A DRIVING CYLINDER OF A PILE DRIVING RIG AND A PILE DRIVING RIG

Field of the invention

The invention relates to a driving cylinder of a pile driving rig and a pile driving rig.

Background of the invention

A driving cylinder is a hydraulic actuator located inside the hammer of a hydraulic pile driving rig, the purpose of the driving cylinder being reciprocate the ram block impacting the driven pile during the driving of the pile into the ground. In currently known hydraulic pile driving rigs, the driving cylinder is usually a double-acting differential hydraulic cylinder, in which the piston rod side cylinder chamber is connected to the piston-side cylinder chamber, most typically by means of a hydraulic hose, or in such a way that the cylinder part is comprised of two cylinder liners within each other, in which case the pressure medium may be conveyed from one cylinder chamber to another through the empty space left between the cylinder liners fitted within each other. By means of this arrangement, the movement of the moving end of the driving cylinder is rendered as rapid as possible because the pressure medium flowing out of the cylinder chamber on the side of the direction of motion of the piston (that is, the cylinder chamber decreasing in volume) can be conveyed to the side of the working cylinder chamber (that is, the cylinder chamber increasing in volume). This type of an arrangement also simplifies the structure and operation of the pressure medium control valve system, because when using a driving cylinder functioning in this manner for controlling the pressure medium for reciprocating the moving end of the driving cylinder, it suffices that the pressure medium outlet duct connected to the piston side chamber and the pressure medium duct between the cylinder chambers are closed and opened in turn.

During the use of the pile driving rig, high impact-like loads are exerted on the driving cylinder, which also generate transverse forces on the driving cylinder. Because of this, the aim has been to fasten the driving cylinder to the structures of the hammer with a suitably flexible fastening. In known solutions, the driving cylinder is fastened, for example, from its piston-side end (upper end) with an articulation and from its piston rod side end (lower end) with a flexible fastening. Another alternative has been to fasten the driving cylinder to the hammer with an articulation from a fastening point at its centre, the aim being to locate the fastening point as close to the centre of

gravity of the driving cylinder as possible. Usually, the moving end of the driving cylinder is fastened to the ram block in an articulated manner with a shackle.
In currently known driving cylinders, the solenoid valve of the driving cylinder is usually located outside the cylinder liners of the heads of the driving cylinder. The disadvantage of these currently known driving cylinder solutions is that the implementation of the solenoid valve closing and opening the pressure medium ducts between the cylinder chambers and leading away from the chambers is complex, requires a considerable number of gaskets due to the several joints and is, therefore, laborious to service and repair.

Patent publication US 5,806,610 discloses a known apparatus for generating impacts for a pile driving rig. The apparatus has a hydraulic cylinder with reciprocating piston located within the hydraulic cylinder.

Brief summary of the invention

Embodiments of the invention introduce a new type of driving cylinder for a pile driving rig, which is structurally simpler than before, more durable, and has a solenoid valve which requires less maintenance and repair than before. Embodiments of the invention introduce a pile driving rig equipped with a driving cylinder disclosed herein.

Embodiments of the invention disclose a driving cylinder, wherein the solenoid valve guiding pressure medium into the cylinder part is a slide valve, which is located at least partly inside at the piston-side head of the driving cylinder, and the slide valve stem of which is at least partly outside the inner cylinder liner in the direction of movement of the piston part, in which case the solenoid valve may be implemented in a simpler way and, for example, with a smaller amount of gaskets between the different parts of the solenoid valve and of the driving cylinder and external flow ducts of the slide valve.

