How to suppress dynamic effects
Weighing in motion

Food one wants to buy as fresh as possible. Not just because of a better taste, but also because of the shelf life and the reduced chance of spoil. When a product is processed immediately after harvesting or catch that also means profit. So when actions such as grading by size or on weight and packaging occur directly on the harvester or on board of a ship, this shortens the way to the store and the consumer buys a fresher product.

Vincent van der Wel

Why isn't that happening right now? Simple, the dynamic movements of the machine while driving and of the ship during navigation affect the weighing results in such a way that it is hard to use them, if at all. Vincent van der Wel of Penko Engineering talks in this article about the weighing system that was developed inside his company.

By means of the specific knowledge with fast measuring with a high internal measuring resolution, we started developing this measuring system based on the most difficult applications. Than other applications are not so bad. The result: a weighing system that not only proofed to be very accurate but moreover is approved for use for trade applications on seagoing ships in class III (ordinary weighing), with 2,500 d or an 0.04% accuracy. Such a result of course one doesn't reach on its own, cooperation took place with AFAK in Katwijk (ZH) and VCU (Visserij Coöperatie Urk).

Background of on board weighing

The definition of weighing equipment is: "a measuring instrument that determines the mass of a body by means of the gravity". Weighing on board of fishing vessels on the high seas logically presents a number of challenges. The first challenge is the variation in the acceleration of gravity. In the European coastal waters this varies from 9.819289 m/s2 in the north to 9.799248 m/s2 in the very south. This means a difference of 0.2%. More serious influences are caused by the waves at open sea. As shown in figure 1 a ship moves around three axes, the X or longitudinal axis, the Y or transverse axis and the Z or top axis, making the ship to roll, pitch and yaw. All the three of these movements take place simultaneously.

Movements around the X and Y axis cause a list of the ship, under "normal" conditions up to 15°, up to 45° during heavy storms. A slope of 15 ° causes uncorrected an error, Ms instead of M, of 1 x cos 15° or 3.4%, as shown in figure 2. In a normal mode a shear force Md affects the weighing result up to 1 x sin 15°, or almost 26% of the load. The magnitude of this effect is unpredictable, the list finds place over 90° in the horizontal plane simultaneously around both the X and Y axis.

But the main influence is caused by the movements of the ship itself. When the on board weighing system is not exactly situated at the intersection of the three axes the swell causes an up and down movement with the shape of a circular arc of the weighing system. This effect causes by a ≤ 15° list a sinusoidal acceleration or deceleration of the scale between 0 and + or - 3 m/s2 with a frequency of 0.03 up to 0.3 Hz, as can be seen in picture 3. So the measuring equipment observes changes of the gravity of 9.8 + or - 3 m/s2 or between 6.8 to 12.8 m/s2. Without appropriate measures this results in errors up to ± 44%!

An additional factor is that the movements caused by the waves, are variable, occur simultaneously and influence each other. This makes the utilization of a preset compensation impossible. Moreover a ship on the high seas is more or less "alive".

The engines, winches and hoists create vibrations transported through the steel construction all over the ship. These vibrations cause extra movements of the scale and influence that way the measurement result too. The environment is also a problem. By nature, the humidity is high and there is plenty of salt water. This requires the use of corrosion resistant materials and a high protection factor for the instrumentation. Finally, the catch - fish and shellfish - is another challenge. For food hygiene and freshness are an obligation. Therefore fast processing with thoroughly cleaned equipment is required

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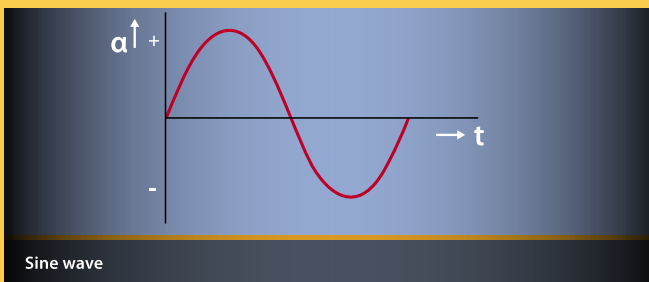
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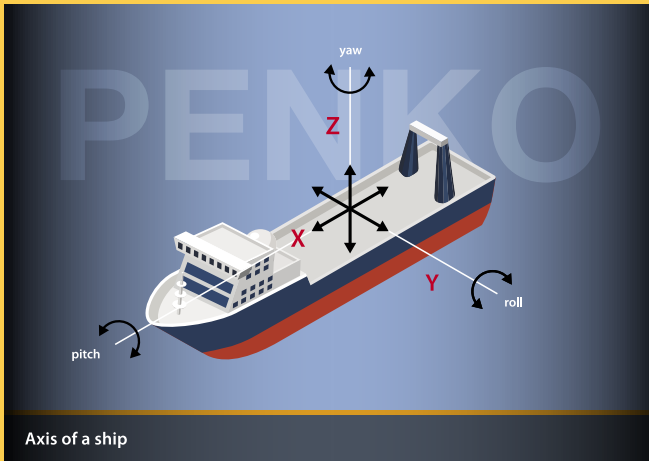
Axis of a ship

