COMPARISON FJELL TD DRYER TO ROTADISC AND OTHER DISC DRYERS

- **Forged claws can be welded with high precision in flat position using robots**
- **Welds can be inspected with NDT before assembly**
- **Welds are not exposed to the material to be dried, thereby risk for stress corrosion cracking is eliminated**
- **Welds do not seal between pressurised and non-pressurised side. Thereby risk for steam leakage is eliminated**
- **Claws act as reinforcement beams in radial direction, thereby increasing the lateral bending strength of the discs, which reduces the risk for leakages in foot welds between discs (big problem with Rotadisc)**
- **Smooth disc surface secures efficient self-cleaning and maximum heat transfer**

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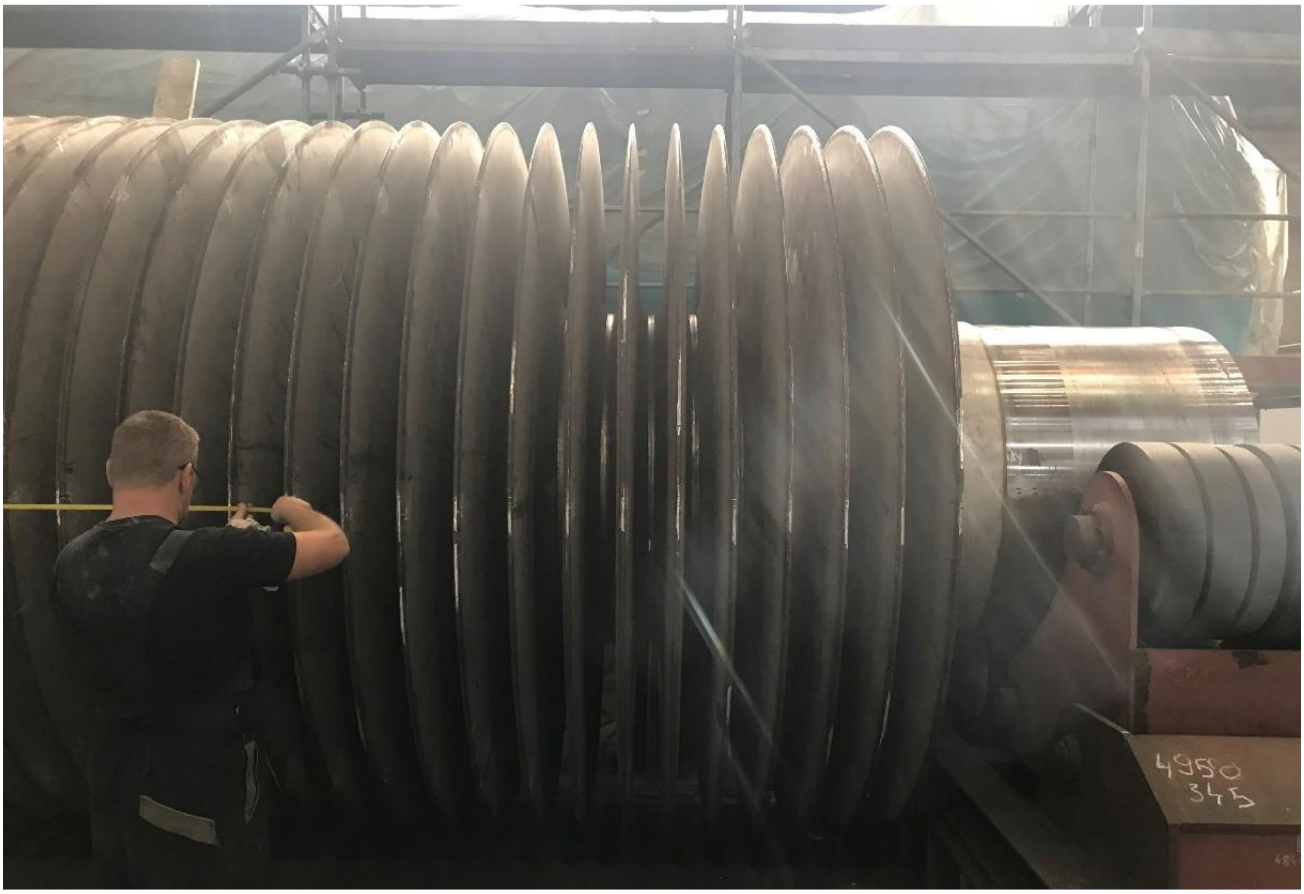

