and carrier 94 ends. The torsion spring 90 is axially compressed between the first 48 and second 88 locating surfaces for transferring torque between the hub 22 and the carrier 75. More specifically, the hub end 92 of the torsion spring 90 is retained in the first slot 46 of the hub 22. Similarly, the carrier end 94 of the torsion spring 90 is retained in the second slot 86 in the second side 78 of the carrier 75. Axial forces due to the compression of the torsion spring 90 retains the first side 76 of the carrier 75 in abutting engagement with the thrust washer 79. The torsion spring 90 also allows relative movement between the carrier 75 and the hub 22 to accommodate changes in the speed of the pulley 50 due to generally oscillating changes in the operating speed of the engine. The torsion spring 90 and the clutch spring 71 are coiled in opposite directions.

[0024] A cap 100 is fixedly assembled to a flange 102 formed in the pulley 50 for preventing contaminants from entering the decoupler assembly 20 and for retaining the lubricant within the decoupler assembly 20.

[0025] In operation, the engine 10 is started and the pulley 50 is accelerated and rotated in a driven direction by the belt 14 driven by the engine 10. Acceleration and rotation of the pulley 50 in the driven direction relative to the hub 22 creates friction between the inner surface 56 of the pulley 50 and preferably all of the coils 72 of the clutch spring 71. It should be appreciated that the clutch spring 71 will function even where at the onset at least one of the coils 72 of the clutch spring 71 is frictionally engaged with the inner surface 56 of the pulley 50. The clutch spring 71 is helically coiled such that the friction between the inner surface 56 of the pulley 50 and at least one of the coils 72 would cause the clutch spring 71 to expand radially outwardly toward and grip the inner surface 56 of the pulley 50. Continued rotation of the pulley 50 in the driven direction relative to the hub 22 would cause a generally exponential increase in the outwardly radial force applied by the coils 72 against the inner surface 56 until all of the coils 72 of the clutch spring 71 become fully branishingly engaged with the pulley 50. When the clutch spring 71 is fully engaged with the inner surface 56, the rotation of the pulley 50 is fully directed toward rotation of the drive shaft 15 of the belt driven accessory 16. Additionally, centrifugal forces help to retain the clutch spring 71 in engaging engagement with the inner surface 56 of the pulley 50.

[0026] The rotational movement of the carrier 75 in the driven direction is transferred to the hub 22 by the torsional spring 90 such that generally the carrier 75, thrust washer 39, hub 22, and the drive shaft 15 from the belt driven accessory 16 rotate together with the pulley 50. Additionally, the torsional spring 90 resiliently allows relative movement between the carrier 75 and the hub 22 to accommodate oscillations in the speed of the pulley 50 due to corresponding oscillations in the operating speed of the engine 10.

[0027] When the pulley 50 decelerates, the hub 22 driven by the inertia associated with the rotating drive shaft 15 and the rotating mass within the belt driven accessory 16 will initially “overrun” or continue to rotate in the driven direction at a higher speed than the pulley 50. More specifically, the higher rotational speed of the hub 22 relative to the pulley 50 causes the clutch spring 71 to contract radially relative to the inner surface 56 of the pulley 50. The braking engagement between the clutch spring 71 and the pulley 50 is relieved, thereby allowing overrunning of the hub 22 and drive shaft 15 from the belt driven accessory 16 relative to the pulley 50. The coils 72 may remain frictionally engaged with the inner surface 56 while the pulley 50 decelerates relative to the clutch assembly 70 and the hub 22. The coils 72 of the clutch spring 71 begin to brakingly engage the inner surface 56 as the pulley 50 accelerates beyond the speed of the hub 22.

[0028] Referring to FIGS. 6 and 7, a second embodiment of the decoupler assembly 20 is shown, wherein elements of the alternative embodiment similar to those in the first embodiment are indicated by primed reference characters. The decoupler assembly 20 is assembled between an output or crankshaft 106 of an engine and the belt 14 to allow the belt 14 to overrun the crankshaft 106. The decoupler assembly 20 includes a generally ring-shaped spring support 110. The slot 46 of the hub 22 has a generally U-shaped cross section for retaining the spring support 110 therein.
A first tab 112 extends outwardly from the spring support 110. A first notch 114 is formed in the hub end 92 of the torsion spring 90 for axially receiving the first tab 112 therein. Engagement between the first tab 112 and the first notch 114 prevents relative rotational movement of the hub end 92 of the torsion spring 90 relative to the spring support 110 and hub 22. Similarly, a second tab 116 extends outwardly from the second locating surface 88 of the carrier 75. A second notch 118 is formed in the carrier end 94 of the torsion spring 90 for axially receiving the second tab 116 therein. Engagement between the second tab 116 and the second notch 118 prevents relative rotational movement of the carrier end 94 of the torsion spring 90 relative to the carrier 75.

The pulley 50 includes an outer periphery 120 for seating the belt 14 therein and an inner flange portion 122. The inner flange portion 122 has a generally U-shaped cross section defined by outer 124 and inner 126 pulley walls and a first connecting wall 128 extending radially therebetween. The carrier 75 is retained between the outer 124 and inner 126 pulley walls and the first connecting wall 128 of the inner flange portion 122, such that the carrier 75 rotates with the pulley 50. A second connecting wall 130 extends radially between the outer pulley wall 124 and the outer periphery 120.

