Choice of truck for installation of concrete pump and distribution boom

Y V Koshkarev and M A Stepanov
Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia
Email: koshevas@mail.ru

Abstract. Numerous mechanisms (up to 10) have hydrostatic transmissions, working from the energy, coming from several hydraulic pumps, driven by the engine of the truck. The selection of engine power is always different for different types of attachments installed on the chassis of the truck. Therefore, when choosing a truck, it is necessary to take into account that both the concrete pump and the boom work simultaneously. The use of concrete pump and placing boom on the chassis of the truck requires increased power up to 300 kW and even more. On the other hand, it is required that the chassis of the truck be able to withstand both static and dynamic loads of equipment, taking into account its size, especially in length. Despite many years of experience in design and production, the issues of choosing a truck for these machines remain little investigated. In this article on the basis of the constructive and statistical analysis the method of the choice of the truck for a concrete pump and a placing boom is offered.

1. Introduction

A truck-mounted concrete pump is generally a machine consisting of a concrete pump and a concrete distribution boom mounted on a truck platform or other wheel platform and powered by the propulsion motor thereof. The main power consumers are thereby the following units:
- a double piston pumping unit;
- a screw mixer inside the feed hopper;
- a spool valve connecting in turn the cylinders of the pumping head with the supply concrete duct also placed inside the hopper;
- a water pump;
- an air compressor;
- a slewing drive of the boom;
- a vertical boom reach control mechanism;
- an outrigger mechanism.

All the listed mechanisms feature thereby hydrostatic transmissions powered by fluid supplied from several hydraulic pumps driven by the vehicle’s propulsion motor via a power take-off attachment (PTA) [1-3].

2. Analysis of basic provisions

The motor is always loaded unequally by various types of attachments mounted on the vehicle chassis. It should be also taken into account that the power demand significantly varies throughout the operation process. The operation of the concrete pump and the concrete distribution boom on an
automotive chassis requires increased power, in average, by up to 200-300 kW and in special cases even up to 455 kW (the most powerful concrete pump in the world) [4].

Utilization of power ratings over 100 kW requires a special transfer gear. A fluid power system is generally driven via a power take-off attachment (PTA) and depending on the propulsion clutch of the vehicle, since during concrete operations the vehicle is immobilized; however, also clutch-independent power take-off attachments are sometimes utilized in truck-mounted concrete pumps [5-6].

In the first case, a PTA on the rear or the side wall of the vehicle's gear box offers numerous benefits:
- less weight than a clutch-independent power drive;
- less energy demand, since it is stopped at disengaged clutch;
- minor operation and repair costs;
- PTA is locked in transit completely preventing any unintended operation.

Briefly, a clutch-dependent PTA should be preferred for truck-mounted concrete pump arrangements, if the vehicle is immobilized for concrete operations.

The wheel arrangement choice (total and driven wheels numbers) of the automotive platform is of decisive significance, since during the placement of the attachments a designer encounters a multitude of problems whereof the major one is the big length of the pumping assembly due to the two long-stroke piston rods of longitudinal arrangement, that is, the minimum length of the assembly shall always exceed the double piston stroke length. Taking into account the varying piston stroke length within 1200 ... 2800 mm, the total length of the pumping unit should be considered, at least, 2500 ... 5700 mm including the cylinder wall thickness [7].

For example, the Russian manufacturer utilizes for concrete pump and boom mounting KamAZ-65115 truck of seven sizes with 4300 ... 6900 mm platform length, for 17350 ... 14650 kg total attachments weight [8-10].

The second problem is the placement of the swiveling turret behind the driver’s cab, with a rotary support with a pin for the tail piece of the boom and a holder for a hydraulic cylinder. Inside the turret, there is a swiveling mechanism and the vertical concrete duct. The swiveling turret has the maximum size from 500 to 1000 mm dependent upon the machine size [11].

Important heed is paid also to the hopper always occupying the aft of the vehicle platform well-accessible for concrete mixture loading.