Fig. 1 *A new TD rotor during final assembly in our workshop APC Presmet in Poland.*

The indirectly steam heated Rotadisc drier was patented and introduced in the fish meal industry in the early 60ies by Stord Bartz, and quickly became a “must” for factories worldwide due to superior energy efficiency, safety, reliability and limited emissions of waste air. The Rotadisc was later introduced in WWTPs in the 80ies. Stord Bartz delived both part-drying and full-drying plants to WWTP plants all over the world. Some examples are KETA Hamburg (6 TST-80 dryers installed early 90ies), Noord-Brabant in the Netherlands (8 TST-80 dryers installed 1997), Seattle Discovery Park WWTP (2 TST-100 dryers in 1994). However, a few projects went very bad, due to limited knowhow about the mechanical loads in the part drying process, therefore the materials selection and mechanical design were not appropriate in some cases. In particular, the project KETA in Hamburg was catastrophic for Stord, because in the first years of operation the sludge was dried to 55-60%TS for landfill, causing enormous stress on the dryers. This caused cracks in the staybolt welds and foot welds between discs, and severe abrasion of disc plates. All 6 rotors were replaced two times before Stord was saved by the bell, because after start-up of the incineration plant (VERA) sludge was only dried to 40-45%TS. The undersigned was personally in charge of the re-design of the dryers at KETA at this time.

FTG was established in 1970 as a subsidiary of Stord and manufactured many disc dryers for Stord over the years. When Stord flagged out dryer production in the year 2000, FTG took over a handful of senior engineers and topped the team with young innovative engineers skilled in modern CAD, FEA and CFD. FTG then developed and placed on the market a modernized and improved disc dryer - the TD dryer. Basis for development of the TD dryer was the extensive experience from design, manufacture, commissioning and aftersales support from about 2000 disc dryers supplied to customers all over the world since 1960ies. The team knew everything worth to know about disc dryers.

Fig. 2 *The distinct difference between the TD dryer and most other disc dryers is that staybolt welds (or welds of other means to maintain the integrity of the disc when exposed to internal steam pressure) is entirely on the inside of the disc. Compared to the Rotadisc promoted by Haarslev and other dryer manufactures today, staybolts are replaced by rigid forged claws welded to the inside of the disc plates, before assembly of the disc plates.*

Advantages:

- Forged claws can be welded with high precision in flat position using robots.
- Welds can be inspected with NDT before assembly.
- Welds are not exposed to the material to be dried, thereby risk for stress corrosion cracking is eliminated.
- Welds do not seal between pressurised and non-pressurised side. Thereby risk for steam leakage is eliminated.
- Claws act as reinforcement beams in radial direction, thereby increasing the lateral bending strength of the discs, which reduces the risk for leakages in foot welds between discs (big problem with Rotadisc).
- Smooth disc surface secures efficient self-cleaning and maximum heat transfer.