According to a first aspect of the present invention, there is provided a driving cylinder of a pile driving rig including a cylinder part with an outer cylinder liner and an inner cylinder liner fitted within each other, a piston part comprising a piston rod extending from inside the inner cylinder liner outside it, wherein in the part inside the inner cylinder liner is a piston fitted tightly and reciprocatingly inside the inner cylinder liner, and in the part extending outside the inner cylinder liner is a fixture for fastening the piston rod to a ram block, a piston-side head which is fastened tightly to the

piston-side end of the outer cylinder liner and the inner cylinder liner in such a way that the pressure medium conveyed inside the driving cylinder will not be able to leak outside the driving cylinder through the joint between the piston-side head and the outer cylinder liner and inner cylinder liner, a piston rod side head which is fastened tightly to the piston rod side end of the outer cylinder liner and the inner cylinder liner in such a way that the pressure medium conveyed inside the driving cylinder will not be able to leak outside the driving cylinder through the joint between the piston rod side head and the outer cylinder liner and inner cylinder liner, at the piston-side head, at least one pressure medium outlet connection for conveying the pressure medium outside the driving cylinder, and pressure medium ducts for connecting the pressure medium outlet connection and the interspace between the outer cylinder liner and the inner cylinder liner to the piston-side cylinder chamber limited by the piston-side head, the inner cylinder liner and the piston, at the piston rod side head, at least one pressure medium inlet connection for conveying the pressure medium from outside the driving cylinder into the driving cylinder, and pressure medium ducts for connecting the interspace between the outer cylinder liner and the inner cylinder liner to the piston rod side cylinder chamber limited by the piston rod side head, the inner cylinder liner and the piston, fastening means for fastening the driving cylinder to the hammer of the pile driving rig, and in which driving cylinder the solenoid valve controlling the operation is a slide valve which is located at least partly at the piston-side head of the driving cylinder, and the stem of which slide valve is at least partly outside the inner cylinder liner in the direction of motion of the piston part.

According to a second aspect of the present invention, there is provided a pile driving rig including the above driving cylinder.

The advantage of the driving cylinder of the pile driving rig according to embodiments of the invention is that the solenoid valve can be made simpler, more durable and more reliable than before. Due to this, the number of separate parts requiring tightness and precise dimensioning, such as hoses and valves outside the driving cylinder, decreases and thus the driving cylinder and a pile driving rig equipped with such driving cylinder, are simplified and more economical in terms of manufacturing costs. This type of driving cylinder also has the following advantages:

- The slide valve may be implemented in such a way that the pressure of the pressure medium, which affects the slide valve stem, is always equal on both sides of the stem, whereupon the slide valve stem of a pressurized driving cylinder is always in force balance. On account of this, the volume flow requirement of control is lower, which means that the control ducts of the slide valve may be smaller, thus

rendering the overall external dimensions of the driving cylinder smaller and the driving cylinder itself lighter.

- Structures subject to the pressure of the pressure medium have no welded joints, which results in better fatigue durability and easier manufacture.
- Conveying the pressure medium from the well utilised pressure accumulators mounted in conjunction with the driving cylinder may be done along the shortest route to the piston rod side head. This gives good operating efficiency with low vibrations in the pressure line.
- The pressure medium may be conveyed away from the driving cylinder along a short route by utilising the damping of the pressure accumulators. This improves operating efficiency, decreasing the strength of oscillations in the return line.
- In the driving cylinder is achieved an even load distribution throughout, because the flow of pressure medium can be made to affect both the solenoid valve of the driving cylinder and also its cylinder and piston parts symmetrically.
- The slide valve stem of a pressurised driving cylinder is in balance with respect to the forces acting on it. The stem is hollow and the same pressure acts on both of its ends. On different sides of the control lug prevails either the control pressure of the stem or it is connected to the outlet line.
- The piston-side head is a replaceable module, which means that it is possible to add new functions (e.g. slow drive) to the driving cylinder subsequently by modifying the piston-side end and the slide valve located in conjunction with it.
- The diameter of the slide valve stem can thus be made smaller than the stem located outside the inner cylinder liner, whereupon it becomes lighter and thus the slide valve becomes faster.
- All bores in the slide valve casing can be made symmetrical around the stem. As a result of this, the flow of pressure medium is steady in all directions, which means that no transverse forces with respect to its direction of movement are exerted on the stem, which forces could cause the stem to seize on the slide valve body.
- The same driving cylinder can be made either such that it either does not have an upper rod or has an upper rod, that is, the piston rod may extend outside the cylinder part either only from one end of the driving cylinder (the piston rod side end) or both ends, in which case there is a gasket housing at the piston-side end and in that case the piston rod also passes through the end where the slide valve acting as the solenoid valve of the driving cylinder is.
- The modular structure makes it possible to have a wide production range by means of which can be implemented various lifting and acceleration forces and thus be responded well to different production requirements. Furthermore, late variation of production is possible due to the modular structure.

