

INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH
TECHNICAL VISIT TO ZOOMLION KAM TIN HONG KONG SERVICE
CENTRE ON 28/4/2018



IMechE Hong Kong Branch visited Zoomlion Hong Kong Service Centre in Kam Tin, New Territories on 28/4/2018

Concrete is an essence for modern building construction. Even though buildings are nowadays have utilised pre-fabricated modules to minimise the *in-situ* works, certain tasks still require casting of concrete at site. In the past, liquid concrete was transferred from the ground to the casting site at elevation by being carried by a concrete bucket lifted by a towered crane. Such transfer in small amount each time was time-consuming and less safe, as it involved lifting. Nowadays, modern concrete pumps are utilised to pump large quantity of liquid concrete from ground to elevation continuously. Involving no lifting, the transfer of the liquid concrete is safer and more time-efficient, shortening the construction period of concrete structures. Concrete pump is a powerful and helpful tool for the construction industry.

The Hydraulic Power

A typical concrete pump comprises of a hopper, a pair of hydraulic-powered positive displacement pumps (cylinder pumps) and discharge pipes.

The hopper is where the liquid concrete is poured into for being pumped. It is equipped with a stirrer to help maintaining the fluidity of the liquid concrete throughout the transfer process.

The twin cylinder pumps work by one piston draws the liquid concrete into a cylinder from the hopper while the other one simultaneously pushes the liquid concrete drawn earlier into the delivery pipe. A S-shaped channel, called “S-Valve”, switches between the cylinders to channel the liquid concrete pushed from the discharging cylinder to the delivery pipe. In parallel, while the discharging cylinder is closed by “S-Valve”, the sucking cylinder is open which permits the liquid concrete inside the hopper to be drawn into it.

The twin cylinders and the jibs are powered by a hydraulic system which comprises of a hydraulic pump, a hydraulic oil cooler, a hydraulic oil container, a nitrogen-driven accumulator and the twin cylinders and jib. The hydraulic pump exerts pressure on the cylinder piston as high as 280 bars, while the cylinder pump discharge pressure varies by the pump size (i.e. cross section area or diameter). For a typical concrete pump mounted on a three (3) axle truck chassis, the discharge pressure is about 60 bars and the transfer rate is roughly 160 m³ of liquid concrete per hour. The power transmission from the hydraulic pump to the liquid concrete being discharged from the cylinder is about 70 % efficiency.

The hydraulic circuit is closed loop, whereby the hydraulic pump, the cylinder pumps and the jib form a closed hydraulic fluid flow circuit. Pressurised nitrogen is released to the cylinder pumps to boost the impulse of pushing the liquid concrete. The high pressure and temperature hydraulic oil in the closed loop is diverted by the relief valve to the hydraulic oil cooler and finally return to the hydraulic oil tank.



Power Take-Off between the truck gearbox and differential gear on the rear axle to offtake power to the hydraulic pump

The hydraulic pump is driven by the shaft power of the truck engine via the power take-off gearbox (P.T.O.). P.T.O. steps-up the shaft speed of the truck engine from 1,150 revolutions per minutes (rpm) to the required 2,350 rpm for powering the hydraulic pump. Usually, the top gear of the truck gearbox provides the gear ratio of 1:1 and the engine speed of 1,150 rpm, and the trucks of Euro 2 emission standard

and after have equipped with the programmable logic control (PLC) to automatically adjust the engine output to suit the P.T.O. loading once the top gear is engaged. Once the hydraulic pumps are in operation, the engine speed raises from 610 rpm at idle to 1,150 rpm autonomously.

Reach Afar

Leaving the cylinder pumps, the liquid concrete runs through the discharge pipes along the jibs and discharges at the pipe end.

The jib of the concrete pump mounted on a 16 m long truck chassis, if in maximum four (4) section, may reach maximum 63 m afar. The jib is made of steel supplied

from Sweden. Should the jib be extending over 64 m and five (5) sections or more, it is to be made of carbon fibre composites. Currently only the Italian can construct concrete pumps of over 64 m of operating range, which carbon fibre-made jibs are fabricated by the famous Italian luxury car brand, Maserati.

