Universidad Austral de Chile
Escuela de Ingeniería Civil Industrial
Sede Puerto Montt

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SCHOOL OF INDUSTRIAL CIVIL ENGINEERING

SUMMARY

OPTIONAL THESIS FOR DEGREE IN INDUSTRIAL CIVIL ENGINEERING

Use of PEXGOL vs HDPE tubing in a system for feeding salmon

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BACKGROUND 1.0.-

In 2014, Crosspipe Systems SA, a Chilean company (whose partners are Kupfer SA and Golan Plastic Products Israel) which is the manufacturer and marketer of PEXGOL pipes in Chile, requested the Austral University of Chile to provide a feasibility study on the use of its pipelines in feeding systems for salmon.

It was agreed to develop a degree thesis to address this study, written by the student and candidate for the title of Industrial Engineer Javier Alejandro Gallardo Zúñiga, supervised by Professor Ing Alex Exequiel Cisterna Castillo, both from this higher education establishment, based in Puerto Montt.

The work for the thesis was developed in the Marine Farms farming centre at Chaicas[1] and lasted 6 months

2.0.- DEVELOPMENT

2.1.1 DESCRIPTION OF THE CULTIVATION CENTRE UNDER STUDY

Figure 2.1 shows the structure of the Chaicas centre which consists of:

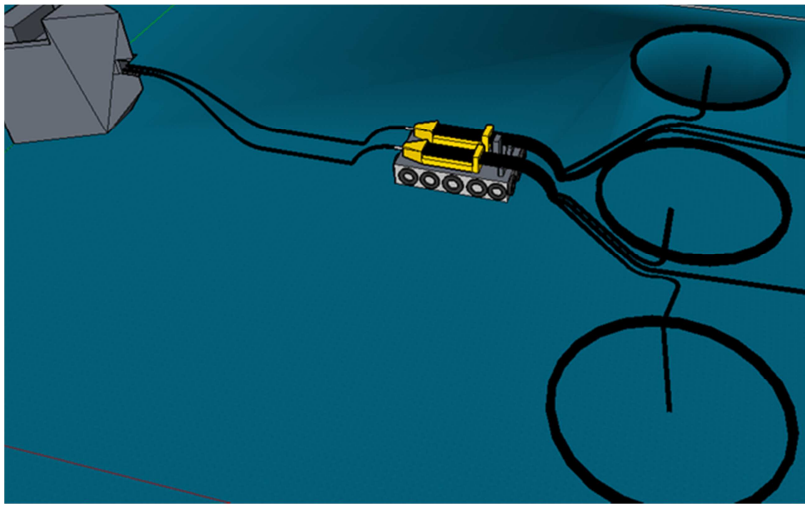
one (1) modified vessel with a feeding system built in,

two (2) main pipelines,

selectors outside the vessel in a floating platform,

set of feeder lines to the farming cages.

Figure # 2.1: Digital Drawing of Chaicas farming centre.



Chaicas is a town located 35 km from Puerto Montt by the Carretera Austral

The farming centre has 15 cages but during the study only six cages, three for each feed line, were in operation. Line 1 fed cages 109.112 and 114; and line 2 fed cages 102, 104.107. At the time of the study Pacific or Coho Salmon were being fattened.

Feed silos 6 and 8, located in the vessel, were for feed line 1 and 5 and 7 for feed line 2. The gauge used for the fattening stage was 12 gauge Optiline Coho 2,200 from the Skretting supplier, for fish of 2.2 [kg].

Each circular feed cage is 40 [m] in diameter, comprising mooring cables for a float and a floating ring. Each cable is fastened to a bracket, and there are a total of 48 of these. The cages were arranged alongside each other, anchored by buoys of 2,000 litres, at a distance of 20 [m] from buoy to buoy in the vertical plane and 60 [m] horizontally, forming circular passageways, each with a total of 36 buoys. The system was anchored by buoys of 3,000 litres, at a distance of 20 [m] from the 2,000 litre buoys, this anchoring using 32 buoys.

The distance for the run of the pipes from the vessel to the selector was approximately 130 [m] and a few extra metres of slack were allowed to absorb waves and ease tensions.

The distance from the selector to the feeding cages is described in the plan delivered by Marine Farm, and is determined by the distance between the buoys to give the following values, expressed in Table No. 2.1.

Table No. 2.1: Distance between selector and cages in the farming centre of Chaicas

Cage	Distance
102	190 [m]
104	310 [m]
107	110 [m]
109	230 [m]
112	110 [m]
114	230 [m]

2.1.2 INSTALLATION OF PEXGOL 90 CL 10 LINE

One 130 m PEXGOL line (PEX a) was installed as the main feed beside a similar HDPE one and measurement variables were established for both for:

1) Wear (in sections 1 and 2)
2) Volumes of feed per day
3) Quantity of fine and broken generated

Figure N ° 2.2: Sections for the study of thicknesses..

