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Design Of Electromechanical Module Of Centrifugal Fan For Flue Gas

Mitko Pavlov

Department MEMETE, Sliven Engineering - Pedagogical Faculty
Technical University of Sofia
Bulgaria, European Union

Abstract

In this paper is proposed construction of electromechanical module (EMM) of centrifugal fan for flue gas. Elements - el. motor, safety clutch with toroidal elastic element, impeller and bearing structure are built and simulated in an environment of automated design system TopSolid'Design [6]. The proposed structure is universal and ensures inclusion to different thermal facilities. The design fully meets the requirements for high accuracy, reliability and stability installation characteristic of complexes of this type.

Keywords: Electromechanical Module (EMM), Centrifugal Fan for Flue Gas, Vane Wheel.

1. Introduction

Centrifugal fan for flue gas facilities are operating under extremely harsh conditions associated with a high temperature of air flowing streams T≥350°C and most aggressive environment - Figure 1 [6,7,9]. They are used in mining complexes, power plants, chemical laboratories and factories and complexes for the carbonization of wood. Represent arranged in a spiral housing scapulo Vane wheel, in rotation of which the air falling within the channels between the vanes, move radially toward the periphery of the wheel. Pumped and on the basis of centrifugal force and enters the housing oriented towards the discharge opening. Vane Wheel most disc has blades formed around its circumference, the number of vane, their shapes and sizes, are different depending on purpose and type of fan. In flue gas fan, the wheel is made of stainless steel with single or double suction with different inclinations of vanes, ensuring adequate capacity and speed of air flow. Centrifugal Fan for Flue Gas axis can occupy both horizontally and vertically, in addiction to the requirements of the system in which the fan is placed. But most often made with a horizontal axis.

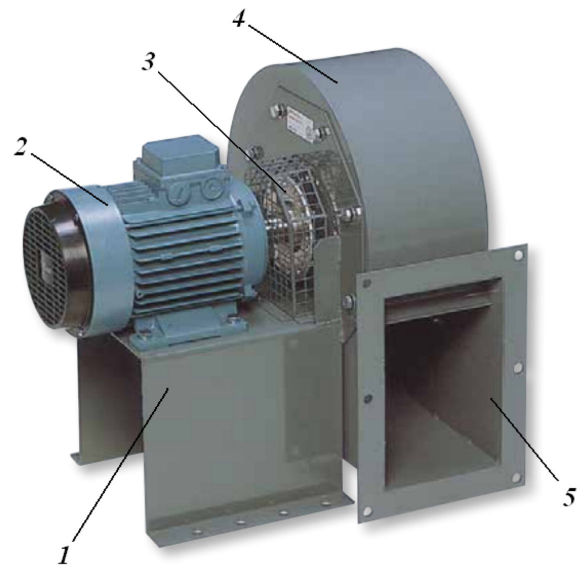

Figure 1 Sample structure of the EMM of centrifugal fan for flue gas [7]:
1.Substructure, 2.Motor, 3.Connector, 4.Housing (Vane Wheel), 5.Air funnel.

2. Design of electromechanical module

The design of electromechanical module of centrifugal fan for flue gas, steps in the following sequence, taking into account technical risk [10]:

- analysis of technical target;
- choice of motor;
- choice of safety clutch with toroidal elastic element;
- constructing the Vane Wheel, housing and the support structure;
- Strength calculations and details of the supporting structure of the EMM, by finite element method.

EMM is designed according to a set schedule Vane Wheel - Fig.2 the following initial conditions specified in Table 1.

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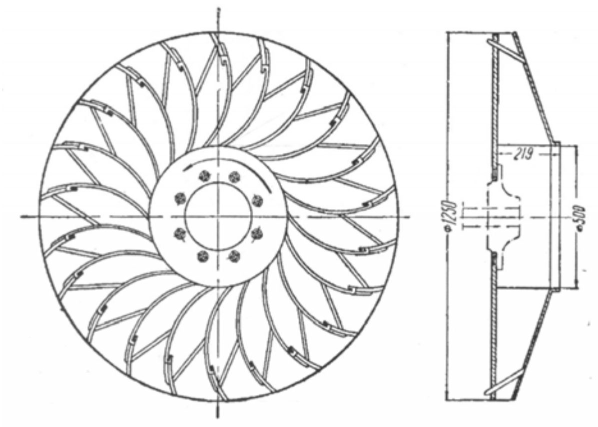