△ The movements around the axles of a ship as a result of the waves.
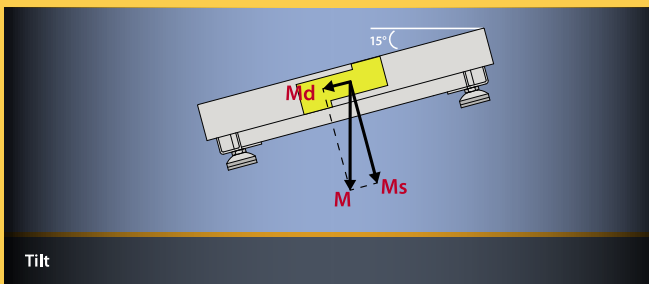
Tilt

△ Tilting of the weighing rig causes a misreading.

Sine wave

△ The influence of the vertical movements on the weighing signal.

△ Action! The UK 150.

Filling crates - Filling buckets and crates with graded or ungraded fish can be done both manually and automatically. When this is done according to the rules, it saves activities ashore what permits the catch to be faster, so fresher, marketed. The applicable rules are laid down in the Metrology Law, which is based on the European directives "on the harmonization of the laws of the Member States relating to the making available on the market of non-automatic weighing instruments" 2014/31/EC and "on the harmonization of the laws of the Member States relating to the making available on the market of measuring instruments" 2104/32/EC.

▽ Bringing in the nets with the catch.

Applications

Grading on weight - Not everything described here is already completely developed. Despite extensive experience with grading exists, this still is not realized in "dynamic" installations yet. What is it about? Every product is individually weighed and, based on this weight, transported to the proper processing or packaging line. The challenge consists in determining the weights of each, relatively small, piece.

Weighing the Catch - Knowing what is caught prevents for surprises. It already can be done by establishing the weight of the net with its contents as soon as the catch is brought on board. This not only offers advantages at sea, but also in fish farms. Appropriate measures can be taken before emptying the net. In fish farms this method offers the ability to extract the correct amount of fish out of the basin, at sea measures can be taken to process the catch efficiently, so fresher. As the the presence of cables should be avoided, chosen is for the use of a battery in combination with wireless data transfer.

Portioning - In many cases the catch is frozen directly after grading. For efficiency reasons, those freezer installations are filled with the amount of fish, ordered by the customer immediately. So before freezing the exact quantities of fish must be dosed. The complete batches are composed out of small so-called frosters, each filled with a maximum of approximately 20 kg of fish. The more precise the weight is dosed, the less overweight or give-away of fish. Moreover, less overweight means less power is used by the freezer, so energy is saved. Because the portioning takes place on board too, no further processing ashore is required. Usually is an accuracy of ≤ 0.5% of the batch, which allows the processing of different batch sizes. Finally, the legal requirements for discontinuous totalizing weighers (hopper weighers), as incorporated in the aforementioned directive for measuring instruments, are applicable.

Proven technology

Although there still are challenges, the technology has proofed itself in fishing. That did not went by itself, the necessary obstacles had to be overcome. The load cells are designed for static use, neatly mounted horizontally on a stable surface. So these onboard applications constitute metaphorical utilization. Hence the necessary developments were required. They showed to be so innovative that they are now protected by a patent. A next stage might be the application in harvesters. Time will learn what further adjustments that requires. But the holy goal remains reducing the way from the net or land to our dish: the supply of fresher food.

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▽ A platform scale on which the catch is packed in buckets.

▽ Weighing the net with its content when bringing in the catch.

▽ A, composed on weight, batch of frozen sea fish.