

高效的多相混输泵为墨西哥湾提升油气产量

在过去的二十年来，多相混输泵获得了市场越来越多的认可。尤其是适用于广泛的流量和压力范围的双螺杆多相混输泵，不仅使老化和已成熟的油田有新的应用，最近发现更能应用于处理含气量高的油井。低设置成本以及占用面积小等特点，使双螺杆多相混输泵特别适用于海上平台应用

Powerful multiphase pumps for increased oil and gas production

During the past two decades multiphase pumps experienced growing acceptance, especially Twin Screw Multiphase Pumps (MPP), which cover a wide range of flow rates and pressures and have found many applications on aging and matured oilfields but also on recent discoveries with high gas content. Low installation costs go along with small dimensions which makes Twin Screw Multiphase Pumps particularly suitable for the installation on Offshore Platforms

自十九世纪中叶，人们初始发现并开发大量油井，石油和油气成为现代工业发展的基石。作为化学工业的原料，或是生产电力的来源，以及显著增长的机动燃料，油与气在全球许多国家的财富增长贡献显著。世界人口的持续增加和新兴经济体的工业成长导致人们对能源需求日益增多。

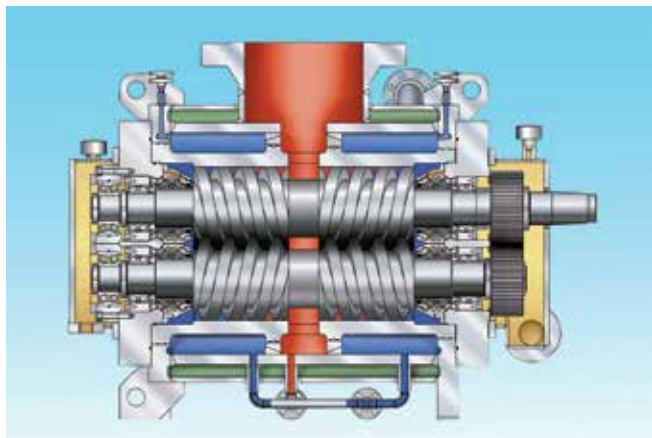
然而，人们早已意识到，低成本的碳氢化合物的时代已不复返。全球大多数产油国在多年前已达到产量高峰，而现今面对供不应求的问题。能源最大的消耗者往往不是最大的生产者。好在，近年来成功的探索，开启了油田与气田崭新的一页。

以区域性的原油生产开发分析，2010年，全球每日产油量增加180万桶。该增长是广泛性的，欧洲及欧亚区域除外。此外，增长广泛属于OPEC成员国国家以及非OPEC成员国国家。同一时期，世界每日耗油量增加270万桶，各区域的增长超过平均值，其中亚太地区占世界耗油量增长的54%。

但是，这些新的储油生产并不容易，石油公司更是面临许多挑战。世界上大多数未开采的油气储备接近北极圈，抑或是在浅的、深的、或极深的海底，或是在不易取得的沙漠中。此类地方多半尚未开发，必须要有合适的基础设施，以成功勘探新的油气田和大量

Many oil producing countries have not yet developed sufficient infrastructures to use the associated gas produced as feed stock and automotive fuel or for power generation and heating purposes. This gas is still widely flared or vented after separation and contributes significantly to the global warming. Statutory measures to ban flaring and MPP contribute to achieve this target by transferring the untreated well flow to centralized treatment facilities where the petroleum gas can be economically processed.

Twin Screw MPP's (Fig 1) are rotary positive displacement pumps of double volute design. They are hydraulically balanced with no thrust loads. The screws are machined from single piece bar stock for maximum stiffness and minimum shaft deflection. They are installed in the replaceable casing insert. For wear protection the screw surfaces are nitrided. The torque from the drive screw is transmitted to the idler screw via oil lubricated timing gears. Heavy duty tapered roller bearings carry the drive and idler screws and the short bearing span contributes to the