Figure 2 Sketch of the vane wheel

Table 1 Starting conditions for the design of the EMM

Torque output M_{out}, N.m	65
Rate of revolution n_{out}, rpm	1500
Durability T, (L_{10}), h	8000

The engine is selected from the catalogs of manufacturers according to the power consumption of the EMM in-relationship [4,6,7]:

$$P_{eng.} \geq P_{EMM} = \frac{M.\omega}{\eta} = \frac{65.157,08}{0,9603} = 10632 kW \qquad (1)$$

where:

- $P_{eng.}$, kW – rated engine power;
- P_{EMM},kW – power consumption of the working machine or in the case of all EMM;
- η = 0,9603 – coefficient of efficiency of EMM.

Based on the calculations selected three-phase induction motor with general purpose and cage rotor - model K160M-4 Company Valiadis Hellenic Motors with power $P_{eng.}$ = 11kW.

The elastic coupling is selected according to Table 2 [4,5] according to M, ω and d_1 diameter output shaft of the engine.In the most common type of kinematics EMM centrifugal flue gas fan is shown in Figure 3. Based on conducted kinematic and dynamic calculations are displayed shaft diameter d,mm and reactions at the supports which are chosen bearings and bearing housings [3,5].

$$d \approx c\sqrt[3]{\frac{P}{n}} mm = 150\sqrt[3]{\frac{11}{1500}} = 29,14 mm \qquad (2)$$

where:

- τ=(120÷200).10^5 Pa, whereupon c=150;
- P=11,kW – power;
- n = 1500min^{-1} – rate of revolution.

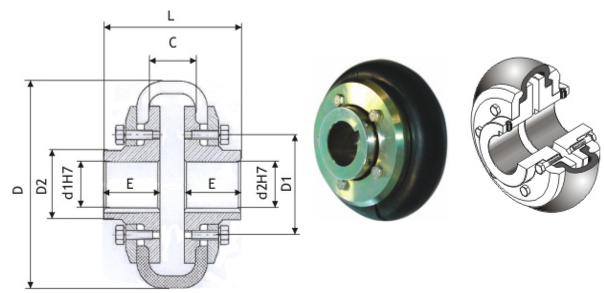

Figure 3 Dimensions of safety flexible coupling with toroidal elastic element type VIELASTIK [3,4,5]

Table 2 Labels - VIELASTIK [4,5]

Name	Nominal torque [kgm]	Maximum torque [kgm]	maximum rate, min^{-1}	D	D1	D2	d1H7	d2H7	L	E	C
85-05	0.5	1.0	3500	85	40	28			45	20	13
100-1	1.0	3.0	3500	100	48	33	16-22	16-22	66	28	20
135-3	3.0	9.0	3500	135	69	48	14-33	22-28	80	35	22
175-7	7.0	21.0	3500	175	90	64	19-39	28-35	112	45	38
210-15	15.0	45.0	2500	210	110	80	25-51	35-42	132	55	38
260-30	30.0	90.0	2000	230	144	95	29-61	42-55	156	65	44
310-60	60.0	180.0	2000	310	164	125	37-81	50-55	171	75	41
370-120	120.0	360.0	1600	370	232	150	37-92	55	196	85	46
400-240	240.0	720.0	1600	400	260	160	37-102	60	220	95	50
450-400	400.0	1200.0	1300	450	260	160	54-112	75	265	110	71

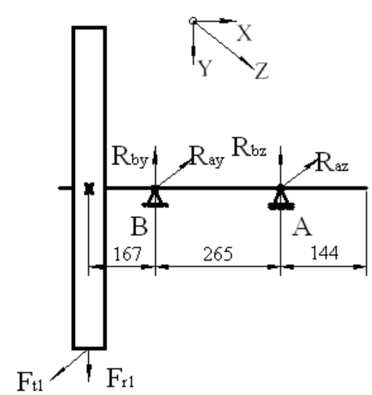

Figure 4 Kinematic scheme of employing centrifugal fan for flue gas

For A and B pillars supporting effects are:

$$R_a = \sqrt{R_{Ay}^2 + R_{Az}^2} = \sqrt{2101^2 + 2406^2} = 3194\, N \qquad (3)$$

$$R_b = \sqrt{R_{By}^2 + R_{Bz}^2} = \sqrt{5436^2 + 6224^2} = 8265\, N \qquad (4)$$

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Selects spherical - roller bearings with integrated seals EXPLORER SNL the company SKF [10] - Table 3. They may be combined with various seals. The dimensions of the bearing boxes FSNL 513-611 are shown in Figure 5.

