UNDERESTIMATION OF THE FRICTION FACTOR IN A PIPELINE AND ITS INFLUENCE IN AN ACCIDENT CAUSED BY WATERHAMMER

GABRIEL SOTO-CORTES [1] and DARIO GUAYCOCHEA-GUGLIELMI [2]

[1] Professor Researcher, Department of Energy, Universidad Autónoma Metropolitana Azcapotzalco, Av. San Pablo 180, 02200 Azcapotzalco, Mexico City, Mexico (Tel/Fax: +5255-53189065, e-mail: gsc@correo.azc.uam.mx)
[2] Professor Researcher, Department of Energy, Universidad Autónoma Metropolitana Azcapotzalco, Av. San Pablo 180, 02200 Azcapotzalco, Mexico City, Mexico (Tel: +5255-53189003, Fax: +5255-53944831, e-mail: sacbi@correo.azc.uam.mx)

The Nuevo Teapa-Venta de Carpio oil pipeline is one of the longest ones in Mexico, with 480 km. Due to an irregular topography and to the necessity of transporting oil from coastal areas to the central plateau, the pipeline has continuous vertical and horizontal curves. The oil pipeline consists of a system of two parallel conduits of 24 and 30 inches respectively, designed according to API standards. With five intermediate pumping stations, the combined transportation capacity reaches about 550,000 barrels daily. It registers head losses which cannot be predicted by conventional formulas or attributed to pipe age or inlay deposits. An analysis, based on field measurements and supported on experimental and numerical concepts, using internal flows criteria and optimization numerical fitting procedures, shows that the friction factor is significantly influenced by dynamic effects. This issue was reported by Idelchik (1994) and Miller (1985); their works show that non-axial speed components produce alterations in the flow pattern and increase energy dissipation. Carmona et al (2002) performed studies about similar effects in a long aqueduct (diameter: 2.1 m and length: 42.6 km) with important alignment changes. The underestimation of the friction coefficient in the case study originates in turn an underestimation of the service pressure in the line. In the present paper, only the sector limited by Pumping Stations 2 and 3 is considered, because the objective is to analyse the influence of the friction factor underestimation in a recent accident occurred between those stations. The accident started when five pumps at Station 3 stopped once their engines run out of gas. Several factors coincided to provoke the accident, other than the shortcoming in the system operation; the protection valves at the inlet of Station 3 did not act effectively to relief the overpressure and the pipe thickness reduction due to corrosion, affected the breaking point of the material. However, another factor, that is the purpose of this discussion, is the underestimation of the normal pressure acting in this particular section of the pipeline. A comparison is made considering two hypothesis (Fig. 1): 1) friction factor calculated following conventional formulas (Coolebrook and White) and 2) friction factor calibrated considering dynamic effects.

Results show that the friction coefficient calculated following conventional formulas, f_1, and that one calibrated considering dynamic effects, f_m, show important differences, specially for partial flow rates. If suction head at station 3 must remain invariant, for the transient analysis of this work, f_m/f_1 implies an underestimation of the dissipative phenomena, which require a significant increment in the pump head at station

2. It is important to say that this high steady flow pressure is not considered for the oil pipeline operative routine. There is not doubts about a risk zone without protection equipment susceptible to collapse. According to the accident conditions, the positive overpressure wave initially traveled from station 3 to station 2; it could explain the breaking point position. For the exposed reasons, the accident could have happened independently of the thickness reduction due to corrosion.

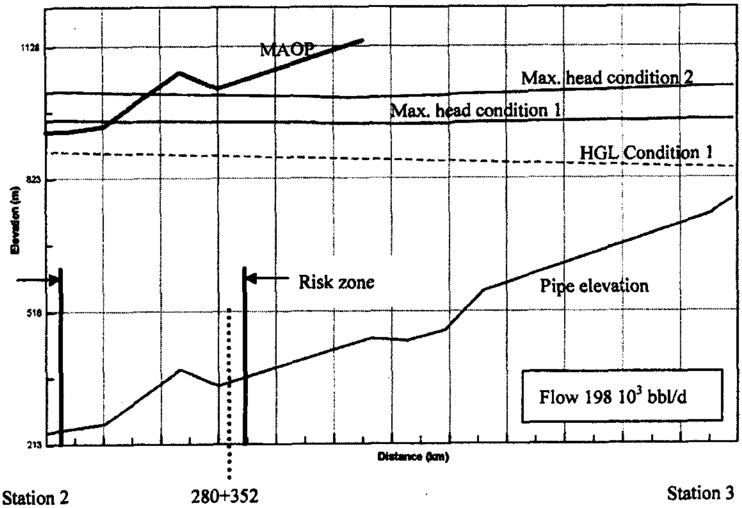

Fig. 2 Maximum transient head and risk zone. Condition 1: f = 0.02549, no dynamic effects considered. Condition 2: f = 0.08137, dynamic effects considered.

REFERENCES

Carmona-Paredes, R.B., Ortiz-Nuñez, L.A. and Sánchez-Huerta, A. (2002), "Efectos dinámicos y temporales en la reducción de la capacidad de conducción en grandes acueductos –estudio con medidas en prototipo", *Revista Ingeniería Hidráulica en México*, Vol. 17(2), pp.5-16 (in Spanish) .

Idelchik, I. (1994), *Handbook of hydraulic resistance*, 3rd. edition, CRC Press, Inc., Boca Raton, Florida.

Miller, D. (1985), *Internal flow systems*, BHRA, Fluid engineering series, vol. 5.

Soto, G. and Guaycochea, D. (2004), "Evidencia de efectos dinámicos en grandes oleoductos", *Proc. XXI Latino-American Hydraulic Congress*, San Pedro, Brasil (in Spanish).