PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVII cycle, 2021-24)

Project draft

1.Field of interest

AGR 09

2.Project title

Sustainability of agricultural tractors usage in open field and in specialized crops, from the performance and environmental standpoints

3.Tutor (membro del Collegio dei Docenti) : D. Pessina

- Eventually: co-tutor/s ---

4.Relevance of the topic and state of the art:

The sustainability of the agricultural machinery must be evaluated not only in terms of pollutant emissions, but also considering their engine, transmission and hydraulic system efficiency, and above all the usage modes adopted. In fact, both in open field (e.g. cereals) and in specialized crop (e.g. wine grape, fruits, vegetables, green maintenance) productions, many tasks do not require high engine power and traction pull, but for example only a remarkable oil flow, because many implements are actually hydraulically driven.
A real chance to optimize the use of the tractors (and all the other self-propelled agricultural machinery) is to create a model (hopefully customizable) to evaluate their real efficiency, taking into account also different scenarios, in terms of time and intensity of usage.
The working conditions, the power requirement and the energy expenditure of the main operations carried out should be considered, for example simulating them in a stationary mode by means of an electromagnetic dynamometer and integrated with a device for measuring the fuel consumption. The basic output should be a series of engine performance curves (power, torque and Specific Fuel Consumption, SFC), both at full and partial loads. On these curves, some characteristic operating points were identified, simulating the typical tractor running conditions when working in vineyard.

5.Layout of the project (draft)

5.1.Materials & Method:

In many agricultural mechanized operations the size of the tractor is the most important feature to be considered, because it is affecting the overall stability (and consequently the overturning risk), especially when the tractor is coupled with heavy implements at the 3-point linkage. In these cases, due also to the working parameters (e.g. low travelling speed) the power request is frequently low or very low, thus affecting negatively the engine efficiency.
Also the time used for carrying out a given operation is likewise affecting the overall machine efficiency: for example, in specialized cultivations the pruning is usually executed twice in a year (before and in the middle of the growing season), while pesticide treatments are much more frequently carried out, up to 15-20 times/year.

To obtain suitable usage scenarios, a suitable number of tasks have to be defined, assuming for each of them the power needed to operate conveniently the implement and the engine speed typically adopted, in order to define the engine load (i.e. the throttle settling).
Moreover, for each working operation the number of execution over the entire season should be considered to better represent the working practice. Finally, some different scenarios have to be pointed out, taking into account the engine power request, for example "*light*" "*medium*" and "*heavy*" intensity scenarios.
Moreover, for each scenario, the typical working capacity (ha/h) should also be defined, referring to a real farm, representing this figure a suitable extension for a convenient mechanization including the operations considered.
For each scenario, the SFC values were the starting data to obtain the real fuel consumption (l/year), taking into account both the whole power need and the time usage over the entire season. Considering the relationship between SFC and the efficiency, the performance of the examined tractors could be ascertained.
Finally, starting from the diesel cost, and considering the usage as constant over a given time period, the fuel expenditure for each type of tractor investigated (and for each scenario) could be ascertained.
An interesting further feature concerns the environmental impact caused by the gas emissions of the tractors, according to the different intensity of use. With reference to SFC and emissive stages, the pollutant emissions for each operating scenario could be estimated.

5.2. Schedule and major steps (3 years):

- **Year 1**: detailed literature investigation finalized to ascertain the recently concluded and the on progress researches and models built on machinery efficiency (especially regarding tractors).
- **Year 2** : field and lab test series on conventional and specialized tractors (and other possibly self-propelled agricultural machines, finalized to the data acquisition on working parameter.
- **Year 3** : setting up of one (or more) model(s) to simulate the power engagement and fuel consumption of the most common agricultural operations, in order to compare the efficiency and the sustainability of the different tractor models that could be used to carry out the various tasks, taking into account also different scenarios in terms of intensity and time of usage.

6. Available funds

Funds availability: coming from earnings obtained thank to the periodical execution of official standard test carried out by the Mechanical Laboratory (head: Prof. D. Pessina).
Amount availability: 10,000-15,000 euro/year

7. Literature:

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8. Pieke C., Stark W., Pfister F., Schyr C. (2017). DLG powermix on the dynamometer, *ATZheavy duty worldwide*, 2/2017.
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