Device, weaving machine and sley drive system for driving a sley (1) in an oscillating manner, wherein the sley drive system (3) comprises a sley lever unit (4) and a sley drive unit (5), wherein the sley drive unit (5) comprises two conjugated cams (51, 52) and the sley lever unit (4) comprises two cam followers (45), each cam follower (45) being associated and drivingly coupled with one of the two conjugated cams (51, 52), and wherein the cam profiles of the two conjugated cams (51, 52) are chosen so that two working cycles of the sley lever unit (4) are carried out during one revolution of the two conjugated cams (51, 52).
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Sley drive system for a weaving machine

Technical Field and Prior Art

[0001] The invention relates to a sley drive system for driving a sley in an oscillating manner, wherein the sley drive system comprises a sley lever unit arranged for oscillation about a sley lever axis and a sley drive unit for driving the sley lever unit. The invention further relates to a device comprising at least two sley drive systems and a weaving machine comprising at least one sley drive system.

[0002] In weaving machines, it is generally known to drive a sley shaft carrying a reed by an oscillating sley lever unit, wherein the sley lever unit is driven by a sley drive unit comprising cams.

[0003] FR 1110124 A describes a sley drive unit comprising one cam being associated with one cam follower. According to FR 1110124 A, a beat-up movement is effected by means of the cam, whereas a return movement of the sley away from the fell line is effected by a spring element. The cam profile of the cam possesses central symmetry, this means along each line running through the axis of rotation of the cam and running in a plane perpendicular to the axis of rotation of the cam, the cam profile is point-symmetrical with respect to the axis of rotation. Further the cam profile is chosen so that two working cycles of the sley are carried out during one revolution of the cam. A steeper slope being provided for effecting the beat-up movement results in the beat-up movement being carried out faster than a return movement of the sley.

[0004] US 4,076,048 A describes a sley drive unit comprising two conjugated cams, which cams each are associated with one cam follower. Each cam follower comprises a cam follower roller mounted on a support arm of a sley lever unit, which support arms are conjointly rotatable about a sley lever axis for rotating a sley lever unit to and fro. The profile of the cams and the cam followers is such that by means of the two conjugated cams one beat-up movement and one return movement is effected during each revolution of the cams.

Summary of the Invention

[0005] It is an object of the invention to provide a sley drive system comprising a sley drive unit with two conjugated cams, wherein energy losses are decreased. It is a further object of the invention to provide a weaving machine comprising such a sley drive system.
[0006] According to a first aspect of the invention, a sley drive system for driving a sley in an oscillating manner with a sley lever unit arranged for oscillation about a sley lever axis and with a sley drive unit for driving the sley lever unit is provided, wherein the sley drive unit comprises two conjugated cams and the sley lever unit comprises two cam followers, each cam follower being associated to and drivingly coupled with one of the two conjugated cams, and wherein the cam profiles of the two conjugated cams are chosen so that two working cycles of the sley lever unit are carried out during one revolution of the two conjugated cams.

[0007] In the context of the application, two cam disks coupled to rotate together about a common axis of rotation and having cooperating cam surfaces are referred to as conjugated cams. When using two conjugated cams and two cam followers, an unintended release of the cam followers from the cams is avoided. Further, using conjugated cams allows to obtain a powerful beat-up of the weft threads and to weave heavier fabrics. However, in particular, when weaving at high speeds or weaving heavy fabrics, the forces in the bearings for the conjugated cams are high, resulting in heat generation and wear of the bearings. In accordance with the invention, in use, the two conjugated cams rotate at half the speed of the speed of the weaving machine. Hence, compared with a system shown for example in US 4,076,048 A, the angular velocity of the cams is reduced to the half. By reducing the angular velocity, a heat generation, and, thus, the energy losses for driving such a sley drive system is minimized. Further, a lifetime of bearings for the cams and the cam followers is increased. The cams in one embodiment are arranged in an oil lubricated cam box. Due to the reduced load on the bearings, the oil temperature is lower compared with prior art systems, so that the oil has a larger viscosity that causes a better hydrodynamic oil film formation, which is additionally favorable for the bearings.

