Recherches pour la Modernization of Silage Fodder Distribution Technologies for Cattle

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Abstract. In order to modernize and turn account the foddering technologies for cattle in live stock farms, a state of the art machine has been achieved aiming to perform several operations within the fodder distributing technology: silage displacement, loading, mincing and mixing, hay and straw bale chopping, fodder automating weighing, mixing homogenizing and distributing the obtained fodder mixture.

The paper presents the results of researches aimed to obtain a special hydraulically driven equipment of displacing and loading the ensilage fodder, its characteristics and mathematical model for calculating the required power $P_E$, the hydraulic power $P_H$, in view of properly choosing the hydraulic equipment.

Keywords: live stock, mechanization, equipment of taking out of silage, power, hydraulic driving

INTRODUCTION

Mechanization and automation of production work and feed preparation support farmers in ensuring qualitative improvement of feeding ratios with direct influence on consumption by improving their digestion degree and palatability. Machinery and equipment used in food preparation and administration in a farm with relatively large herds of animals must meet several conditions: the ability to process many types of feed; allow easy operation and maintenance; have a high efficiency by replacing a large number of workers; pollution to be as low as possible; machines equipment coming into contact with feed do not affect its quality.)

In cattle farms any breeding system needs equipment for spreading concentrated fodder, fibrous fodder as raw and silage fodder, being endowed with a structure appropriate to stubble access and manger feeding (Manisor, 1991).

The modern technologies of fodder spreading are performed by means of special trailed or propelled machines, executing successively as many as possible specific operations:
- Displacement, loading, mincing and mixing the silage;
- Chopping the hay and straw bales and mixing the matter;
- Automatically weighing the fodder varieties by electronically registering the fodder quantity to be distributed;
- Extending the hydraulic and electronic system to as many as possible works performed by the respective equipment.

The silage being an important part of unique fodder structure, the silage process will be one of the three methods, which uses fodder plants for animal feeding, the other two being represented by pasture and hay producing.
Therefore, the activity of ensilage fodder displacement and loading into distributing machines will be very important. In live-stock farms different technologies are used according to the production organizational system, the regime and system of foddering and milking, the farm technical endowment, the biological material quality, the season and local climate conditions (Nedelcu, 2008).

Taking into account the fact that, the quality of fodder taken out of silo and the technological energetic indexes are influenced by equipment structure and technical characteristics, it has been achieved a calculation model of power consumption suitable for this equipment, this model being applied for determining the power consumption in case of a hydraulic equipment.

MATERIALS AND METHODS

The relevant researches have been performed within The National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, R&D department, an analysis of development stage of cattle foddering technologies at Romania’s and world level has been made and, at the same time it has been performed an analysis of technical solutions used for building state of the art equipment and of hydrostatical applications stage of machines designed for cattle foddering.

The researches results have been concretized in a functional model of foddering machine – symbolized with MF8 with a body working capacity of $8m^3$ – designed to work in aggregate with 65HP or bigger power tractor. The machine comprises sub-assemblies, which perform the fodder displacing and loading into the body, the different fodder quantities weighing, their mixing, homogenizing, transport and distribution to cattle or sheep (A.Nedelcu 2008, 2009).

The technical equipment of ensilage fodder displacement and loading is the result of a computer aided design activity which uses Solid Works and AutoCAD programs. In order to establish the equipment functional and constructive characteristics, a calculation model has been elaborated, as a result of working process analysis and information about:

- technical characteristics of foddering machine;
- characteristics of processed fodder;
- technical solutions to be adopted for technical equipment driving;
- power source;
- hydraulic equipment existing in state-of-the art technique;
- market of performant supplies of hydraulic equipments.

During the working process, in order to load the ensilage matter into the body, the machine will approach the bin by its rear part and with its equipment of taking out of silo lifted to extreme or to layers height so that part “attached” by the roll should not surpass its diameter, after that the rear mobile shutter is let down on soil, the roll’s orbital hydraulic engine is put into operation and, then the equipment is slowly brought down, by acting its hydraulic cylinders. The knives helically placed on the roll ensure the displacement of the matter out of the silo, due to centrifugal force and the fan created effect throws it, into the body, being conducted by the equipment special shaped guard. The operations are repeatedly performed till the desired ensilage matter is loaded.

The roll holder arm is driver by two hydraulic cylinders with double effect, placed on body’s sides.

After having brought the equipment in its upper working position, the rotative hydraulic engine is started up and it operates the roll, whose rotative speed is of 540 rot/min.
The roll driving and the roll holder arm lowering is simultaneously performed. When the roll reaches is cutting position it is recommended to lift the arm, without acting the roll.

By repeated maneuvers of positioning the tractor-machine in comparison with the stack, the fodder quantity is loaded into the body according to recipe.

