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## A DESIGN FOR A MAGNETIC-WHEELED FLAW DETECTOR PLATFORM

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At the same time, classical solutions for pipeline diagnostics are not suitable for technically complex sections (bends, turns, transitions of different diameters, etc.) and require the development of new technical solutions.

Generally, flaw detection is the focus of both engineers and scientists' interests. At the same time, one of the features of the technical condition monitoring is that about 45% of main gas lines are not adapted for in-line inspection and requires various methodologies development and more advanced inline inspection tools.

Mobile robotic systems development for technical condition diagnostics and non-destructive testing inside field pipelines is one of the directions of the development of modern in-line diagnostics [4]. After all, automation of technological processes significantly increases labor productivity, reduces the number of workers and service personnel, improves working conditions, increases the productivity of equipment, which corresponds to the energy strategy of Russia until 2030 [2].

The robotic application rate is currently quite high in the industry. This is due to the fact that the operations performed have a high level of repeatability and are easily implemented in algorithms. Many operations have been replaced by automated systems. But in the oil and gas industry, the robotics rate is not enough, and it only comes into use. In this case, the process of detecting, selecting types, and measuring parameters of defects in the pipe base metal and welded defects during in-line diagnostics is automated. So, the question of A2072 IntroScan scanner-flaw detector effectiveness compared to its analogues arises. Despite the revealed advantages in experimental and industrial exploitation, the flaw detector platform 's drawbacks Introscan A2072 have been identified as well.

They are as follows: - maneuvering with DN 300 mm tees is not possible due to significant radius of rotation and dimensions; - not overcoming vertical obstacles due to the platform configuration; - when tipping, the platform becomes unrecoverable due to metal debris sticking to the magnetic wheels while moving on the pipe side surface.

This invention provides novel means for a small-sized platform of a magnetic-wheeled pipe flaw detector. It allows: - performing unlimited maneuvering in a complex pipeline manifold with DN ≥ 300 mm; - overcoming vertical obstacles in a pipeline manifold without being equipped with a mechanism to deactivate magnetic wheels; - automatically turning over on its wheels after possible tipping.

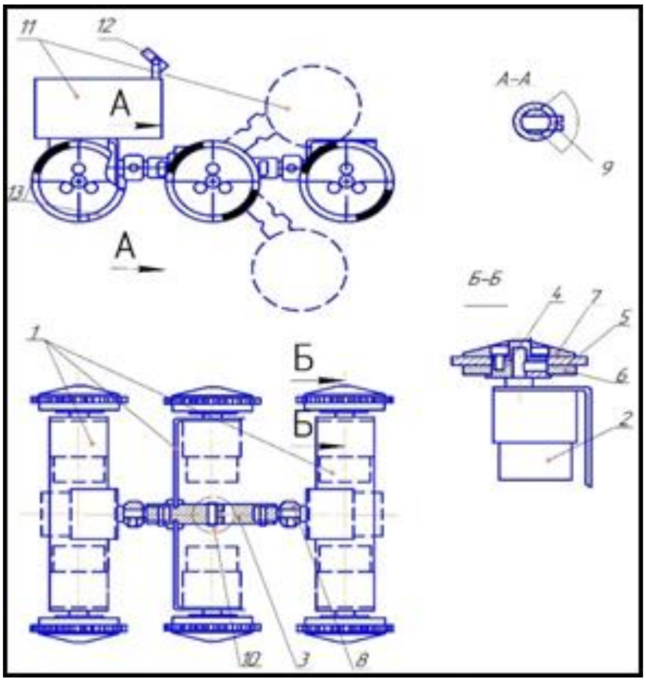


***Fig. 1 A platform for a magnetic-wheeled pipe flaw detector, where: 1 - chassis; 2 – a gear motor; 3 - longitudinal axis; 4 - an intermediate bush; 5 – a wheel; 6 – a ring magnet; 7 – a non-magnetic plate; 8 – a bush; 9 – a stop; 10 – a transverse joint; 11 – the technique of the trolley; 12 – a video camera; 13 - non-magnetic inserts.***

The invention concept lies in the fact that the presented flaw detector platform containing magnetic motor-wheeled modules comprises a longitudinal axis interconnecting the platform chassis with rotation limiters via longitudinal joints. In addition, the longitudinal axis has a transverse joint and extreme bushes of the longitudinal axis are connected to the gear motors shafts mounted on the extreme chassis of the platform longitudinally. Figure 1 shows the platform for a magnetic-wheeled pipe flaw detector.

