NEW TECHNIQUE TO INSTALL POWER CABLES INTO DUCTS

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ABSTRACT

An improved method to install high voltage cables into ducts using water flow is described. Instead of using a single pig, a number of (dividable) Multi-Pigs are mounted around the cable, exerting a distributed force resulting from the equally shared pressure differences over each pig. Because the capstan effect is reduced the installation lengths are increased considerably, while pulling forces on the cable remain small. The Multi-Pigs can also be used to flow cable lengths to any desired location, loose from the cable insertion equipment. This is especially of use in difficult to reach (for cable drums) places, e.g. tunnels.

KEYWORDS

Cable installation; duct; jetting, floating, pushing, water, pressure, pig, multi-pig, free flowing.

INTRODUCTION

There is a growing trend to get high voltage energy cables underground [1]. Compared to direct burying the cables, the adoption of ducts offers the benefit of drastically reduced disturbance to the neighbourhood, provides for additional cable protection and enables upgrading of the cable connection [1]. Furthermore, the duct can optionally be used for cooling, with gas (air) or liquid (water), passive or active, to allow for higher current loads [2].

The classical method to install high voltage energy cables into ducts is pulling by means of a winch rope. This technique is costly, limited to relatively short lengths, requires the extra step of installing a winch rope, requires manpower at both ends (drum side and winch side) and also causes wear of the cable because of the high pulling loads. An improvement of the pure pulling method is the push pull method, where the pulling is assisted by a cable push at the drum side. For aluminium high voltage energy cables, which are relatively lightweight, the WaTuCab (Water Tube Cable) method offers a further advantage [1]. Here, installation is done by means of a pulling pig (no more pulling with winch rope from other side) that is "powered" by means of water under pressure, also offering reduction in the effective weight of the cable because of buoyancy (Archimedes effect).

In this paper an improved method for the installation of cables using water is described. Instead of using a single pig, a number of (dividable) Multi-Pigs are mounted around the cable, exerting a distributed force resulting from the equally shared pressure differences over each pig. Because the capstan effect [3] is reduced the installation lengths are increased considerably, while pulling forces on the cable remain small. The Multi-Pigs can also be used to flow cable lengths to any desired location, loose from the cable insertion equipment. This is especially of use in difficult to reach (for cable drums) places, such as tunnels.

THEORY

The force to install a cable into a duct is caused by sidewall forces between cable and duct, resulting in friction. The following effects contribute to the pulling force build-up in the cable [3,4,5]:

1. Cable weight (gravity). This results in a pulling force that is proportional to the installed length of the cable.
2. Cable tensile force. In bends and undulations of the duct this causes a sidewall force proportional to the local tensile force in the cable. This results in a pulling force that increases exponentially with the installed length of cable. This effect is known as the Capstan effect. It dominates most cable pulls.
3. Cable compressive force. The same Capstan effect is present for compressive forces. Additionally also the cable buckles under the compressive forces, causing additional sidewall forces. This leads to an asymptotic pulling force built-up: from a critical force the cable cannot be pushed any further. The smaller the cable stiffness, the larger the buckling friction.
4. Cable stiffness in bends and undulations in the duct trajectory. This results in extra friction. For the cable head in a bend the effect is even larger. The higher the cable stiffness, the larger the friction from cable stiffness in bends and undulations in the duct.

Jetting

Some methods have been found to limit the force build-up. More than 2 decades ago, in telecommunications, the jetting method has been introduced [3,4,5]. An airflow is forced into a duct, while at the same time pushing the cable. There is no pig at the end of the cable, so the air can flow at much higher speed than that of the cable. This storm generates a cable propelling force that is distributed over the entire length of the cable. When dimensioning such that the air propelling force locally compensates the friction caused by the cable weight (effect 1), the local force in the cable can be kept low. This eliminates effects 2 and 3 for a large part. Even though the air drag forces are an order of magnitude smaller than commonly used forces to pull a cable, installation lengths by jetting usually exceed those obtained by pulling, especially in duct trajectories with many bends and undulations. Also no winch rope needs to be installed and manpower is only needed at one side. Today the jetting method is widely used all over the world to install telecommunications cables into ducts. Installation lengths of up to 3.6 km (in one "jet") have been reported.

Floating

Instead of air also water can be used [1,3,4,5,6]. This causes a reduction of the effective weight of the cable because of buoyancy (Archimedes effect). It would even be possible to tune the cable density such that the effective cable weight becomes zero.