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Conference Article

Snow Blower Application at Backhoe Loaders

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Abstract

During heavy snowfalls in winter, clearing large piles of snow on the roads is a very laborious process. It is necessary to take quick action to make the closed roads usable and not to stop the flow of life. Snow blowers are needed when equipment such as snow knives are not sufficient. However, since these types of machines are specially produced abroad, their costs are high. The Türkiye General Directorate of Highways and Hidromek Company have carried out a series of studies in order to popularize the use of snow blower. It is foreseen that if snow blower adaptation can be provided to backhoe loader construction machines that are widely used all over the world and especially in Türkiye, access to this equipment will be easier. Thus, technological dependence on foreign sources will also be reduced. As a result of the studies, the design of a snow blower with a capacity of 2000 tons/hour and its adaptation to the backhoe loader machine were achieved. Due to the need for such a high snow spraying capacity, radical changes were made in the main lines of the machine. Placing a power unit instead of the excavator part of the machine and placing a snow rotary attachment on the front arm was deemed the most appropriate solution.

Keywords: Snow Blower, Backhoe Loader, Power Unit

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1. Introduction

Backhoe Loader construction machines are widely used machines in many areas. Backhoe Loader is self-propelled crawler or wheeled machine having a main frame designed to carry both front-mounted equipment and rear-mounted backhoe equipment, normally with stabilizers or outriggers [1]. These machines have low costs and versatile working capabilities. Backhoe loader construction machines are mainly used in jobs such as loading, digging, leveling and load holding. The main structural components of the machine are shown in Figure 1. These components are loader arm, loader bucket, digger bucket, digger mechanism, cabin and body.

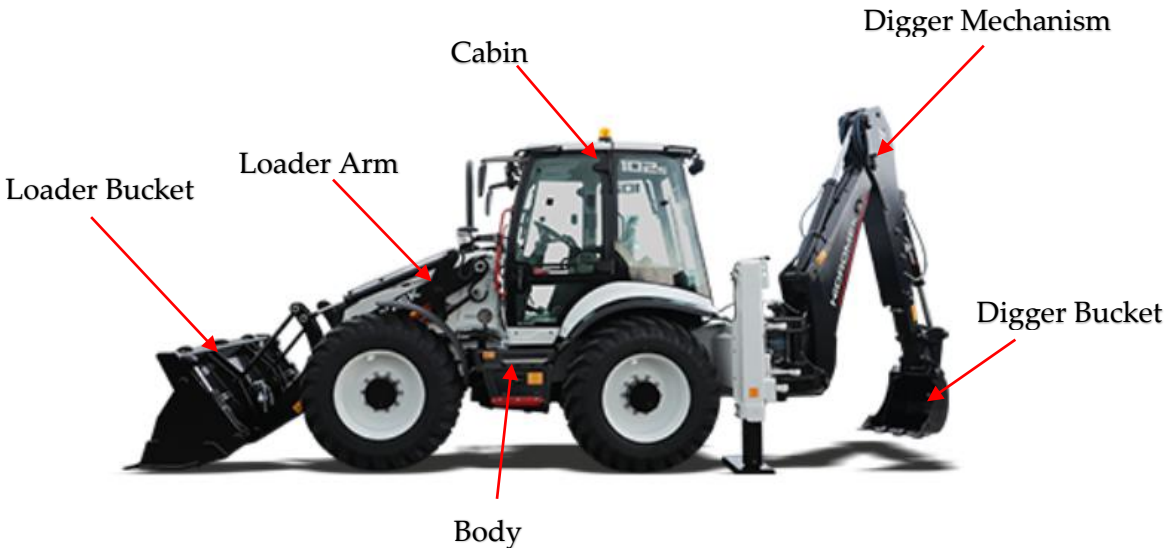

Figure 1: Backhoe Loader Main Components

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Snow blower machines have various capacities. The main components of a snow blower with high snow spraying capacity are given in Figure 2. These are auger, fan, body, flue and power unit [2].