[Section 1] [Section 2] [Points 1,2,3,4]

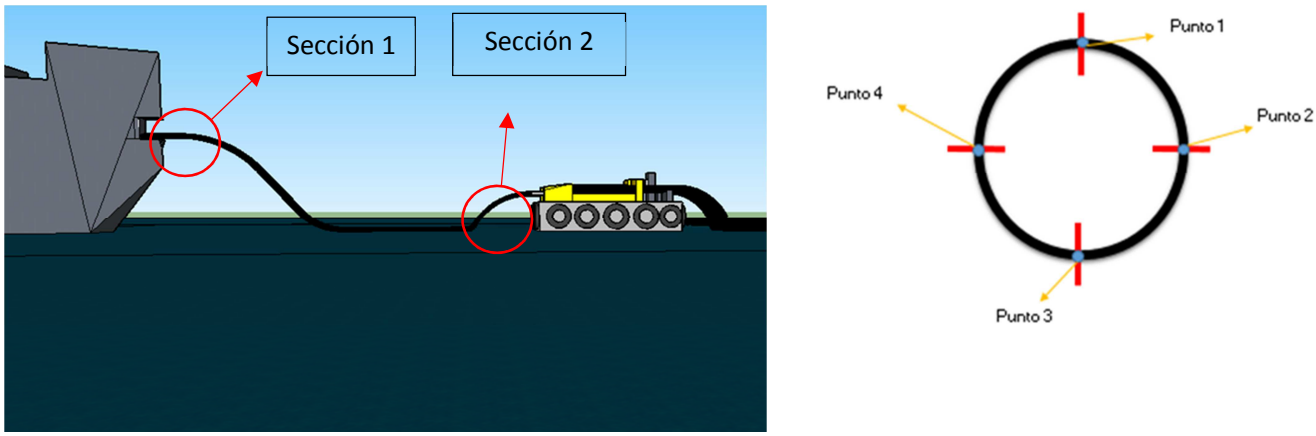
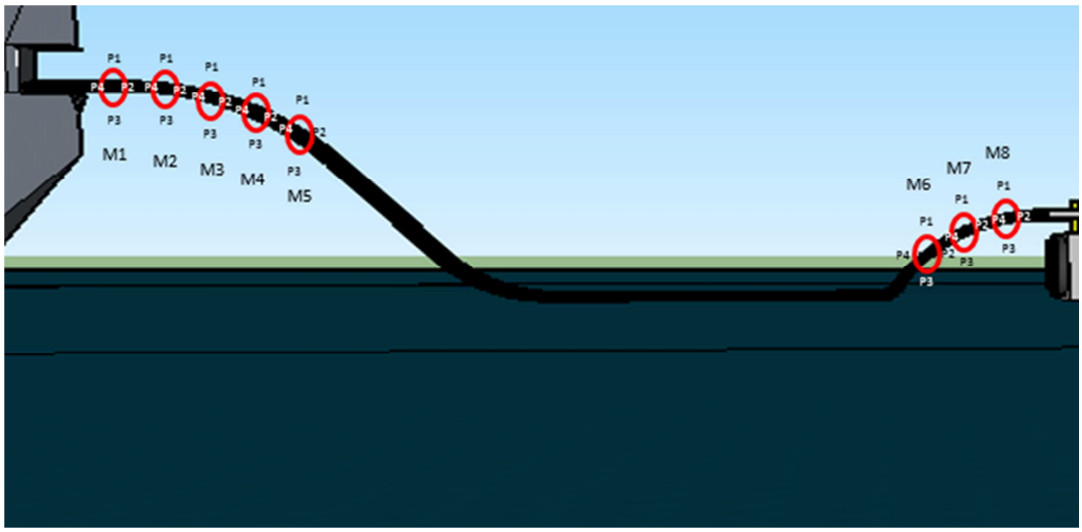


Figure No. 2.14: Measuring points for piping (ultrasound)



3.0.- RELEVANT RESULTS AND CONCLUSIONS

3.1.1 Wear

a) The average rates of wear give an expected result for PEXGOL piping compared with HDPE piping under the same operating conditions. Average values of 3.26 - 4.69 mm / month for HDPE versus 0.0 - 0.26 mm / month for PEXGOL were obtained.

It is concluded that the operational life of the HDPE is projected at only 2.6 - 3 months under the feed rates assessed as average. Under the same conditions the PEXGOL is projected to last nearly 18 times as long, that is 4.5 years (54 months).

See tables with the values measured by ultrasound:

HDPE	Average Wear [mm]
P_1	4.69
P_2	3.73
P_3	3.26
P_4	3.63

PEXGOL	Average Wear [mm]
P_1	0.26
P_2	0.02
P_3	0.00
P_4	0.14

3.1.2 Fine and broken feed particles.

a) The volumes of fine and broken feed particles measured in the two pipes in the test period showed a reduction of 0.89% at the output of the PEXGOL pipe compared to the HDPE pipe. This substantial reduction in the amount of fine particles is associated with the low roughness values of the inner wall of PEXGOL tubes, which is very smooth and minimises the breakdown of food or biomass by rubbing against the inner surface when forced to move at the transport speed.

The savings due to reducing the loss of feed or biomass by generation of fine particles may become higher than 60% per cycle.

The table below shows the economic impact of reducing biomass losses at the end of the cycle. This study was developed with experimental results and some market prices:

Fine particles & losses	**Measured at the Selector**
HDPE (percentage fp&l)%	1.4103%
Amount of food lost [kg]	24.257
Loss in USD dollars	$ 35.173
Loss in CLP pesos	$ 22.104.277
PEXGOL (percentage of fp&l)%	0.5201%
Amount of food lost [kg]	8.946
Loss in USD dollars	$ 12.971
Loss in CLP pesos	$ 8.151.755
Savings in CLP pesos	$ 13.952.522
Percentage of saving	63%

3.1.3 Conclusions to consider

a) PEXGOL pipes constitute a potentially economical option to be considered in salmon feed systems.While the cost per metre of pipe is greater than for HDPE at the start of the investment, the long-term benefits as evidenced in the experiments, namely high wear resistance and greater durability, compensate for the difference in price, reducing to zero maintenance costs and costs and stoppages due to accelerated wear, and minimizing losses from fine and broken food particles.

Total savings through operational stability and reduction of losses are expected to be of the order of 45% per cycle.

b) PEXGOL pipes have a very smooth internal surface and high mechanical strength, and can be supplied in long lengths ranging from 300 to 2000 running metres.

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