图一 Leistriz双螺杆多相混输泵切面图
Fig 1 Cut-a-Way of a Leistriz Twin Screw MPP

生产。中南美洲发现了许多油气田，尤其是墨西哥和巴西更是开发了足够国家储备多年的资产。

今日，许多油田处于成熟期。储油的压力随年而降，必须采用人工提取方式，例如注入气体或水，或使用ESP（Electrical Submersible Pumps）电潜泵将井流提升到表面，产生足够的压力以利于操作传统分离设备。多相混输泵，能在极低的井口压力条件下，高效地提升成熟油井的产量。

许多石油生产国家尚未具备足够的基础设施，将副产的油气作为化工原料、机动车辆燃油、发电或用于加热用途。这些油气仍然经常在分离后被燃烧处理或排入大气之中，其中释放出来的二氧化碳，或更为严重的甲烷，明显导致温室效应。大多数国家已采取法规，在未来的几年内禁止燃烧或排放油气。多相混输泵将未经处理的井流传输到集中的处理设备，进而在这方面拥有相当的经验与成就。

双螺杆泵—多相混输系统

双螺杆多相混输泵是双流道容积螺杆泵，经过液压平衡，轴承上不带有轴向载荷。介质由泵吸入口进入泵后，被分别导入两个流道，并经由相对的螺纹在螺杆组内加压。螺杆与转轴由一个完整的坚硬原材精密加工而成，拥有最大的硬度与整体特性，并在任何使用情况下，确保螺杆的轴挠度降到最低。接着，螺杆被安装在可更换的铸钢内衬壳套内。螺杆的表面经过渗氮硬化处理，防止磨损。主螺杆的转矩经由润滑过的定时齿轮传送到副螺杆。外置的润滑油系统为定时齿轮、以及承载主、副螺杆的重荷载且超长使用寿命的锥形滚柱轴承，提供适度的润滑油。极短的轴承间距设计，减少螺杆的轴挠度。

泵的螺杆与壳套无直接接触。确保螺杆与壳套之间在任何使用情况下保持一定的间隙，是双螺杆多相混输泵设计的一个基本并且必要的重点。

泵的双螺杆，由sic-sic（碳化硅）材质构成的双机械密封，在介质和与大气接触端形成密封。并使用一个符合API 54冲洗方案要求的外置密封系统为各边的机械密封提供干净并冷却的密封油。所有机械密封安装在泵的吸入端，因此只受泵入口压力的作用。

minimization of the shaft deflection.

There is no contact between pump screws and casing insert. To maintain a clearance between the pump screws and the casing insert under all operating conditions is a basic and essential design criteria for Twin Screw MPP's.

The screw shafts are sealed by double acting mechanical seals with SiC seal faces on both product and atmospheric side. An external barrier system in accordance with the requirements of API Plan 54 provides clean and cool seal oil to each seal. All mechanical seals are installed on the suction side of the pumps and hence, exposed to suction pressure only.