**RESULTS AND DISCUSSION**

Following the researches regarding the processes of ensilage fodder displacing and handling and its relevant equipment there have resulted:

1. Project and functional model of *the equipment aimed at displacing and loading the ensilage fodder* (Fig.1), with the following technical characteristics:
   - Overall dimensions, mm:
     - length, .......................................................... 4530
     - width, .......................................................... 2082
     - height............................................................ 2410
   - Roll’s dimensions, mm:
     - max. diameter.................................................. 610
     - max. length..................................................... 1180
   - Roll’s rotative speed, rot/min, ................................ 540…700
   - Working width, mm, ............................................. 1180
   - Number of knives.................................................. 26
   - Hydraulic drive:
     - roll ........................................................ orbital engine OMP 100
     - frame ....................................................... two hydraulic cylinders

![Fig.1. Displacing and silage loading equipment](image)


2. *Mathematical model of calculation of required power, P_E, for the equipment driving*:

   \[ P_E = P_{roll} + P_{H \text{ frame}}, \text{ kW} \]

   \( P_{roll} \) - power required for the roll driving, kW
   \( P_{H \text{ frame}} \) – power required for frame driving, kW
\[ P_{\text{roll}} = P_t + P_a \]

Where:

\( P_t \) – power necessary for cutting / displacing the ensilage fodder
\[ P_t = \frac{s \cdot a \cdot b \cdot p_o \cdot \omega}{2 \cdot \pi \cdot 1000} \cdot z_t, \text{ kW} \]

\( P_a \) – power necessary for throwing out the matter;
\[ P_a = \frac{B_r \cdot a \cdot v_E \cdot \gamma \cdot v_a^2}{2 \cdot 1000}, \text{ kW} \]

Where:

\( s \) – travel of aggressive roll, m
\( a \) – knife working depth, cm
\( b \) – knife working width, cm
\( p_o \) – fodder resistance to milling, N/cm^2, is chosen for silage p_o = 8…17 N/cm^2 (Scripnic, 1979);
\( z_t \) – number of knives on rotor
\( \omega \) – rotor angular speed, rad/s
\( P_a \) – power necessary for throwing out the matter
\( B_r \) – working width of milling cutter’s rotor, m;
\( V_E \) – equipment rate of travel, m/s
\( \gamma \) – soil volumetric mass, kg/m^3.
\( v_a \) – speed of chips throwing, \( v_a \approx v_p \) (peripheral speed).
Scripnic et al. (1979) recommend \( P_a \approx (0.1...0.2) P_t \).

\( P_{H \text{ cadru}} \) – The power required for the equipment frame driving is determined by hydraulic cylinders operating. During the downward motion, the hydraulic cylinders are fed with a pressure, \( p \), [bar], and a flow rate \( q \), [l/min]
\[ P_{H \text{ cadru}} = \frac{n \cdot q \cdot p}{600}, \text{ kW} \]

\( n \) – number of hydraulic cylinders of the respective endowment.

It results:
\[ P_E = \frac{s \cdot a \cdot b \cdot p_o \cdot \omega}{2 \cdot \pi \cdot 1000} \cdot z_t + \frac{B_r \cdot a \cdot v_E \cdot \gamma \cdot v_a^2}{2 \cdot 1000} + \frac{n \cdot q \cdot p}{600}, \text{ kW} \]

3. The equipment being hydraulically the necessary hydraulic power is determined by means of known parameters and operating diagrams of hydraulic equipment made available by the manufacturer.

For the orbital engine OMP 100, manufactured by Sauer Danfoss, the results are shown in Fig 2 and Tab.1:

| Tab.1 Table of driving necessary power, hydraulic power and diagram operating parameters |
|---|---|---|---|---|---|---|
| Power consumed by the roll | Values of operating diagram of OMP 100 orbital engine | Engine hydraulic power | Hydraulic power for frame driving |
| | | | | | |
| P_t kW | P_a kW | P_{tambur} kW | n_t rot/min | M_{rec} Nm | q bar | p l/min | P_H kW | P_{H \text{ cadru}} kW |
| 3,5 | 0,7 | 4,2 | 540 | 80 | 55 | 70 | 6,5 | 0,6 |
CONCLUSIONS

- In order to update and capitalize the cattle foddering technologies special trailed or self-propelled machines are necessary, aiming at successively executing different operations such as: silage displacement and loading, electronic weighing of different fodder quantities, mixing, homogenizing, transport and distributing it to animals;

- Using certain competitive equipment determines: high quality works, reduced work labour, all with positive consequences on nutritive value of achieved fodder mixture, economic efficiency and environment;

- The silage taking over by the technical equipment is vertically performed, without affecting a greater surface of bin’s opening which the is when a part is broken with Ifron or Vola equipment and the part cut out with silage special mill does not permit the aeration of the mould development;

- Daily loading of the required amounts calculated under the consumption food ratios for the herds of farm animals does not give way to accumulate scrap silage to be used in the following days in this way preserving the organoleptic qualities of the unsillage matter for that day;

- The presented calculation model is useful to design activity for analyzing and establishing the functional and dimensional characteristics, calculating the theoretical power consumption, determining the hydraulic power required and choosing the driving hydraulic equipment.

- In case of equipment designing, the mathematic model, $P_e$, allows a comparative analysis of power consumption depending on constructive parameters variation $s$, $a$, $B_r$, $z_t$,
becoming the common working method for establishing the constructive solutions and technical characteristics.

REFERENCES

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