(fatigue, power output). Heat transfer per mass of SMA is relatively high when the SMA member **22** is formed from thin-wire SMA. Increased heat transfer allows the heat engine **14** to cycle material more quickly, especially with a convection heat source as the hot region **18**.

[0098] The SMA member **22** may be formed as a continuous loop without joints, or as a single loop element having a single joint forming the straight, thin wire into the continuous loop. Alternatively, a single wire may be looped multiple times around the path defined by the pulley members, but still have only one joint. The exact diameter of the thin-wire SMA forming the SMA member **22** may be varied based upon the operating conditions of the heat engine **14**, such as, without limitation: the first temperature of the hot region **18** and the second temperature of the cold region **20**; the amount of strain introduced in the SMA member **22** during expansion and travel around the loop; the operating frequency of the heat engine **14**; and the predicted lifecycle of the SMA member **22** or the heat engine **14**.

[0099] Forming the SMA working element into a loop may require one or more joints in the SMA member **22**. The joint may be created through laser welding the two ends of the SMA working element together.

[0100] Welding processes may re-melt the material and create non-uniform grain structure. Post processing of the joints may improve the resulting ultimate tensile strength and cyclic fatigue characteristics of the SMA member **22**. Removing the non-uniform grain structure may reduce the likelihood of dislocation collecting and reduce fatigue fractures in the SMA member **22**. Post processes of the SMA member **22** may include, but are not limited to: annealing, drawing, rolling, swaging, and varieties of thermo-mechanical processing combinations.

[0101] Referring now to FIG. **5**A, FIG. **5**B, and FIG. **5**C, and with continued reference to FIGS. **1-4**, there are shown schematic fragmentary cross-sectional views of additional SMA working element forms. The working elements shown are manufactured or assembled as bands, which have greater width-to-thickness ratios that wires.

[0102] FIG. **5**A shows an SMA member **122** that is formed from parallel wires, strips or strands **123** of thin-wire SMA. FIG. **5**B shows an SMA member **162** that is formed from parallel wires, strips or strands **163** of thin-wire SMA that are partially-embedded within a matrix **166**. FIG. **5**C shows a composite SMA member **192** that is formed from multiple units of a smaller SMA member.

[0103] FIGS. **5**A, **5**B, and **5**C represent additional SMA working element forms that may be used with various types and configurations of heat engines, such as those shown and described herein. Features and components shown and described in other figures may be incorporated and used with those shown in FIGS. **5**A, **5**B, and **5**C.

[0104] FIG. **5**A shows tack welds **124**, which join the parallel strands **123** to form the SMA member **122**. Alternatively, the parallel strands **123** may be joined by localized, interlocking deformations which mechanically link the parallel strands **123** without the heating processes involved in welding. Although not shown, the parallel strands **123** may also be free, such that each strand **123** is not joined to the others. A pulley **140** is schematically shown to demonstrate contact between the SMA member **122** and the drive pulleys of the heat engine into which the SMA member **122** is incorporated.

[0105] Generally, the cross-sectional shape of the strands **123** shown is round. However, the thin-wire SMA strands **123** may be formed with other cross sections, such as, without limitation: square, rectangular, oval, box-beam, or I-beam. The other shapes of SMA strands **123** may also be formed into bands.

[0106] FIG. **5**B shows that the SMA member **162** is formed from the SMA strands **163** arranged into a mat or band formation and then into a continuous loop. An outer portion (relative to the pulley **140**, which is shown schematically) of the strands **163** is collectively coated or embedded by an elastomer to form the matrix **166**.

[0107] The matrix **166** keeps the individual strands **163** separate and also conducts heat from the strands **163**. However, the matrix **166** does not come directly into contact with the pulley **140**, so that the matrix **166** is not compressed between the pulley **140** and the strands **163**. Additionally, the partial matrix may better handle the dynamic (size-changing) relationship between the strands **163** and the matrix **166**.

[0108] The elastomer forming the matrix **166** may be intrinsically thermally conducting or may be filled (or doped) with materials to enhanced heat conduction. These fillers may include metal or carbon/graphite wires, microwires, and nonwires as well as other high aspect-ratio fillers like platelets. The matrix **166** may be placed into direct contact with the heat source to conductively draw heat into the strands **163** in the hot region. Similarly, the matrix **166** may assist in expelling heat to the cold region by conducting heat from the strands **163** and convectively or conductively communicating that heat to the cold region.

[0109] The SMA members **122**, **162** shown in FIGS. **5**A and **5**B are illustrated with only four strands **123**, **163**. However, many more strands **123**, **163** may be used in forming the SMA members **122**, **162** into wider bands (having greater width-to-thickness ratios).

[0110] In large-scale heat engines, the added width, thickness, length, and (possibly) number, of SMA working elements may require multiple idler pulleys to maintain tension and take up slack in the SMA working elements. For example, and without limitation, a bricklayer pattern may be used with multiple units to build up, in a staggered fashion, to a larger and stronger composite SMA working element. While single, thin-wire working elements may be efficient in small-scale operations, it may not be practicable to simply enlarge the single wire for large-scale energy production from the heat engines. Larger, stronger, and more durable SMA working elements may better allow the heat engines into which the SMA working elements are incorporated to produce substantial energy outputs.

[0111] Note that while FIG. **5**B shows only individual thin-wire SMA strands **163**, the matrix **166** may also be used with braids, meshes, or weaves of SMA. With weaves or meshes, for example, the matrix **166** would be applied after assembly of the weave or mesh and would still be located away from the pulley **140**. Spring-form SMA strands **163** may also be combined with the matrix **166** to form larger, more-effective working elements.

[0112] As shown in FIG. **5**C, smaller working element groups or units may be treated as base building units, and additional units may be stacked and layered to form a larger belt, such as the composite SMA member **192**, only a portion of which is shown. The composite SMA member **192** is formed from multiple units of an SMA member **194**, which has similar elements to the SMA member **162** shown in FIG. **5**B.