The carrier 75 includes a slot or split 132, which helps the carrier 75 to flex and accommodate loads associated with the rotation of the decoupler assembly 22.

Referring to FIG. 8, a third embodiment of the decoupler assembly 20a is shown, wherein the body 28 and first flange 41 of the hub 22 are formed separately and fixedly connected in a subsequent assembly operation. The body 28 of the hub 22 is generally cylindrical and extends between the first 24 and second 26 ends. The first flange 41 includes a mounting portion 140, which has a center bore 142 for receiving the outer flange surface 36 of the hub 22 therethrough. The first flange 41 includes a generally U-shaped cross section defined by an end wall 134 extending radially between generally parallel inner 136 and outer 138 flange walls. The spring support 110 is retained between the inner 136 and outer 138 flange walls and the end wall 134, such that the spring support 110 rotates with the first flange 41.

The outer periphery 120 and the inner flange portion 122 of the pulley 50 are formed separately and fixedly connected in a subsequent assembly operation using any suitable method, such as welding. The generally U-shaped cross section of the inner flange portion 122 opens toward the first flange 41. The carrier 75 is retained between the outer 124 and inner 126 pulley walls and the first connecting wall 128, such that the carrier 75 rotates with the pulley 50.

A ring plate 143 is mounted concentrically onto the outer mounting surface 36 adjacent the abutting surface 38. A thrust washer 144 is disposed between the first flange 41 and the ring plate 143. The thrust washer 144 is axially spaced apart from the end wall 134 of the flange 41 for receiving the inner flange portion 122 of the pulley 50 therebetween.

A torsional vibration damper 146, as known by those skilled in the art, is fixedly secured to the outer flange wall 138 of the first flange 41 for dampening vibrations experienced at the crankshaft 106 associated with the operations of the engine.
41. The decoupler assembly of claim 30, wherein the at least one torsion spring is axially compressed between the carrier and the hub.

42. The decoupler assembly of claim 30, further comprising a bearing disposed between the hub and the pulley.

43. The decoupler assembly of claim 30, wherein the plurality of coils are abutted against one another.

44. The decoupler assembly of claim 30, further comprising a torsional vibration damper fixed for rotation with the hub.

45. The decoupler assembly of claim 30, wherein the groove is formed on an axial end face of the carrier.

46. The decoupler assembly of claim 30, further comprising a lubricant disposed on coils of the clutch spring.

47. The decoupler assembly of claim 46, wherein the lubricant is a grease.

48. The decoupler assembly of claim 46, wherein the clutch spring exits the carrier in a radially outward direction.

49. The decoupler assembly of claim 46, wherein the at least one torsion spring and the clutch spring are coiled in opposite directions.

50. The decoupler assembly of claim 46, wherein the at least one torsion spring uncoils as a magnitude of the rotary power transmitted between the carrier and the hub increases.

51. The decoupler assembly of claim 50, wherein at least one of the carrier and the hub includes a tapered ramp and an abutting wall that is perpendicular to the tapered ramp and wherein the at least one torsion spring abuts each of the abutting walls.

52. The decoupler assembly of claim 46, wherein the carrier is mounted on the hub.

53. The decoupler assembly of claim 46, wherein the wire has a cross-sectional shape with an outer side that abuts the inner surface of the pulley, the outer side having a contour that is configured to distribute load transmitted from the clutch spring to the pulley over multiple points of contact spaced along the outer side.

54. The decoupler assembly of claim 53, wherein the outer side has a flat contour.

55. The decoupler assembly of claim 54, wherein the wire has a square cross-sectional shape or a rectangular cross-sectional shape.

56. The decoupler assembly of claim 46, wherein the wire has a cross-sectional shape with an outer side, which abuts the inner surface of the pulley, and lateral sides that are coupled to the opposite lateral sides of the outer side, the lateral sides having a flat contour.

57. The decoupler assembly of claim 56, wherein the wire has a square cross-sectional shape or a rectangular cross-sectional shape.

58. The decoupler assembly of claim 46, wherein the at least one torsion spring is axially compressed between the carrier and the hub.

59. The decoupler assembly of claim 46, further comprising a bearing disposed between the hub and the pulley.

60. The decoupler assembly of claim 46, wherein the plurality of coils are abutted against one another.

61. The decoupler assembly of claim 46, further comprising a torsional vibration damper fixed for rotation with the hub.

62. The decoupler assembly of claim 46, wherein the groove is formed on an axial end face of the carrier.

63. A decoupler assembly comprising:
   a hub that is adapted to be coupled to a shaft such that the shaft co-rotates with the hub;
   a carrier that is rotatably mounted on the hub;
   at least one torsion spring between the carrier and the hub;
   a pulley having an outer periphery, which is adapted to engage an endless power transmitting element, and an inner surface; and
   a clutch spring formed only of wire, the clutch spring having a plurality of coils, wherein less than one complete coil is engaged to the carrier, wherein at least one of the plurality of coils is engaged against the inner surface of the pulley when rotary power is transmitted between the pulley and the hub, at least a portion of the plurality of coils contacting to reduce gripping engagement with the inner surface of the pulley in response to deceleration of the pulley relative to the carrier beyond a predetermined extent.

64. The decoupler assembly of claim 63, further comprising a lubricant disposed on coils of the clutch spring.

65. The decoupler assembly of claim 64, wherein the lubricant is a grease.

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