[0008] The profile of the conjugated cams is chosen suitably by the person skilled in the art to effect a desired to-and-fro movement of the sley by a rotation of the cams by an angle of 180°.

As one to-and-fro movement of the sley is effected by a rotation of the cams by an angle of 180° instead of a rotation of the cams by an angle of 360° as known from US 4,076,048 A, when rotating the conjugated cams over a certain angular range, a slope of the cam surfaces is steeper than in prior art drive systems. Hence, a pressure angle between the cam and the cam followers is less favorable with respect to the prior art, and expected contact forces between the cams and the cam followers are higher compared to prior art systems. Therefore, the expected higher contact forces will deter the person skilled in the art from providing two conjugated cams rotating at half speed. However, the invention is based on the surprising advantage that the Hertzian contact pressure between the cams and the cam followers when providing two conjugated cams rotating at half speed is smaller than in prior art systems, in particular as the contact forces in the invention are higher due to the less favorable pressure angles caused by
the steeper slope of the cams than in prior art systems. The combination of larger contact forces with lower speeds ensures hereby still for an increase of the life time, in other words the increase of the contact forces is more than compensated by the halving of the speed.

[0009] In preferred embodiments, each cam follower comprises a roller rolling on an associated cam surface, which roller is rotatably mounted by a bearing on a support arm of the sley lever unit. When reducing the angular velocity of the cams without modifying a diameter of the rollers of the cam followers, the angular velocity of the rollers and, thus, a heat generation in the bearings for the rollers is reduced.

[0010] When increasing a diameter of the rollers, the angular velocity of the rollers is further decreased. If a diameter is chosen too large, there is a risk that the roller cannot follow the cam surface along its circumference. In addition, in particular if a cam box is provided, space limitations are given. Preferably, a diameter of the rollers is maximized while ensuring a rolling on the associated cam surface and/or considering space limitations. In particular, a diameter between about 65 mm and about 85 mm has proved to be advantageous when using cams having an enveloping diameter of about 150 mm.

[0011] In one embodiment, the two conjugated cams are fixedly mounted on a cam shaft, wherein a gearing unit is provided between a drive motor and the cam shaft. When decreasing the angular velocity of the conjugated cams without increasing the moment of inertia of the conjugated cams, the kinetic energy of the drive unit is reduced. Due to the reduced kinetic energy, larger speed variations in the rotation of the cams may arise. In order to avoid such speed variations, a gearing unit between a drive motor shaft and the cam shaft is provided, wherein the drive motor shaft rotates at a higher speed than the cam shaft. As a result, the kinetic energy is sufficient to limit speed variations in the rotation of the cams.

[0012] In one embodiment, the sley drive system is driven by a main drive motor of the weaving machine, wherein a gearing unit is provided between the main drive motor and the cam shaft. In preferred embodiments, the sley drive system comprises a sley drive motor which is distinct from the other drive motors of the weaving machine. In one embodiment, the cam shaft is directly coupled to the sley drive motor. In preferred embodiments, the gearing unit is provided between the sley drive motor and the cam shaft.

[0013] In a preferred embodiment, the cam followers are provided on a sley lever unit comprising a fork element having two support arms arranged to conjointly pivot about the sley lever axis. By providing the two cam followers on a common fork element, a compact
construction is obtained. Preferably, the length of the support arms is maximized while considering space limitations. Hence, forces in the bearings of the conjugated cams, as well as forces in the bearings of the cam follower rollers, can be reduced by increasing the length of the support arms for the cam follower rollers. To drive the sley lever unit, a defined torque is required. The driving torque applied by the cam followers is equal to the forces applied at the distal end, in particular at the cam follower rollers, multiplied by the length of the support arms. Hence, when maximizing the length of the support arms, lower forces are sufficient for driving the sley lever unit. On the other hand, a maximum length of the support arms is limited by the available space in the weaving machine.