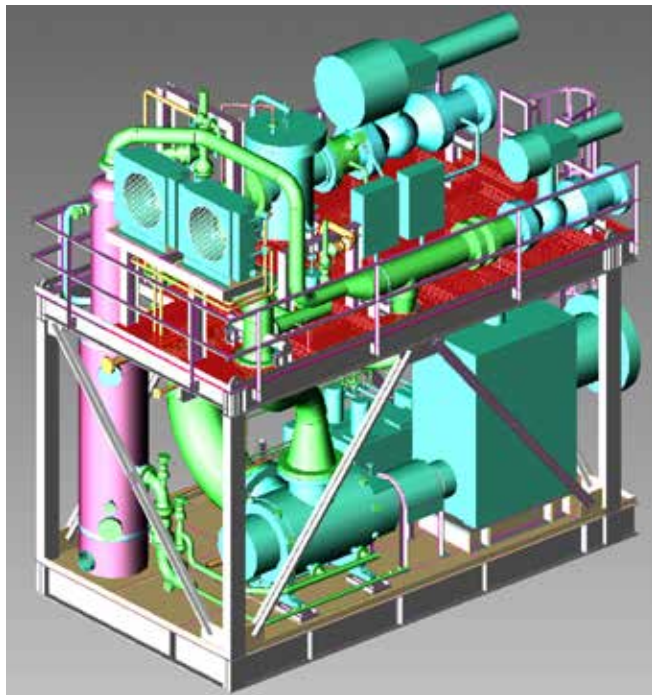
A Large Multiphase Production System

The Gulf of Mexico is historically the most important area in North America for providing oil and gas as feedstock to Petrochemical Industry in the USA and Mexico. In the Mexican Territorial waters, significant discoveries of oil and gas have been made in the last 30 years. The oil is typically heavy with an API gravity of 18 to 22 with significant amounts of associated gas produced with the oil. A lot of the gas is used in power generation for gas turbine driven pumps and compressors and in processing of the crude oil. When the wells started to flow initially, water injection was used to maintain reservoir pressure. As the wells were aging gas lift was introduced. This method of production is also sufficient to bring up the oil and to provide sufficient pressure in the pipeline to overcome line losses and the arriving pressure of the first stage separator.

Gradually the gas lift is not enough to recover the oil in the reservoir and the bottom hole pressure of the well reaches a point where the oil cannot any longer move from the formation to the well bore. At that moment there are some few remedies left to save the reservoir from abandonment and one of these is the fast developing technique of multiphase pumping.

In the case of the Ku-Maloob-Zaap Field the production from the wells were estimated to drop very quickly and in the next few years reach a point where they would have to be abandoned. After lengthy studies, it was decided by the Mexican State Oil Company that three of the usually unmanned wellhead platforms were going to be equipped with multiphase pumps.

The multiphase pumps propositioned were analysed in detail. Production curves were showing a pressure draw down at the wellhead of 12 bar would have a significant positive impact on the bottom hole pressure and the ability of the wells to continuous producing. At this low well head pressure the associated gas will expand significantly which means at pump inlet the gas fraction (GVF) can be up to 97%. With the wells sometimes intermittent liquid production (oil and water) it was necessary to provide the pumps with a liquid recirculation system to keep the pumps primed at all times even with long



图二 多相混输泵防磨损三维图
Fig 2 Completed Multiphase Pump Skid in 3D

泵操作参数及设计说明

安装在三个平台上的双螺杆多相混输泵的设计参数如下：

泵壳材质为锻造碳钢，侧进上出，所有焊接部分经过严谨的非破坏性测试质量控制。

泵的螺杆由渗氮硬化处理过的碳钢制造而成，以防止磨损。可更换的内衬材质为铸造碳钢。

所有会接触到液体或受压的泵体部分所采用的材料，符合美国 NACE MR 0175 最新版本的要求与规范。

所有泵均配置一个液体缓冲系统（再循环系统）。此系统安装在撬内，泵出口端的下游位置。泵在运行时，以最低97%的效率，将液

gas slugs. Each of the three platforms have 24 producing wells tied to a common suction manifold which in turn is connected to either five or six of the multiphase pumps, depending on the platform. The pumps operate in parallel driven by 1900 kW variable frequency controlled electrical motors. The speed of the motors which control the pumping capacity and thereby the pressure in the suction manifold is automatically set to follow the desired optimal manifold pressure.

All pumps are packaged in modules (Fig 2), including controls and instrumentation. In addition to the pumps (16 in total), three air conditioned containers were supplied which contain the frequency converters, automation, switchgears and controls.

The pumps and system design originates from Leistritz Pumpen GmbH in Nuremberg, Germany and Leistritz Corporation, Allendale, NJ USA. Experienced U.S. partners were used in designing and building the pump modules and E-buildings with all the required controls and automation systems.

Operating Data and Design

The Twin Screw Multiphase Pumps Type L4MG 410 installed on each of the three platforms are designed for the parameters shown in Fig 3.

The construction materials for all wetted and pressurized pump parts meet the requirements of NACE MR 0175, latest edition.