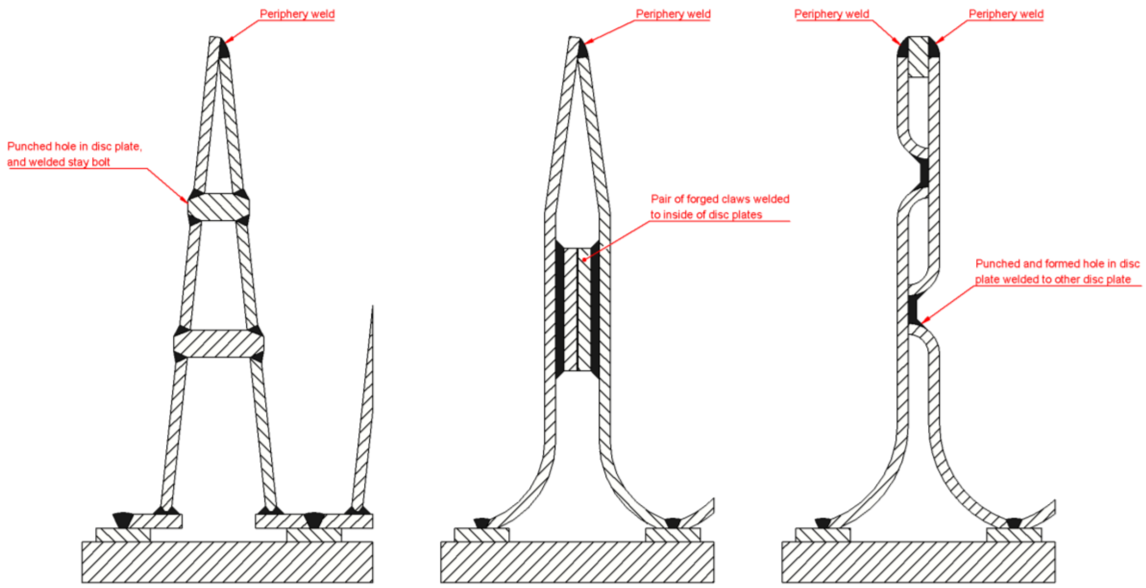

Fig. 3 *Common principles for disc design heavy duty disc driers: Rotadisc by several manufacturers (left), Fjell-TD disc (centre), Haarslev HM disc (right). Advantage of TD disc is superior mechanical strength and minimal risk of steam leakage.*

<u>For part drying of sludge there are three important elements to consider in the design:</u>

1. Dryer must have significant mechanical strength to withstand the bending and twisting from sludge, particularly if dry solids content approach the glue phase starting at 50-60%TS.
2. The steam and condensate flow to and from the discs must be optimum to support the high specific evaporation rate in part drying.
3. For materials selection and welding must one must carefully consider the corrosivity of the sludge (pH, halogens, sulphides and Fe^{3+}) and content of abrasive particles. Also important is the intended temperature of the heating medium and atmosphere in the dryer (ratio of air to water vapour).

1. <u>Mechanical strength</u>

In the design phase it is typical the stress in discs caused by the internal pressure that is evaluated, because this is required as part of the pressure vessel certification. certified as pressure vessel. However, the steam pressure it-self seldom causes cracks in the welds. Cracks are mostly caused by the cyclic loads on the discs from viscous sludge in motion as the dryer rotates. With cyclic stress in welds in combination with halogens the risk of fatigue and/or stress corrosion cracking is severe.

A TD disc typically has 30-36 pairs of rigid forged clamps inside each disc. If a sideways load is put on the tip of a disc, as indicated in Fig. 4, the stiffness of these clamps prevents effectively any flexing of the disc sideways. The clamps transfer shear force from one disc plate to the other so that both disc plates and the clamps resist the external load as one rigid unity. The bending moment resulting from the force is taken up as two reaction forces in the foot weld on each side of the disc. The stresses caused by these reaction forces will be low.

The Rotadisc or the HM disc do not have such rigid reinforcements inside the discs. Any external sideways loads on the discs caused by viscous sludge in movement will therefore cause the disc plates to flex more like two independent plates. The staybolt welds between the discs will experience high localized bending stress when the discs are exposed to external sideways loads. Also, foot welds between the discs will experience higher stress because of bending moments in each individual disc plate. Fig. 4 illustrate the difference.

FTG has since year 2000 years never experienced a steam leakage from a TD dryer. The mechanical strength of the TD dryer is evident both from experience and FEA analysis. Our experience is that dryers with staybolts or other welded stays always have a significant risk for steam leakages due to cracks. Each rotadisc or HM dryer have in the order of 10.000 welds between the discs exposed to the environment in the dryer and exposed to cyclic stress as the dryer rotates and moves the sludge along. Obviously, some of these welds will have flaws.