[0014] In one embodiment, the two conjugated cams possess central symmetry. In the context of the application, central symmetry means that along each line running through the axis of rotation of the cam and running in a plane perpendicular to the axis of rotation of the cam, the cam profile is point-symmetrical with respect to the axis of rotation. In another embodiment, the cam profiles of the conjugated cams do not possess central symmetry. When the cam profiles do not possess central symmetry, a movement of the sley differs for two consecutive working cycles, in particular two consecutive weaving cycles. This allows obtaining weaving effects. In an embodiment, the conjugated cams impose a symmetrical movement course to the sley shaft. In another embodiment the conjugated cams do not impose a symmetrical movement course to the sley shaft, so that the sense of rotation of the conjugated cams does influence the movement of the sley and the movement of the sley during beat-up movement differs from a return movement. Both movements in one embodiment are optimized. In other words, it is possible that the conjugated cams possess central symmetry or do not possess central symmetry, and/or impose a movement course that is symmetrical or not symmetrical.

[0015] In preferred embodiments, the slope of the cam profiles is chosen so that a fast movement is achieved when the sley moves away from the fell line. This allows starting the insertion of a weft thread earlier in the weaving cycle of an airjet weaving machine. Due to an elasticity of the woven fabric and the force of the tensioned warp threads, the sley is additionally forced away from the fell line, so that a fast movement when the sley moves away from the fell line does not necessarily result is high forces at the cam followers.

[0016] When providing cam profiles possessing central symmetry, the cams are balanced. This allows to omit additional balance masses, resulting in a lower inertia of the sley drive unit. A balancing is advantageous, as unbalances introduce centrifugal forces acting on bearings. Although in accordance with the invention, the angular velocity of the cams is less than in the
prior art, and therefore higher forces in the bearings resulting from unbalances are less crucial, balanced systems are still favorable.

[0017] Preferably, the two cam profiles are chosen so that the center of gravity of the two conjugated cams coincides at least essentially with the axis of rotation of the cam shaft. Thereby, centrifugal forces introduced by the rotation of the cams are reduced and the weaving machine is less subjected to vibrations and also the forces in the bearings for the conjugated cams are reduced. Also due to an absence or at least reduction of the centrifugal forces of the conjugated cams, the bearings can be designed for smaller load.

[0018] According to a second aspect, a device comprising at least two sley drive systems each with two conjugated cams and two cam followers is provided, wherein the at least two sley drive systems are arranged coaxially and offset. The sley drive systems together drive the sley, wherein, in preferred embodiments, a number of sley lever units is provided, which sley lever units are driven by means of an associated sley drive unit. As the cams rotate at an angular velocity, the cams also function as flywheels.

[0019] The number of sley drive units can be chosen suitably by the person skilled in the art considering the weaving width and the required force.

[0020] According to a third aspect, a weaving machine comprising a sley drive system is provided. Preferably, the cam followers of the at least one sley drive unit are arranged below the fabric. This arrangement allows for a rigid construction.

**Brief Description of the Drawings**

[0021] Further characteristics and advantages of the invention will emerge from the following description of the embodiments schematically illustrated in the drawings. Throughout the drawings, the same elements will be indicated by the same reference numerals. In the drawings:

Fig. 1 is a side view of a sley drive system and a sley to be driven in an oscillating manner by the sley drive system;

Fig. 2 is a schematic illustration of two conjugated cams and two cam followers associated and drivingly coupled with the two conjugated cams of the sley drive system of Fig. 1;
Fig. 3 shows a movement course of the sley shaft of the sley drive system of Fig. 2;

Fig. 4 is a schematic illustration of two conjugated cams and two cam followers associated and drivingly coupled with the two conjugated cams of a first alternative sley drive system similar to Fig. 2;

Fig. 5 shows a movement course of the sley shaft of the sley drive system of Fig. 4;

Fig. 6 is a schematic illustration of two conjugated cams and two cam followers associated and drivingly coupled with the two conjugated cams of a second alternative sley drive system similar to Fig. 2;

Fig. 7 shows a movement course of the sley shaft of the sley drive system of Fig. 6;

Fig. 8 is a schematic illustration of two conjugated cams and two cam followers associated and drivingly coupled with the two conjugated cams of a third alternative sley drive system similar to Fig. 2;

Fig. 9 shows a movement course of the sley shaft of the sley drive system of Fig. 8; and

Fig. 10 shows a front view of a device comprising three sley drive systems.