While solving the aforesaid problems, the designer has to select a long wheelbase chassis. However, one more problem occurs – not to exceed the total mass of the truck-mounted concrete pump and the admissible axis load, which may differ in different countries. In view of the aforesaid, the world manufacturing praxis of truck-mounted concrete pumps adheres to the following axis number limits assigned to the boom reach (see table 1). The results were obtained in the course of statistical analysis of 66 units [12].

| Parameter      | Value     |
|----------------|-----------|
| Boom reach, m  | 15 - 24   |
|                | 24 - 35   |
|                | 35 - 50   |
|                | 50-61     |
| Number of axis | 2         |
|                | 3         |
|                | 4         |
|                | 5         |
| Wheel arrangement | 4x2, 4x4 |
|                | 6x4, 6x6  |
|                | 8x4, 8x8  |
|                | 10x4, 10x10 |
| Maximum load, t | 18        |
|                | 25        |
|                | 32        |
|                | 35        |

3. Results

The number of boom sections of the truck-mounted concrete pump unit almost does not correlate with the delivery head and with the concrete pump set performance. For example, the company SCHWING GmbH being one of the world’s leading manufacturers of truck-mounted concrete pumps utilizes in all its models except for S55SX only 4 boom sections, whereas Putzmeister Concrete Pumps GmbH, another important German manufacturer, utilizes 4 sections for up to 31.4 m reach, and 5 sections in other models [13-14]. A larger variety of this parameter of the boom is demonstrated by Zoomlion
Heavy Industry Science & Technology Co., Ltd (China): 3 sections at reaches up to 18.2 m, 4 sections at reaches up to 28.8 m, 5 sections at reaches up to 39.6 m, 6 sections at reaches up to 55 m and 7 sections at reaches up to 101 m (world’s biggest truck-mounted concrete pump) [15-16]. The variety of truck-mounted concrete pumps in terms of the delivery head, see Fig. 1.

![Figure 1. Variety of models manufactured in the world in terms of the delivery head.](image)

Consequently, the number of boom sections [17-18] of the existing design arrangements of concrete distribution booms can be taken from 3 to 6. Thereby it should be stressed that the increased number of sections makes the boom more complex, more power absorbing, requires more time for folding/unfolding and bigger height clearances in transit, provides however process benefits during concrete operations in terms of better adaptations to the architectural form of the erected building and contributes to increased operation range on the concreting elevation mark in the specified reach and height.

4. Conclusion
The following conclusions can be stated:
1. the choice of the type of truck to install the concrete pump and boom is influenced by the stroke of the pump piston and the height of the concrete mixture delivery;
2. the number of boom sections does not affect the overhang and feed height of the concrete mixture, but changes its adaptability to the building.

References
[1] Alexeev S N 1952 Nasossnyy transport betonnoy smesi (Moscow: Gosstroyizdat)
[2] Ede A N 1957 Mag. of Concrete Research 9 129–40
[3] Browne R D and Bamforth P B 1977 J.ACI 74 193–203
[4] Sakuta M, Kasanu I, Yamane S and Sakamoto A 1989 J. of Concrete Research 22
[5] Chapdelaine F 2007 Thèse présentée à la Faculté des études supérieures de l’Université de Laval 98 -104, Quebec, Canada
[6] Ngo T T 2009 PhD dissertation Cergy Pontoise, France 52-58
[7] Pompes a beton stationnaires Liebherr 2018 https:// www.liebherr.cjm./external/products/
[8] Hicks T G Handbook of Mechanical Engineering Calculations Second Edition 1998 (McGraw-Hill Education) 112-115
[9] Hydraulic and pneumatic cylinders 1968 Ranges of basic parameters GOST 6540-68 (Standard of USRR)
[10] ISO 21573-1/2006 Building construction machinery and equipment. Concrete pumps. Part 2 Procedure for examination of technical parameters
[11] Uvarov M F, Stepanov M A and Koshkarev E V 2013 *EBS ASV*, 112-6 
http://www.iprbookshop.ru/20010.html
[12] Koshkarev E V, Skel V I and Christoforov V A 2014 *Mech. of const.*, 11 18-9
[13] Plavelsky E P and Sharapov R R 2017 *ICIE conference 2017* 206 86-92
[14] Hongbin T and Wu R 2015 *Adv. Mech. Eng.*, 175 pp.16-8
[15] MIOP Design and Consulting Pty, Ltd 2017 Concrete Placing Booms Mounted on Tower 
http://mip.com.au/Index_TowerBooms.html
[16] Koshkarev Y and Stepanov M 2019 *ICIE Springer, Cham*, 2211-7 DOI 
http://doi.org//10.10007/978-3-319-95630-5_238
[17] Plavelsky E P and Sharapov R R 2017 *International Scientific Conference on Energy 
Management of Municipal Transportation Facilities and Transport EMMFT 2017, Advances 
in Intelligent Systems and Computing*, 692 29-32
[18] Power take-off by hydraulic pumps 2017 www.volvotrucks.com