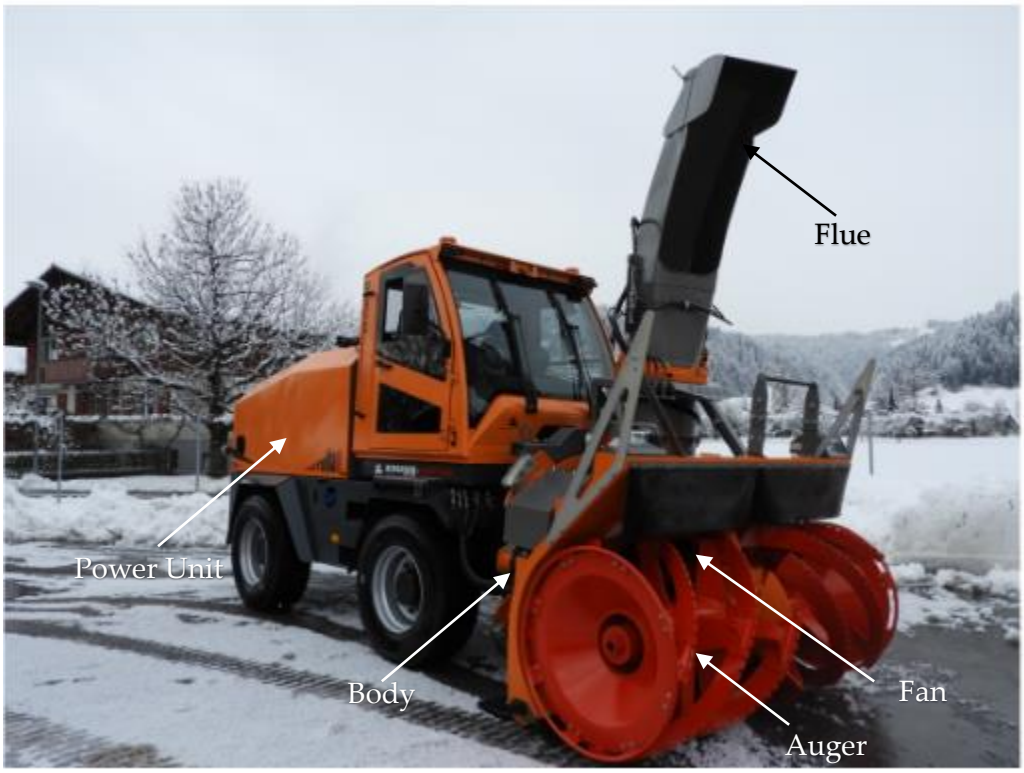

Figure 2: Snow Blower Main Components

The aim of this study is to use backhoe loader construction machines as snow blowers in winter months.

2. Materials and Methods

Snow material behaves differently under different conditions. Snow density varies between 50 kg/m³ - 500 kg/m³ depending on the type of snow layer (see Figure 3). It can be assumed that the density of newly fallen snow is on average 10% (100 kg/m³). According to this expression, it can be said that 10 mm of a 100 mm snow column is water. As the snow waits, its density increases and this value can reach up to 50% - 60%. In cases of heavy snowfall, it is inevitable that the intervention will become difficult and the waiting time will increase. Therefore, it is expected that a high-density snow layer will be encountered during the snow removal process.

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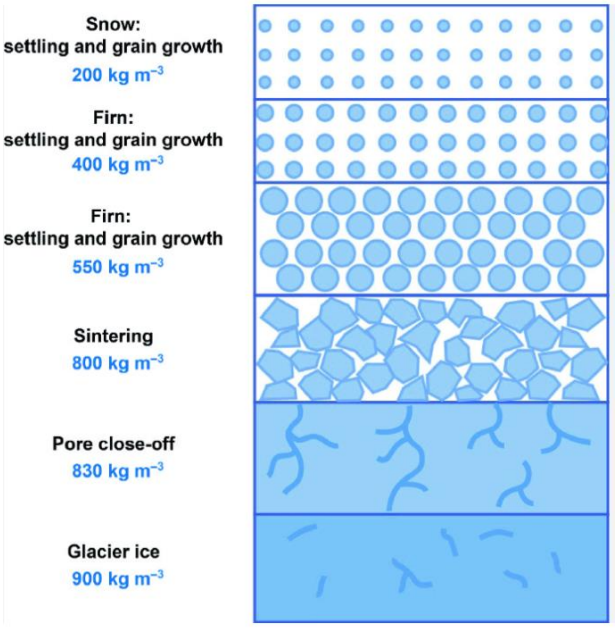

Figure 3: Snow Density Layer

2.1. Determining Design Requirements

Upon the guidance of the General Directorate of Highways and field investigations, the needs given in Table 1 were determined.