**Detailed Description of Embodiments**

[0022] Fig. 1 schematically shows in a side view a sley 1 of a weaving machine. A reed 10 is mounted to the sley 1 for beating-up weft threads against a fell line 20 of a fabric 2 in a manner generally known. The sley 1 with the reed 10 is moved in an oscillating manner to and fro by means of a sley drive system 3.

[0023] The sley drive system 3 shown in Fig. 1 comprises a sley lever unit 4 arranged to rotate to and fro about a sley lever axis 40 and a sley drive unit 5 for driving the sley lever unit 4.

[0024] The sley drive unit 5 comprises two conjugated cams 51, 52. The cams 51, 52 are fixedly mounted on a common cam shaft 53 to rotate conjointly about a central axis 50, which in this example is also the axis of rotation of the cam shaft 53. The cams 51, 52 are arranged offset to one another in axial direction, so that the cam 51 is hidden by the other cam 52 as indicated with broken lines in Fig. 1. The cam shaft 53 is mounted by means of a bearing (not
shown in Fig. 1) on a support element 6 of the weaving machine, for example a support element 6 that is part of the housing 30 (shown in figure 10).

[0025] The sley lever unit 4 shown in Fig. 1 comprises a fork element 42 having two support arms 43, which are fixedly mounted on a sley shaft 44 to pivot conjointly about the sley lever axis 40, this is the axis of rotation of the sley shaft 44. The sley shaft 44 is mounted in the sley lever unit 4.

[0026] In this embodiment the sley shaft 44 is part of the sley 1. A sley beam 11 onto which the reed 10 is mounted is fixed via sley legs 41 onto the sley shaft 44 of the sley 1.

[0027] The distal end of each support arm 43 functions as a cam follower 45, each of the cam followers 45 being associated to and drivingly coupled with one of the two conjugated cams 51, 52. The cam followers 45 each comprise a roller 46, 47 rolling on a cam surface of the associated cam 51, 52. Each roller 46, 47 is rotatably mounted by a bearing 48, 49 on the respective support arm 43.

[0028] In the embodiment shown, the cams 51, 52 are driven by a sley drive motor 7 (shown schematically in figure 1), which is distinct from other drive motors (not shown) of the weaving machine. A gearing unit 8 is provided between the sley drive motor 7 and the cam shaft 53, wherein a motor shaft 12 of the sley drive motor 7 rotates at a higher speed than the cam shaft 53.

[0029] The cam followers 45 in the embodiment shown are arranged below a fabric 2 allowing for a compact structure.

[0030] As will be described in more detail with reference to Figure 2, the cam profiles of the two conjugated cams 51, 52 are chosen so that two working cycles of the sley lever unit 4, this means two beat-up strokes of the reed 10 are carried out during one revolution of the two conjugated cams 51, 52.

[0031] Fig. 2 schematically illustrates two conjugated cams 51, 52, the fork element 42 with the support arms 43 and the rollers 46, 47.

[0032] In the embodiment shown, the cam profiles of both cams 51, 52 are central symmetrical about the central axis 50, this is the axis of rotation of the cams 51, 52. The sley drive system 3 of Fig. 2 imposes a movement course 31 on the sley shaft 44 as shown in Fig. 3, which is
symmetrical with respect to a plane 35. For the movement course 31, there are indicated in
to one revolution and in vertical the horizontal the angular position of the central axis 50
the relative angular position of the fork element 42. Hence, a pivot movement of the fork element 42
and the sley lever unit 4 (shown in Fig. 1) is independent of the sense of rotation of the two
cams 51, 52.

[0033] In Fig. 2 a fork element 42 is shown in one of its extreme positions. A further rotation of
the cams 51, 52, regardless the sense of rotation of the cams 51, 52, will cause the fork
element 42 to pivot in clockwise direction, this means the reed 10 shown in Fig. 1 will move
away from the fell line 20 until reaching its rearward end position. The rearward end position will
be reached after the cams 51, 52 have rotated about 90°. Thereafter, the rotation of the cams
51, 52 will cause the fork element 42 to rotate in counterclockwise direction and the reed 10 will
move towards the fell line 20 for beating up a weft thread.