Table 3 Designation of bearing housings SNL [10]

Shaft d_a	Appropriate bearings (basic designation) Self-aligning ball bearings		Spherical roller bearings		CARB bearing	Designation Housing
mm	-					-
44,45	1310 K	2310 K	21310 K	22310 K	-	FSE 512-610
45	1310 K	2310 K	21310 K	22310 K	-	FSE 512-610
45	1310 K	2310 K	21310 K	22310 K	-	SE 512-610
45	1210 K	2210 K	-	22210 K	C 2210 K	SE 510-608
49,2125	1211 K	2211 K	-	22211 K	C 2211 K	SE 511-609
49,2125	1311 K	2311 K	21311 K	22311 K	-	FSE 513-611
49,2125	1311 K	2311 K	21311 K	22311 K	-	SE 513-611
49,2125	1211 K	2211 K	-	22211 K	C 2211 K	FSE 511-609
50	1211 K	2211 K	-	22211 K	C 2211 K	FSE 511-609
50	1311 K	2311 K	21311 K	22311 K	-	FSE 513-611

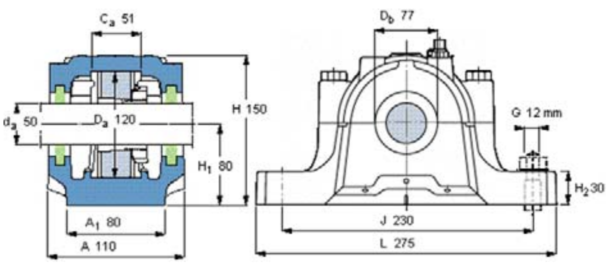

Figure 5 Dimensions of bearing housings SNL FSNL 513-611 [10]

Quality functioning of the whole module depends mainly on precision in the manufacture and installation of the central shaft. Priority in recent years preferred technology involving the use of combined tools for cutting and surface plastic deformation [3,4,5,6,9], as they provide in establishing a minimum error of form at extremely low roughness. Reliability indicators are tools surcharge, which ensures their high technical resource [3,4,5,6,11].

3. Structure of the module

In general terms the structure of the EMM is shown in Figure 6. It consists of the following major elements:

- support frame,
- motor,
- safety flexible coupling with toroidal elastic element,
- bearing housings,
- shaft line – figure 7,
- Vane Wheel,
- housing – figure 8.

The movement is transmitted through the dowel compound from the shaft of the motor to the drive plate of Safety flexible coupling with toroidal elastic element. The output shaft of the clutch is a central shaft of electromechanical module. He is supported by two bearing housings SKF SNL. At the end of the shaft is established fan flue gas composed of vane wheel and housing. All elements of the module are set on a metal supporting structure, mainly composed of hot-rolled profiles and details of sheet material. Assembly of individual assemblies is through bolted connector.

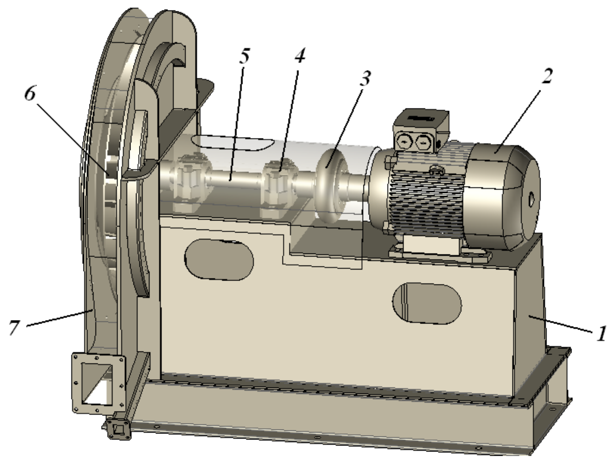

Figure 6 EMM of centrifugal fan for flue gas:
1.Support frame, 2.Motor, 3.Safety flexible coupling with toroidal elastic element, 4.Bearing housings, 5.Shaft line, 6.Vane Wheel, 7.Housing