Table 1: Design Requirements According to Field Need

Indication	Description	Unit	Value
Cfan	Fan capacity	ton/h	2000
hs	Snow Height	mm	250
ϱs	Snow density	kg/m³	300
xm	Throw distance	m	25

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Some design limits specific to the backhoe loader machine are given in Table 2.

Table 2: Design Limits

Indication	Description	Unit	Value
Wt	Total weight (power unit and front attachment)	kg	5660
Wp	Weight of power unit with fluid	kg	3000
Wa	Weight front attachment	kg	2660
Dfan	Fan outer diameter	mm	1050
Dau	Auger outer diameter	mm	960
Lau	Auger length	mm	2700

2.2. Design Details

System calculations have been made to achieve the targeted outputs in the snow blower design. In these calculations, the required power, torque and speed calculations have been made (see Table 3).

Table 3: System Calculation

Nfan=Cfan/60*1000/(Vfanxϱs)	556	rpm
f=Nfan/60	9	hertz
Ƈ=FxgxDfan/2/1000	687	N.m
vfan=2*π*Dfan/2/1000*ffan*kfan	14	m/s
Xm=vfan*cos45°*(2*vfan*sin45°/g)	19	m
Pfan=Ƈfan*Nfan/9543	40	kW
Vau= π*(Dau²-dau²)/4*Lau/1000	1.03	m³
Cau=Cfan*1.5	3000	ton/h
Nau=Cau*1000/60/(Vau*ϱs)/kau	270	rpm
Ƈau=Vau*ϱau*g*Dau/2/1000	3640	N.m
Pau=Ƈau*Nau/9543	103	kW
Pt=(Pfan+Pau+Pac)/ɳ	203	kW

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The explanations of the variables included in these calculations are given in Table 4.

Table 4: Variables at calculations

Indication	Description	Unit
g	Gravity of earth	m/s^2
ϱs	Snow density	kg/m^3
v	Vehicle Speed	km/h
Vfan	Fan volume	m^3
kfan	Fan transfer coefficient	-
Nfan	Fan Speed	rpm
ffan	Frequency of fan	hertz
Cfan	Fan torque	N.m
vfan	Fan velocity	m/s
Pfan	Power-fan	kW
dau	Auger inner diameter	mm
kau	Auger transfer coefficient	-
Vau	Auger volume	m^3
Cau	Auger capacity	ton/h
Nau	Speed auger	rpm
Cau	Auger torque	N.m
Pau	Power auger	kW
Pac	Power accessories	kW
Pt	Power total	kW

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2.2.1. Hydraulic System Design

For the hydraulic system design, a hydraulic diagram was first created (see Figure 4). Hydraulic component selection was made according to the calculated power capacity.