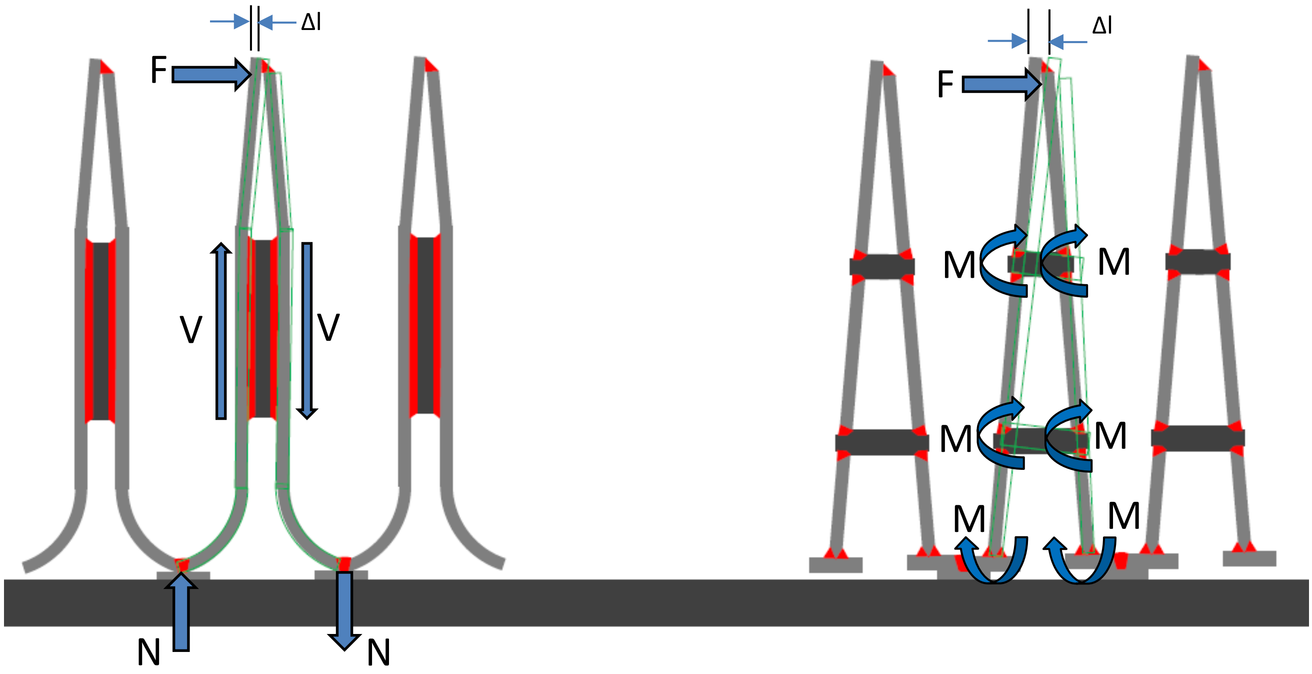

Fig. 4 *Illustration of how external sideways loads on a disc caused by movement of sludge create reaction forces in a TD dryer (left) and a Rotadisc type dryer (right). The clamps inside the TD prevents large deformations of the discs, and the additional stress in welds cause by the force will be low. The staybolts of a rotadisc type will not provide the same stiffness, which will result in additional stress in the welds cause by bending moments in the disc plates that the tiny bolts try to oppose.*

2. <u>Heat transfer and specific evaporation</u>

On the inside the TD uses same steam and condensate flow principle as the Rotadisc. Condensate is drained from the disc each time the condensate baffle passes the top. However, in Rotadisc dryers the condensate baffle plate is installed after disc plates are welded together, and does not seal very efficiently, thereby condensate trapped inside discs will reduce the overall heat transfer. For the TD dryer this baffle is fully welded to one disc half before assembly of the disc, and baffle is installed in approximately 45° angle facing the direction of rotation. Thereby condensate will be trapped in the trough formed by the disc plate and the welded baffle, and nearly 100% will be drained each rotation.

Moreover, as can be seen in Fig. 5, the TD dryer has very smooth outer surface and tends to stay cleaner with less build-up of fouling in applications susceptible to fouling. This increases the heat transfer coefficient from the disc surface to the material to be dried. <u>FTG's experience is that the TD dryer has marginally better specific evaporation rate than other disc dryers in same application.</u>

Fig. 5 *Small rotadisc dryer delivered last year by FTG to client in Japan (left), Fjell TD rotor after 5 years in WWTP sludge (centre) and Haarlsev HM dryer before start up in a fish meal plant in Japan (right).*

1. Corrosion and abrasion resistance.

There are much less machining and welding involved during manufacture of a TD rotor than a Rotadisc, therefore the cost increase when more exotic materials are requires is mainly caused by the cost of the disc plate materials. The internal claws are always made from forged carbon steel, since not in contact with the corrosive environment in the dryer. FTG has delivered rotors in carbon steel, austenitic steels and duplex. We have also produced discs completely coated with tungsten carbide hard facing by means of thermal spraying for extremely abrasive applications. We have also the option to use clad steel in case of extreme corrosion, for example carbon steel with titanium explosion cladding. Any weldable and formable pressure vessel materials can in principle be used for a TD rotor.

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