- A cylinder structure without an upper rod is functionally advantageous, because it can be utilised to shorten the overall length of the hammer approximately by one stroke length (1 m). On account of this, smaller cranes can be used for moving pile driving rigs at construction sites.

In a preferred embodiment of the driving cylinder of a pile driving rig according to the invention, the fastening of the driving cylinder on the hammer body of the pile driving rig is implemented by means of a stroke damping mounting in a centre piece at the centre of gravity of the driving cylinder. This reduces the stroke-like loads exerted on the body of the hammer by the driving cylinder and noise.

In a preferred embodiment of the driving cylinder according to the invention, the fastening of the moving end of the driving cylinder to the ram block is implemented by means of a fixture fastened on the piston rod by means of a wedge attachment and on the ram block by means of a flexible flange attachment. Due to such fastening, the ram block, and on the other hand the driving cylinder, are not subjected to as strong transverse forces as in known solutions, where the end of the piston rod is attached to the ram block with an articulation.

Description of the drawings

The invention is described in greater detail in the following, with reference to the accompanying drawings, in which

Fig. 1 shows a driving cylinder according to the invention, as seen diagonally from the side,

Fig. 2 shows the driving cylinder of Fig. 1 as a partial cross-sectional side view,

Fig. 3 shows a diagonal side view of the lower head of the driving cylinder of Figs. 1 and 2 when detached from the driving cylinder,

Fig. 4 shows a diagonal side view of the upper head of the driving cylinder of Figs. 1 and 2 when detached from the driving cylinder,

Fig. 5 shows a cross-section of the upper head of Fig. 4 as a section of the upper head at the electric pilot valve comprised therein (cross-section A–A shown in Fig. 4),

Fig. 6 shows a cross-section of the upper head of Fig. 4, as a section at the discharge ducts at the upper head (cross-section B–B shown in Fig. 4),

Fig. 7 shows the inner cylinder liner of the driving cylinder of Figs. 1 and 2 as a diagonal side view,

7. A driving cylinder (10) of a pile driving rig according to claim 6, wherein inside the slide valve body (37) and the slide valve head piece (38) is a stem cylinder (41), wherein the stem (39) is configured to reciprocate from a first position to a second position and from a second position to a first position.

8. A driving cylinder (10) of a pile driving rig according to any of the claims 1 to 7, wherein the piston-side head (14) and the piston rod side head (15) are fastened to the outer cylinder liner (12) and the inner cylinder liner (13) with studs (23, 24) pulling the head pieces against the outer cylinder liner (12) and the inner cylinder liner (13)

9. A driving cylinder (10) of a pile driving rig according to any of the claims 1 to 8, comprising a centre piece (22) fastened between the piston-side head (14) and the piston rod side head (15).

10. A driving cylinder (10) of a pile driving rig according to claim 9, wherein the centre piece (22) comprises a fastening flange (25) located at the centre of gravity of the driving cylinder (10).

11. A driving cylinder (10) of a pile driving rig according to claim 10, the driving cylinder (10) comprising piston-side studs (23) and piston rod side studs (24), and in which driving cylinder (10), the piston-side studs (23) are fastened between the piston-side head (14) and the centre piece (22) and the piston rod side studs (24) are fastened between the centre piece (22) and the piston rod side head (15).

12. A pile driving rig comprising a driving cylinder (10) according to any of the claims 1 to 11.

13. A pile driving rig according to claim 12, wherein the driving cylinder (10) is fastened to the hammer of the pile driving rig from the centre piece (22) of the driving cylinder (10) by means of a bearing piece (63) damping impacts and vibrations.