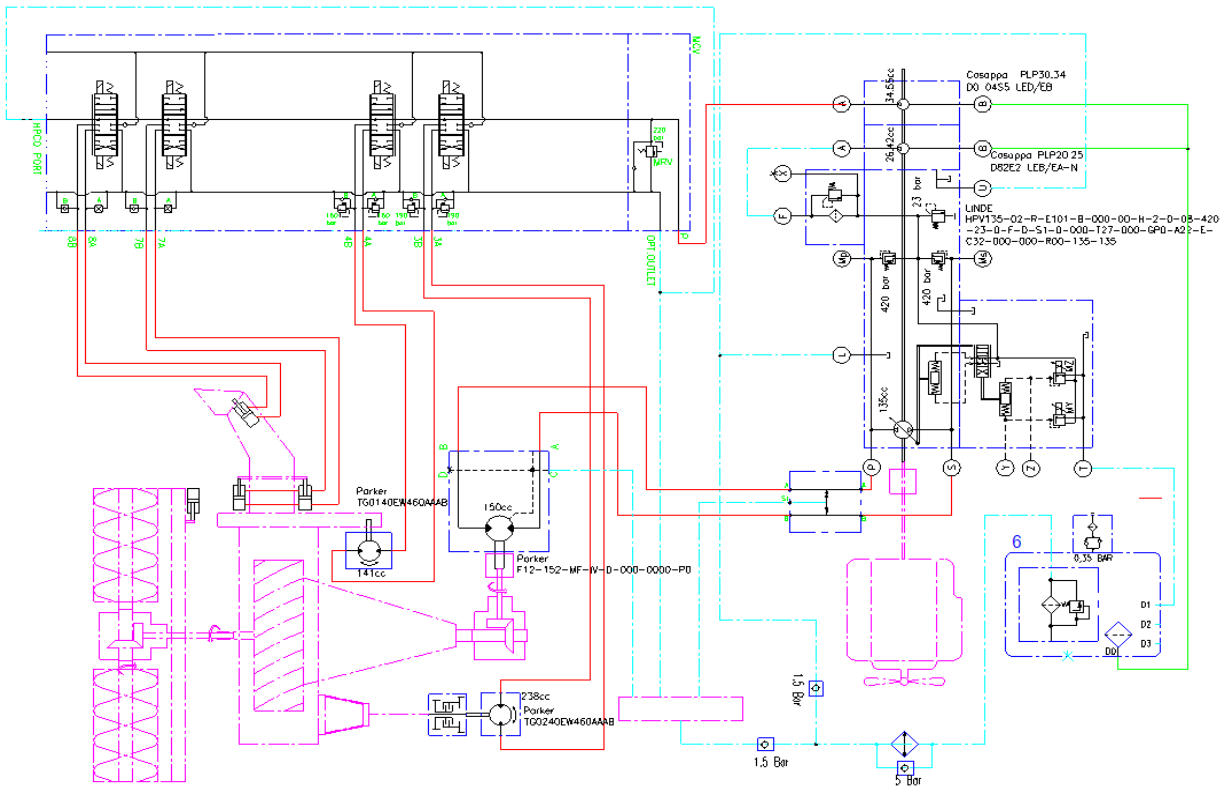

Figure 4: Hydraulic Diagram

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2.2.2. Mechanical System Design

Due to the physical dimensions of the diesel engine determined according to the calculations, placing a power unit instead of the excavator part of the machine and placing a snow blower attachment on the front arm was deemed the most appropriate solution (see Figure 5).

Figure 5: Placing of power unit and snow blower attachment

The main components of the snow blower are auger, fan, flue and body (see Figure 6).

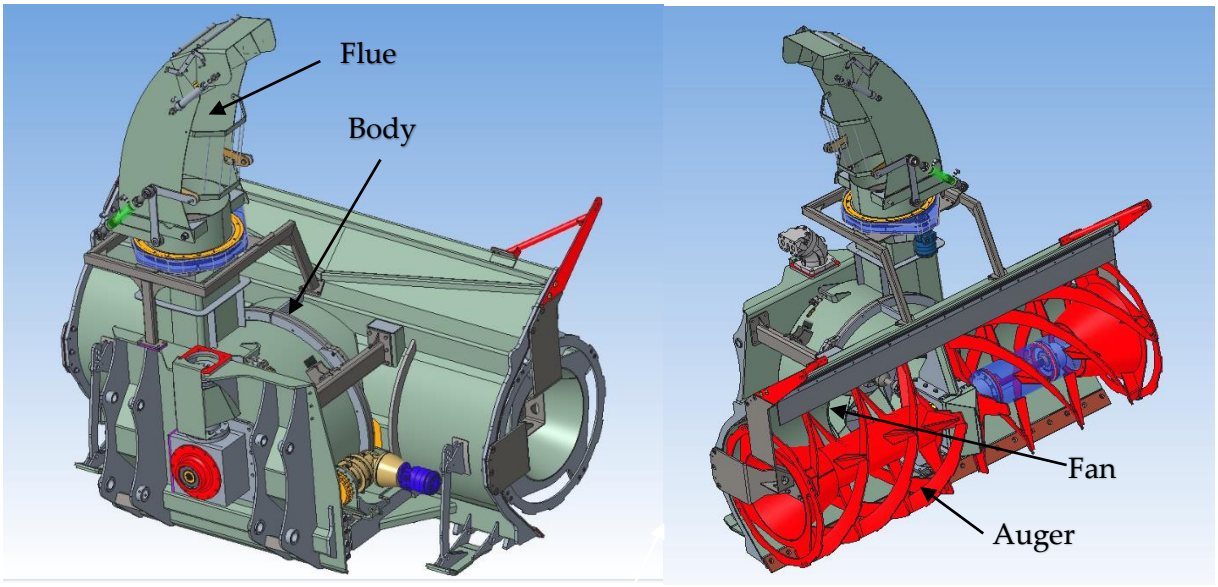

Figure 6: Snow Blower Main Components

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2.2.3. Powertrain Design

Diesel engine selection was made according to the power and torque determined in the design calculations. Cooling, air intake, fuel and exhaust systems are designed for the diesel engine. Additionally, a hood design surrounding the power package has been made (see Figure 7).