Each pump is equipped with a liquid management system, located on the skid downstream the pump discharge. During the pump operation liquid is separated from the multiphase flow and collected in the reservoir of the liquid management system. A recirculation volume equal to approx. 3.0 percent of the actual flow rate is constantly injected into both suction areas of the pumps. During gas slugs this amount of liquid is sufficient to ensure continuous gas compression. The large surface of the reservoir contributes to the quick heat dissipation and renders additional cooling unnecessary. The volume of the

	Maloob B	Zaap B	Zaap D
总流量	19,300 m ³ /h (2,912,700 bpde)	13,500 m ³ /h (2,174,850 bpde)	15,400 m ³ /h (2,325,800 bpde)
差压	12 bar (174 psi)	9 bar (130 psi)	12 bar (174 psi)
含气率	97 %	97 %	97 %
水泵安装数	6	5	5
单泵功率	1,866 kW (2,500 HP)	1,493 kW (2,000 HP)	1,866 kW (2,500 HP)

图三 操作参数
Fig 3 Operating Datas

体稳定地从混输液流分离。分离的液体储存在缓冲系统中的储罐里，相等于实际流量3%的液体连续从储罐注入泵的两个吸入端区域里。当抽吸到段塞流时，这些液体足够确保油气压缩的连续动作。液体储罐略大的面积使散热快速，免除了外加冷却系统的需要。液体缓冲系统储罐的容量，根据客户指定的最高段塞流长度而设计。

所有的泵在发货前，一律会经由现场见证的静压测试和现场见证的出厂认可测试。

结论

双螺杆多相混输泵以及传统双螺杆泵，成功地应用在墨西哥湾的近海区域。随着成熟和老化油田数量的增加，以及已使用多年油田的寿命延长和新建绿色油田的特殊性质，市场对多相混输技术的要求将会逐年剧增。

多功能的双螺杆泵操作范围广泛，可处理任何比例的液体和气体的混合物，还可处理最高流量达5,000m³/h、最高压差150巴内、各种粘度的液体。双螺杆多相混输泵，不仅投资与运营成本相对较低，并且免除了燃烧与排放尾气的需要，对环境保护做了相当的贡献。

本文由德国Leistritz的Sven Olson, Hans Jürgen Schöner和Michael Radke博士撰写

reservoir is adapted to the maximum expected gas slug length specified by the customer.

Conclusion

Twin Screw MPP's and conventional Twin Screw Pumps are successfully used offshore in the Gulf of Mexico. The increasing number of aging and mature fields, the life extension of brown fields or the special characteristics of green fields will generate a consistent demand for multiphase technology. The versatile Twin Screw Pumps have a large operating window and handle combinations of liquid and gas in any concentration and cover a large range of viscosities at flow rates up to 5,000 m³/h and differential pressures up to 150 bar. Capital and operational expenditures are low for Twin Screw MPP Installations and they contribute to the protection of our environment by eliminating the need for flaring and venting. ■

This article was written by Sven Olson, Hans Jürgen Schöner, Dr. Michael Radke, Leistritz Pumpen GmbH, Nuernberg, Germany

Leistritz
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德国雷士螺杆泵及系统

雷士螺杆泵能够满足您最严苛的工况需求与应用。欢迎各界客户来电洽询。

Screw Pump Program

泵系列	L2 双螺杆	L3 三螺杆	L4 双螺杆 (双轴流)	L5 五螺杆	LPS 螺杆泵成套系统
介质属性	低研磨性和低腐蚀性、低/高粘度及低/高润滑性介质	无研磨性或腐蚀性、低/高粘度及低/高润滑性介质	有/无研磨性、有/无腐蚀性、有/无润滑性等各种粘度的介质	轻度或无研磨性、轻度或无腐蚀性、有/无润滑性等各种粘度的介质	有/无研磨性、有/无腐蚀性、有/无润滑性等粘度的多相混输介质 (100%含气)
最高流量	900 m ³ /h (3,960 GPM)	700 m ³ /h (3,100 GPM)	5,000 m ³ /h (22,000 GPM)	1,700 m ³ /h (7,500 GPM)	5,000 m ³ /h (22,000 GPM)
最大压差	16 bar/232 psi	280 bar/4,060 psi	150 bar/2,175 psi	10 bar/145 psi	150 bar/2,175 psi
最高粘度	100,000 cst	15,000 cst	150,000 cst	100,000 cst	150,000 cst
最高温度	280°C/536°F	280°C/536°F	350°C/662°F	280°C/536°F	350°C/662°F

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