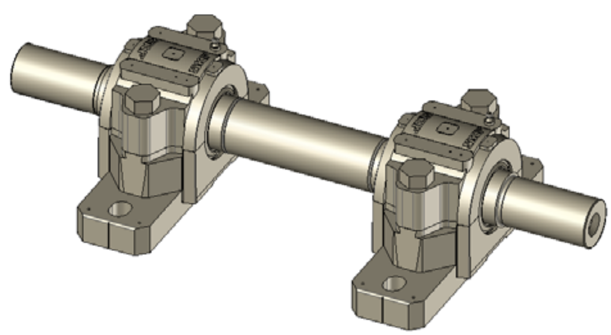

Figure 7 Shaft line

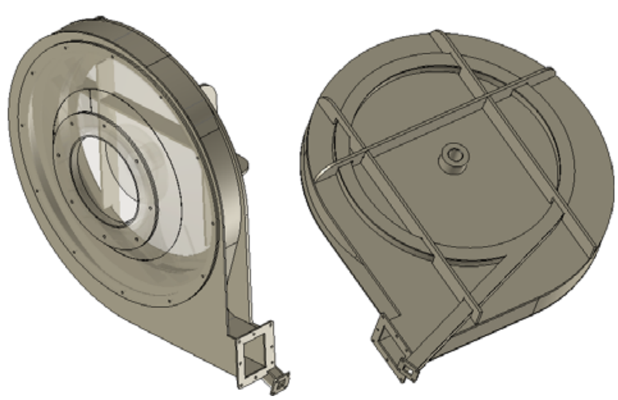

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Figure 8 Housing

4. Strength deformation check - FEM analysis

The check is performed on the supporting structure by finite element method through module TopSolid'CastorXpress. The functions of the modules require consistent data entry in a series dialogue frameworks - type of material, brand, characteristics, Poisson's ratio, Young modulus, density, network parameters, external load, fixed element.

In general, the method of the concentration distribution of the power load and deflection is shown in Figure 9 a,b.

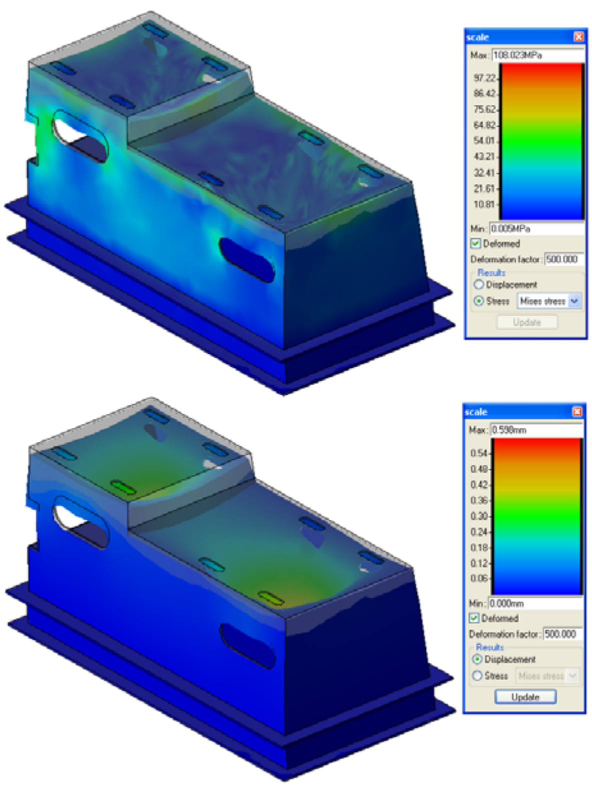

Figure 9 FEM analysis - bearing structure:
a)verification of strength, b) deformation check.

Generated linear static three-dimensional model, defines a zone of maximum deformation location (surface segmentation with red color).

The analysis results show that the strength and strain the structure fully meets the requirements, such as:

$\sigma_{or.} = 34{,}792\text{MPa} << [\sigma_{or.}] = 160\text{Mpa}$,

$f = 0{,}039 \text{ mm} << [f] = 4{,}1\text{mm}$ – max. deflection.

3. Conclusions

1. Proposed new construction (EMM) of centrifugal fan for flue gas.
2. Individual groups are prefabricated elements which ensure their mobility and recalibrating.
3. The analysis by finite element method proves the feasibility of the structure even at loads exceeding permissible

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Mitko Pavlov, is a student in the Master's degree in Mechanical Engineering and Technology at the Technical University of Sofia, Sliven Engineering – Pedagogical Faculty. He is also an employee of "Mini Maritsa Iztok EAD" Radnevo hell with post Mining machinery Mechanic. Research scientific interests of Mitko Pavlov, include Cutting tools, High Speed Machining, Reliability of the Industrial systems, Mining machines and in particular complete device of Wheel Excavators. He is married with two daughters.