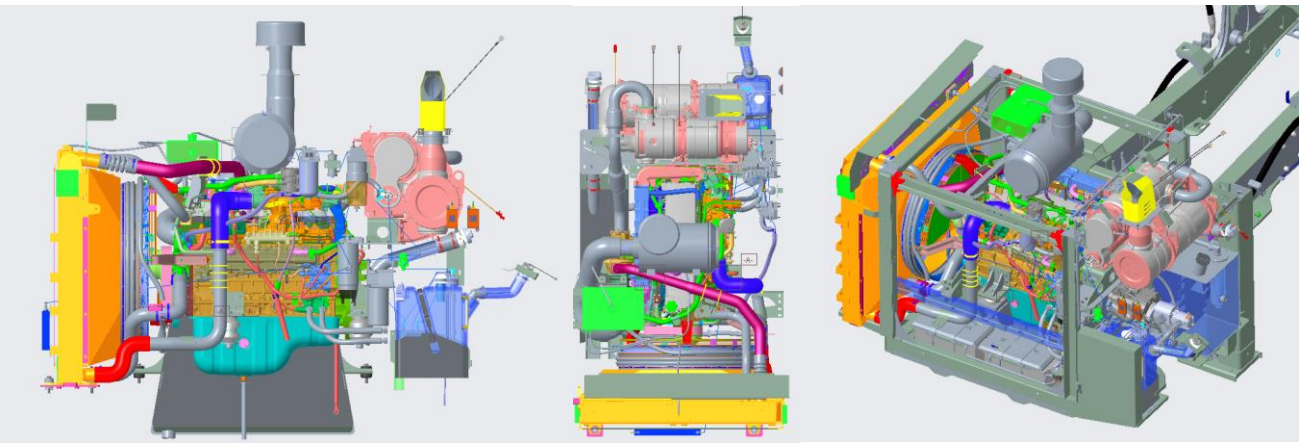

Figure 6: Powertrain Design

The design was verified by performing stress analysis of the structure carrying the power unit and the connection system to the machine chassis (see Figure 7).