[0034] The force required for driving the cam followers is equal to a pressure force multiplied by
the cosinus of the pressure angle. The pressure angle A, B is the angle between the speed
vector of the center of a roller 46, 47, which is perpendicular to its support arm 43, and the force
vector between the respective roller 46, 47 and the associated cam 51, 52, as shown in Fig. 2.

[0035] As will be apparent to the person skilled in the art, the steeper the slope of the cam
surfaces of the cams 51, 52, the higher the pressure angle A, B. The person skilled in the art
will therefore design the cam profile to avoid pressure angles above a limit value, for example
above 30°.

[0036] In the embodiment shown, the two support arms 43 have the same length, wherein the
length of the support arms 43 is maximized while considering space limitations. In other
embodiments, the support arms 43 differ in length.

[0037] Fig. 4 schematically illustrates two conjugated cams 51, 52, a fork element 42 with the
support arms 43 and rollers 46, 47 of an alternative sley drive system 3. In the embodiment
shown in Fig. 4, the cam profiles of both cams 51, 52 impose a movement course 32 to the sley
shaft 44, as shown in Fig. 5, that is not symmetrical with respect to a plane 35. Hence, a pivot
movement of the fork element 42 and the sley lever unit 4 (shown in Fig. 1) and also the
movement of the sley 1 and the reed 10 differ for the backward and the forward movement. In
case of a clockwise rotation of the cams 51, 52, the profile sections 511, 524 and 513, 522 will
determine the movement of the sley 1 and the reed 10 away from the fell line 20, whereas the
profile sections 512, 521 and 514, 523 will determine the movement of the sley 1 and the reed
10 towards the fell line 20. In case of a counter clockwise rotation of the cams 51, 52, the profile sections 512, 521 and 514, 523 will determine the movement of the sley 1 and the reed 10 away from the fell line 20, whereas the profile sections 511, 524 and 513, 522 will determine the movement of the sley 1 and the reed 10 towards the fell line 20. This allows an independent optimization of the forward and the backward movement. However, thecams 51, 52 possess central symmetry, and the opposing profile sections 511 and 513, the opposing profile sections 512 and 514, the opposing profile sections 521 and 523, and the opposing profile sections 522 and 524, respectively, are equal to each other.

[0038] The cam profiles according to Fig. 4 are chosen for example to move the reed 10 away from the fell line 20 at high speed for allowing the insertion of a weft thread to start earlier in the weaving cycle of an airjet weaving machine.

[0039] Fig. 6 schematically illustrates two conjugated cams 51, 52, a fork element 42 with the support arms 43 and rollers 46, 47 of an alternative sley drive system 3, wherein the cam profiles of both cams 51, 52 impose with respect to a plane 35 a symmetrical movement course 33 on the sley shaft 44, as shown in Fig. 7. Fig. 8 schematically illustrates two conjugated cams 51, 52, a fork element 42 with support arms 43 and rollers 46, 47 of another alternative sley drive system 3, wherein the cam profiles of both cams 51, 52 impose with respect to a plane 35 a symmetrical movement course 34 on the sley shaft 44, as shown in Fig. 9. In other words, all four profile sections 511, 512, 513, 514 and 521, 522, 523, 524 of both cams 51, 52 are designed individually. When using such conjugated cams, a movement of the sley 1 differs between two consecutive working cycles. This allows obtaining weaving effects.

[0040] Fig. 10 shows schematically a front view of a device 9 comprising three sley drive systems 3 for driving conjointly a sley 1, which are arranged coaxially with respect to a sley lever axis 40 and offset in axial direction. As shown in Fig. 1, each sley drive system 3 comprises a sley lever unit 4 and a sley drive unit 5, which are housed in a housing 30 and therefore not visible in Fig. 10. The sley lever units 4 have a common sley shaft 44, which is driven to pivot to and fro, which is part of the sley 1. The sley beam 11 of the sley 1 is mounted on the sley shaft 44 via several sley legs 41, which are distributedly arranged along the sley shaft 44. The reed 10 is mounted on the sley beam 11.