In terms of design, the platform for a magnetic-wheeled pipe flaw detector consists of three chassis 1 with mounted gear motors 2 and interconnected with a longitudinal axis 3. Wheels 5, ring magnets 6 and non-magnetic plates 7 are installed on side gear motor axis 2 via intermediate bushes 4. Mounted on the shafts of the longitudinally mounted gear motors 2, the extreme bushes 8 of the longitudinal axis 3 are fixed by the stop 9. The longitudinal axis 3 has a transverse joint 10. The extreme chassis 1 have some space for technique of the trolley 11 and a video camera 12 to be installed. The platform wheels 5 are equipped with non-magnetic inserts 13 equally spaced around the perimeter.

This platform for a magnetic-wheeled flaw detector works as follows. The platform is installed on the inside surface of the steel pipe to be examined. Ring magnets 6 made of electrical steel with high magnetic properties, provide magnetization of the platform to the examined steel pipe. The provision on the longitudinal axis 3 of the bush 8 having capability of rotation limited by the stop 9 in sector C and of the transverse joint 10, ensure a complete fit of all platform wheels 5 to the curved surface. Then, power is supplied to the side gear motors 2. If the platform wheels 5 rotate clockwise (Fig.2), the platform moves forward. If the platform wheels 5 rotate in the opposite direction, the platform moves back. The rotation of the left and right wheels 5 in opposite directions ensures the platform rotation in place. The shafts of longitudinally mounted gear motors 2 in normal operation are not rotated due to the design of their gears [3].

When the platform of the magnetic-wheeled flaw detector tips on its side or roof, the operator working remotely through a video camera 12 and longitudinal gear motors 2, will turn over the platform. Switching on longitudinally mounted gear motors 2 in turn, the operator achieves the parallel position of the central and right chassis 1 (Fig. 2) to the surface onto which the platform has tipped over with the wheels 5 down. When placing the platform on wheels 5, the provision of the stop 9 on the longitudinal axis 3 ensures the forced rotation of all three chassis 1 relatively to each other. Moreover, after the above-mentioned adjustments, the provision of a transverse joint 10 ensures the placing the right chassis 1 wheels 5 (Fig.2) on the surface of the pipe. The magnetization force of the right chassis 1 wheel 5 and relative rotation of the adjacent chassis 1 allows putting the entire platform on the wheels 5. When putting the platform on the wheels 5, the non-magnetic plates 7 on the wheels 5 allow reducing the rotation torque. As the platform tipped sideways, the wheels 5 magnetization to the pipe surface is excluded.

If the platform runs into a vertical obstacle, the wheels 5 will slip up until the non-magnetic inserts 13 of the middle wheels 5 will reach the desired position, i.e. the non-magnetic inserts will be downward. In this position, due to the non-magnetic plates 7, the magnetization force of the front wheels 5 to the vertical surface of the obstacle F1 is greater than the force of their magnetization to the horizontal surface F2. The traction force Ft of the front wheels along the vertical obstacle is determined by the formula: $F_t = k_{aw} \cdot F_1$, where $k_{aw}$ - a wheel-to the support surface friction coefficient; $F_1$ – the magnetization force.

Under the condition Ft > F2, the front wheels 5 of the platform begin to move upward along the vertical obstacle. The back wheels 5, also equipped with non-magnetic plates 7, slip after running into a vertical obstacle until the non-magnetic plates 7 of the back wheels 5 occupy the desired position. Similarly, the platform goes down from the vertical obstacle. With the front and then the back wheels 5 locked in a horizontal section, non-magnetic inserts should be parallel to the vertical surface due to slipping of the wheels 5 (Fig. 2).

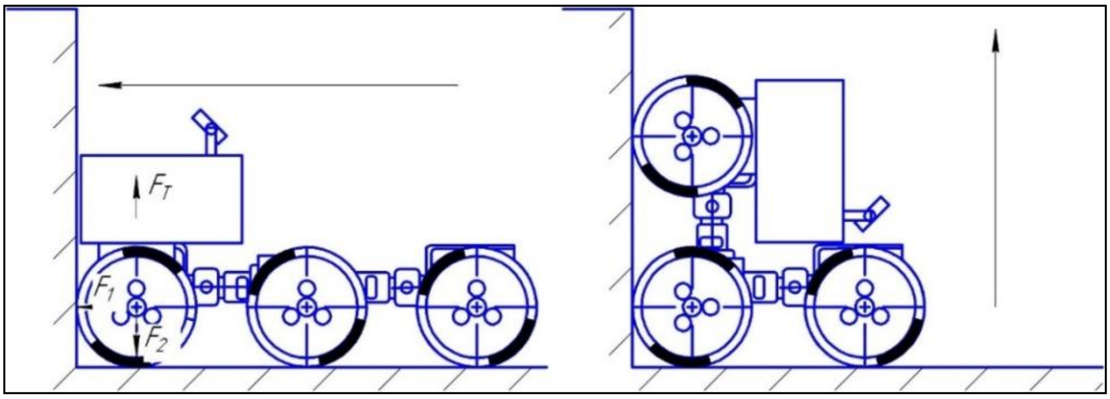


***Fig. 2 Overcoming a vertical obstacle***

It is worth noting that the ring magnets 6 should be selected so that their forces will be sufficient to hold the platform in any position in relation to the examined object, even despite the provision of non-magnetic plates 7 on the front wheels 5 [1].