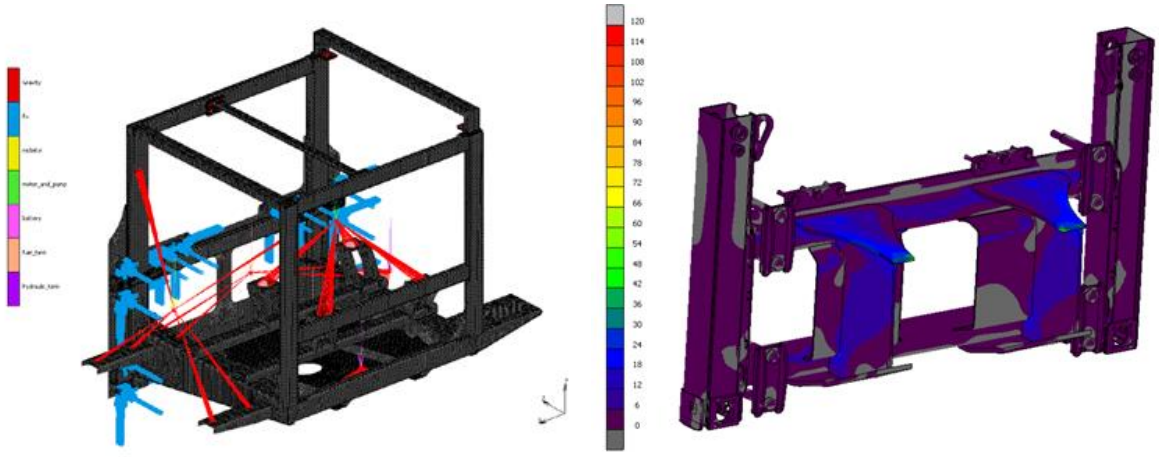

Figure 7: Structural analysis

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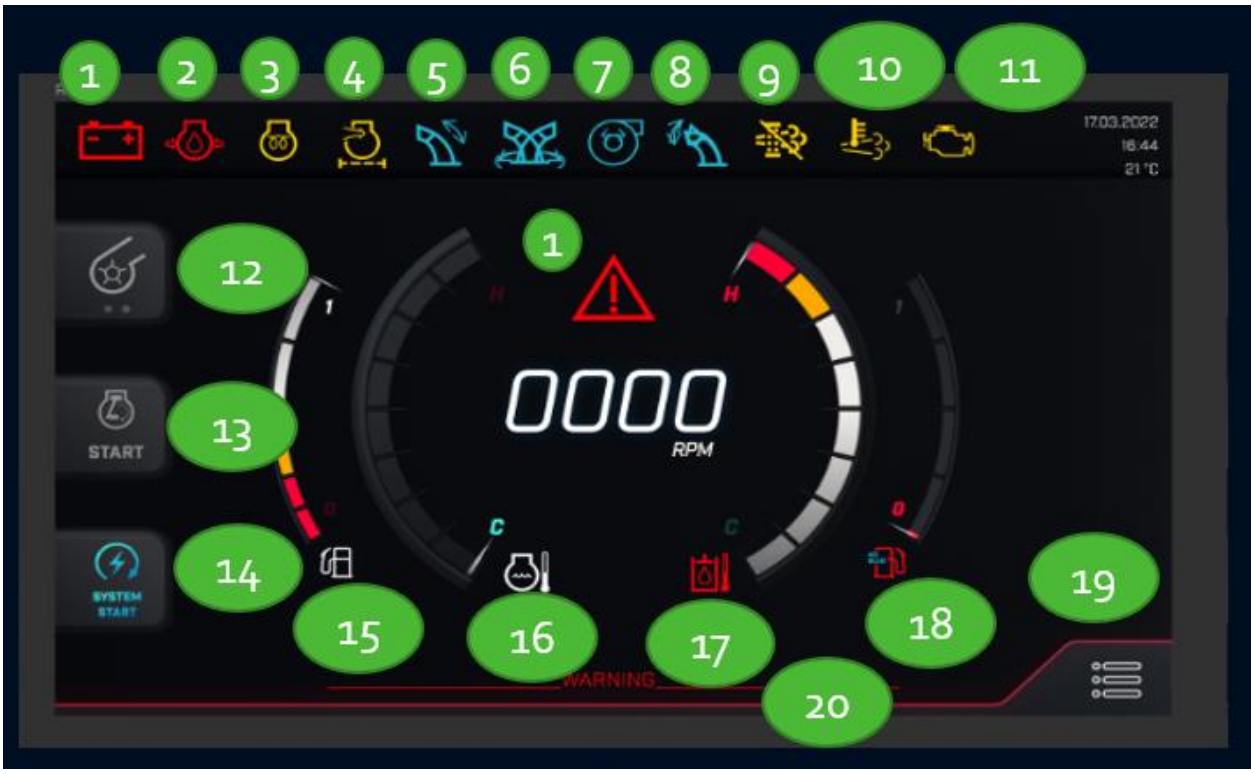
2.2.4. Electronic System Design

Software interfaces and screens that enable control and monitoring of the snow blower attachment and power unit have been developed (see figure 8).



1- Battery charge warning	11- Engine malfunction lamp
2- Engine oil pressure warning	12- Fan forward/reverse active
3- Glow (preheater)	13- Engine start/stop
4- Air filter clogging	14- Power unit active / passive
5- Flue up/down	15- Fuel level indicator
6- Flue right/left	16- Engine water temperature indicator
7- Body right/left	17- Hydraulic temperature indicator
8- Flue cap up/down	18- DEF level indicator
9- Regeneration forbidden	19- Menu entry
10- Regeneration is active	20- Fault and warning section

Figure 8: Screen of Snow Blower

3. Result

The product images resulting from all system designs are as follows (see Figure 8).