[0041] In an embodiment, each of the sley drive systems 3 is assigned to a common sley drive motor 7. In other embodiments, each sley drive system 3 uses an individual drive motor.
Figs. 2, 4, 6 and 8 illustrate that numerous embodiments are conceivable for providing two conjugated cams 51, 52. Preferably, profiles are chosen so that the center of gravity of the two conjugated cams 51, 52 coincides at least essentially with the central axis 50, this is the axis of rotation of the cams 51, 52. In one embodiment, the diameter of the rollers 46, 47 is maximized while ensuring a rolling on the associated cam surface and considering space limitations of the housing 30.

The sley drive system, the device and the weaving machine according to the invention are not limited to the embodiments described by way of example and shown in the drawings. The sley drive system, the device and the weaving machine can also be carried out within the claims according to variant embodiments, shapes and dimensions, and combinations of the described and shown embodiments that fall under the claims are also possible;
1. Sley drive system for driving a sley (1) in an oscillating manner, wherein the sley drive system (3) comprises a sley lever unit (4) arranged for oscillation about a sley lever axis (40) and a sley drive unit (5) for driving the sley lever unit (4), wherein the sley drive unit (5) comprises two conjugated cams (51, 52) and the sley lever unit (4) comprises two cam followers (45), each cam follower (45) being associated and drivingly coupled with one of the two conjugated cams (51, 52), characterized in that the cam profiles of the two conjugated cams (51, 52) are chosen so that two working cycles of the sley lever unit (4) are carried out during one revolution of the two conjugated cams (51, 52).

2. Sley drive system according to claim 1, characterized in that each cam follower (45) comprises a roller (46, 47) rolling on an associated cam surface, which roller (46, 47) is rotatably mounted by a bearing (48, 49) on a support arm (43) of the sley lever unit (4).

3. Sley drive system according to claim 2, characterized in that a diameter of the rollers (46, 47) is maximized while ensuring a rolling on the associated cam surface and/or considering space limitations.

4. Sley drive system according to claim 1, 2 or 3, characterized in that the two conjugated cams (51, 52) are fixedly mounted on a cam shaft (53), wherein a gearing unit (8) is provided between a sley drive motor (7) and the cam shaft (53).

5. Sley drive system according to any one of claims 1 to 4, characterized in that the sley drive system (3) comprises a sley drive motor (7) which is distinct from the other drive motors of the weaving machine.

6. Sley drive system according to any one of claims 1 to 5, characterized in that the cam followers (45) are provided on a sley lever unit (4) comprising a fork element (42) with two support arms (43) arranged to rotate conjointly about the sley lever axis (40).

7. Sley drive system according to claim 6, characterized in that the length of the support arms (43) is maximized while considering space limitations.
8. Sley drive system according to any one of claims 1 to 7, characterized in that the cam profiles of the two conjugated cams (51, 52) each possess central symmetry.

9. Sley drive system according to any one of claims 1 to 8, characterized in that the cam profiles are chosen so that the center of gravity of the two conjugated cams (51, 52) coincides at least essentially with the central axis (50) of the cam shaft (53).

10. Device comprising at least two sley drive system (3) according to any one of claims 1 to 9, each with two conjugated cams (51, 52) and two cam followers (45), wherein the at least two sley drive systems (3) are arranged coaxially and offset.

11. Weaving machine comprising at least one sley drive system (3) according to any of claims 1 to 9 with a sley lever unit (4) and a sley drive unit (5) for driving the sley lever unit (4), the sley drive unit (5) comprising two conjugated cams (51, 52) and the sley lever unit (4) comprising two cam followers (45).

12. Weaving machine according to claim 11, wherein in use the cam followers (45) of the sley drive unit (5) are arranged below a fabric (2).
A. CLASSIFICATION OF SUBJECT MATTER
INV. D03D49/60
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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