The jib may rotate from the truck 120 degrees if the front and rear outriggers extend half of their full length, and 360 degrees full length. The outriggers are not fitted with sensor for detecting the float level, relying on the crane operator to ensure the stability of outriggers.

The discharge pipes are compound pipe in design. The outer pipe is ordinary carbon steel such as the Chinese grade Q345, while the inner pipe is cemented carbide which characters very high hardness and very low ductility (i.e. very brittle). Nowadays aggregates for concrete can be in various materials, from the conventional sand and gravel to bitumen, fibre and even Styrofoam, and only cemented carbide can withstand the extraordinary high abrasion of the flow of liquid concrete. The higher the light reflection of the cemented carbide surface, the higher the hardness of the material. Currently the German-made commercially available cemented carbide surpasses the Chinese-made one in terms of hardness, and the price difference can be in the ratio of 3:1.

Frictional losses are taken in consideration in designing the liquid concrete to flow through the discharge pipes. As a rule of thumb, the pressure drops 1 bar per 3 m of straight pipe and 3 bars per 90 degree elbow. The design life of the discharge pipes is about 50,000 m³ of liquid concrete transfer.



A Zoomlion-made concrete pump mounted on a Mercedes Benz Actros 3347 truck

In selecting the truck for housing a concrete pump, usually the concrete pump original equipment manufacturer (OEM) provides the truck OEM the parameters, such as weights, dimensions and power consumptions, and the truck OEM nominates a suitable model. In Hong Kong, the European trucks are preferred over the Japanese ones because their power-train has higher margin to drive the concrete pump hydraulics. Also in Hong Kong, truck-mounted concrete pumps are considered mobile construction equipment and are not licensed to be on the public roads. Escort is needed should a truck-mounted concrete pump be mobilised.

Remarks

Concrete pumps leverage on the positive displacement pumping principles to transfer liquid concrete continuously and time-efficiently. For a truck-mounted concrete pump, the power to drive the cylinder pumps is taken from the truck engine through P.T.O. to the hydraulic pump, whereby high hydraulic pressure as high as 280 bars is generated to thrust the cylinder piston and discharge the liquid concrete from the cylinder pump at about 60 bars. Compound pipes are used to channel the liquid concrete from the cylinder pumps to the discharge end, with the inner pipe made of cemented carbide to combat against abrasion during the transfer of liquid concrete.



Mr. Kenny Ip of Paak Wan Machinery Limited received the certificate of appreciation from Mr. Benny Sit, organiser of the technical visit

A modern truck-mounted concrete pump is an integration of the hydraulic system, PLC system, automotive and material engineering. The oldest unit in active operation in Hong Kong was built in 1979; yet its operating principles are the same as the modern Zoomlion-made ones which the member of Institution of Mechanical Engineers (IMechE) were privileged to visit on 28/4/2018.

IMechE Hong Kong Branch thanks Mr. Kenny Ip of Paak Wan Machinery Limited and his colleagues of Zoomlion for their offer of and detailed explanation in the technical visit.

Reference

<http://www.schwing-stetter.co.uk/Pages/ConcretePumpingOverview.aspx>

Encl.
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ZOOMLION
HEAVY INDUSTRY(HK) CO., LTD.
中聯重科(香港)有限公司



IMechE Hong Kong Branch
Activity Sub-Committee – Technical Visit Group

TECHNICAL VISIT to Zoomlion Hong Kong Service Centre

Founded in 1992, Zoomlion Heavy Industry Science & Technology Co., Ltd. is mainly engaged in developing and manufacturing equipment in the areas of engineering industry and agricultural industry. Zoomlion is China's first construction machinery company to be listed on both Shenzhen and Hong Kong stock exchanges, with registered capital amounting to RMB 7.664 billion.

Zoomlion Kam Tin Hong Kong service centre provided new commercial truck assembly service such as mobile crane, concrete mixer truck and concrete pump truck. It also provides aftersales repair and overhaul services in Hong Kong region.

Date: 28th Apr, 2018
Time: 9:00am – 12:00noon

Free of charge for IMechE Members
Number of participants is limited to 20.
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