The absence of an additional mechanism for deactivating the magnetic field in the platform design leaves additional space for technological equipment placement on the platform, and kinematics provides unlimited maneuvering in complex piping.

The proposed platform is adequately for designing small-sized pipe flaw detectors on its basis, as well as other technological devices used in various National Economy Sectors. The platform capability to turn over on its wheels independently eliminates the emergency situations occurrence during diagnostic work, and kinematics provides unlimited maneuvering in a complex pipeline manifold.

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## GEOCHEMICAL FEATURES OF THE CHEMICAL COMPOSITION OF THE BOTTOM WATER OF THE LAPTEV SEA


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Evaluation of the exchange of chemical elements at the natural boundaries of the seas is the basis for understanding the cycle of substances on our planet.

In the system water - rock - gas - organic matter V.I. Vernadsky, attached decisive importance in the formation of the composition of water not to rocks, but to gases and organic matter (Falkowski et al., 2000; Reeburgh, 2007). In this regard, the work is devoted to the study of the chemical composition of near-bottom sea waters under conditions of methanogenesis.

The main point in identifying the features of methane manifestations in the seabed water is the comparison of the abundance of chemical elements in the seabed water at the anomalous (6492) and background (6491) stations in the Laptev Sea. Anomalous station - a station at which samples of the bottom sea and pore water were taken at the places where the bubbly gas emerged. The background station is located close to the anomalous one, the difference is that no methane gas unloading was observed at this sampling point.

The data used in the work was obtained in September-October 2019 during the 78th expedition on the research vessel "Akademik Mstislav Keldysh". Bottom seawater samples were taken with bathometers by sounding with the Rosette complex.

The bottom water temperature varies from -0.3 to 0.27 ° C. In terms of acid-base properties, the bottom sea water is slightly alkaline, the pH is 8.23 at the background station (6491), and 8.13 at the anomalous sampling point (6492) (Table 1). These values are characteristic of the redox conditions of the geochemical environment of ordinary seawater with pH values of about 8.2 and Eh = + 0.3 mV. (Garrels Christ)

The oxygen content is 11.9 mg / L at the background level and changes to 8.5 mg / L at the abnormal level. Alkalinity is 2.65 / 161.65 at a depth of 23.9 and pH 8.23 and 2.95 / 180 at a depth of 20.3 m and 2.71 / 165.3 at a depth of 20.4 m with a pH change of 8.13 and 8.07, respectively. The concentration of nitrates is 3.42 mol (212.2 mg / l), and the concentration of ammonium ion is 1.29 on the surface and 0.97 at a depth of 23.9 m at the background station and 1.01-1.25 mol / 18.2-22.5 mg / l at a depth of 20.3-20.4 m. The ratio of nitrates to ammonium is more than 9.4, the predominance of oxide forms of nitrogen indicates the oxidative nature of the geochemical environment. The phosphate content in the bottom water at the anomalous station is 0.225 mol / 94.97 mg / l.

***Table 1***

***Chemical composition of the sea bottom water at the background and anomalous stations in the Laptev Sea***

| № station | T | pH | M* | $HCO_3^-$ | $SO_4^{2-}$ | $Cl^-$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $K^+$ | $Br^-$ | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **units** | °C | ед.pH | мг/л | мг/л | мг/л | мг/л | мг/л | мг/л | мг/л | мг/л | мг/л | мг/л |
| 6491 | -0,3 | 8,23 | 30100 | 162 | 2074 | 16821 | 280 | 1003 | 9634 | 163 | 63 | 1,09 |
| 6492 | 0,27 | 8,13 | 28100 | 158 | 1904 | 15586 | 250 | 946 | 8839 | 297 | 52 | 1,27 |
| 6492 | 0,27 | 8,07 | 27960 | 165 | 1720 | 15829 | 183 | 987 | 8954 | 226 | 52 | 1,02 |

The values of the total salinity in the studied waters are 30099.89 mg / l (background station) and increase to 28100 mg / l (anomalous station). At the same time, in the waters of the background station, the geochemical coefficient Cl / Br