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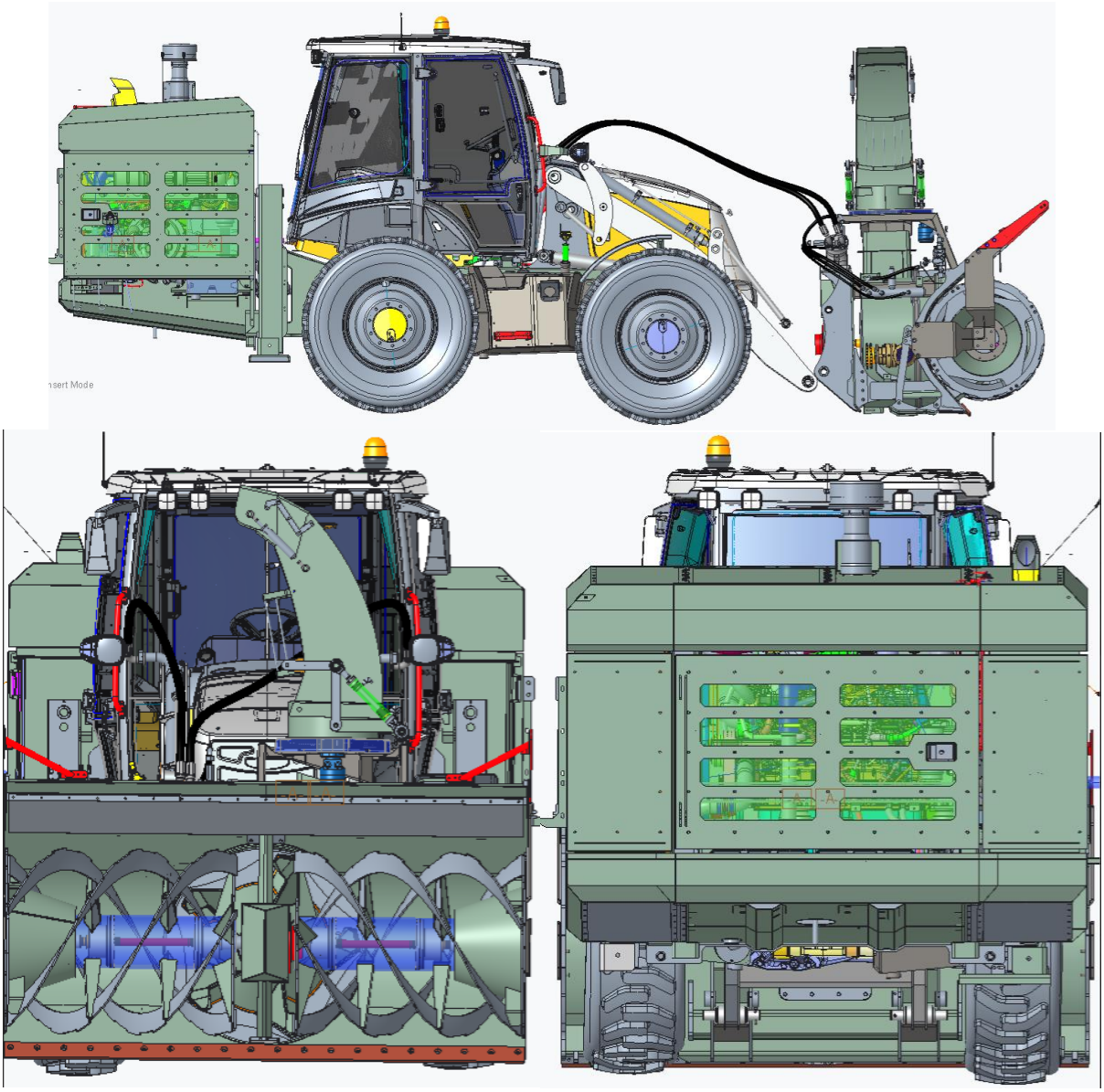

Figure 8: Final Product

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4. Discussion and Conclusion

After the system designs, the final product was produced and verification tests were carried out. Additionally, field studies were carried out in the mountain villages of Rize and Trabzon and positive results were obtained (see Figure 9).

Figure 9: Field Study

5. Acknowledge

HİDROMEK A.Ş supported this study. I would like to thank HİDROMEK.

References

[1] EN 474-4, Earth-moving machinery - Safety - Part 4: Requirements for backhoe loaders,2022
[2] Zaugg AG Eggiwil (2021), Rolba 1500 [Online].
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