A NEW PROCEDURE OF THE SEATING OF COMBUSTION ENGINE AT THE MARINE POWER PLANT

Leszek Piaseczny

Polish Naval Academy, Faculty of Mechanical and Electrical Engineering
Smidowicza Street 69, 81-103 Gdynia, Poland
tel.: +48 58 6262603, fax: +48 58 6262503
e-mail: l.piaseczny@amw.gdynia.pl

Abstract

There has been presented a new procedure of the seating of a combustion engines at the marine power plant with steel chocks cemented by a thixotropic polymer composition between the engine's spot footing and the foundation ledge. A combustion engine is seated on foundation at the marine power plant by steel chocks or the chocks that are cast from polymer composition at the marine power plant. The arrangement, number and dimensions of foundation chocks, as well as arrangement, number and dimensions of the lateral and frontal stoppers that secure chocks work, are established by an engine manufacturer and are approved by Classification Society that supervises the vessel's construction and operation. The author's intention was to develop such chocks that combine the good resistance of steel chocks with the easiness of adjustment the bearing surfaces of polymer compositions chocks. Combination of these features was obtained for steel chocks which are glued by the relatively thin layers of polymer compositions between the engine spot footing and the foundation ledges. Such a method of making the chocks and seating with them the engines on foundation was claimed with the Patent RP No. 192120 on 24th July 2000 for the Polish Naval Academy. In order to receive the approval of the Polish Register of Shipping to use new chocks at the marine power plants, the author carried out appropriate research, results of which are presented below. The results obtained in the research show that by seating of a combustion engine with these steel-thixotropic polymer chocks at the marine power plant, the foundation bolts tension can be diminished to the value equal to five times of the engine weight.

Keywords: *marine power plants, combustion engine, seating, polymer composition*

1. Introduction

There are three aims of the chocks in seating of a combustion engine on the foundation at the marine power plant:

- they significantly limit the interfaces of the engine and foundation, and checking these planes by mechanical working at the marine power plant is difficult and expensive,
- they facilitate alignment of the engine with a cooperating gear, e.g. a generator, a reduction gear and shafting. When the process of the engine alignment takes place, the distance between the engine spot footing and the ledges of foundation is changing at the engine length, especially when multi-cylinder engines are seated in one line. Such a problem can be solved easily by changing the chocks thickness at the engine length. In case of seating the engine without any chocks, the process of checking the whole plane of the engine spot footing to the ledges plane of the foundation requires more shipbuilders' work,
- they lower noise and vibrations transfer onto the hull construction, which are generated through non-uniform work of a combustion engine that obviously has a limited number of cylinders.

A combustion engine is seated on foundation at the marine power plant by steel chocks or the chocks that are cast from polymer composition at the marine power plant. The arrangement, number and dimensions of foundation chocks, as well as arrangement, number and dimensions of the lateral and frontal stoppers that secure chocks work, are established by an engine producer and are approved by Classification Society that supervises the vessel's construction and operation.

Each chock is usually crossed by two foundation bolts, through-bolts or the bolts fitted with the tension equal to 10-fold the engine weight when steel chocks are in use. According to the research [1], it is possible to decrease tension of foundation bolts by applying the chocks cast from polymer composition.

Steel chocks are of the following features:

- low cost of steel and relatively high cost of checking the bearing surfaces of chocks to the planes of engine spot footing and foundation ledges,
- high compressive strength and high rigidity, which enables to neglect the chocks deformation when they are compressed with high tension by foundation bolts and also to acknowledge that the tension does not interfere the alignment of the engine with the cooperation mechanism,
- the necessity of producing the chocks of various thicknesses depending on their location at the engine length,
- low equal to 0.1, coefficient of rest friction of steel by steel, which forces to use high tensions of foundation bolts in order to create tension forces that protect the engine against its sliding down from the foundation because of the vibrations produced during the engine work,
- despite applying high tensions of foundation bolts, an additional protection of the engine against its sliding down is required, such as lateral and frontal stoppers,
- high tension of foundation bolts brings danger of relaxation of tension during engine work, which forces periodical checks of tension of bolts being in operation and restoring the sufficient tension,
- lack of possibility of dampening the noise and vibrations formed during engine work and enabling them to spread in the hull construction,
- lack of thermal deformation with the temperature increase, which results from the combustion engine work (up to 80^{o}C).

Chocks cast from polymer composition at the marine power plant are of the following features:

- lack of the work of adjustment of bearing surfaces to the plane of the engine spot footing and the plane of foundation ledges. These planes adjust themselves when the chock is cast. It results in lowering the costs of the engine seating,
- low compressive strength, low rigidity and occurrence of shrinkage when curing the polymer compositions. Hence, the regulations of Classification Societies limit the compression load from the engine weight of the chocks made of the polymer compositions to 0.7 N/mm^2 [2]. The chocks deformation due to tension of the foundation bolts and shrinkage during the curing should be taken into account when the engine is aligned with the cooperative mechanism,
- they dampen well the noise and vibrations occurring when the combustion engine is operating, and limit their propagation at the hull construction,
- they have a high coefficient of rest friction of steel (≈ 0.7), which enables to decrease the number or tension of the foundation bolts, decrease the number of the lateral and frontal stoppers, which protect the engine against its sliding down the foundation,
- at the lower tension of the foundation bolts, the relaxation of the engine work is decreasing, and this enables to lower the frequency of controlling the tension and restoring the foundation bolts tension during the engine work,
- it is required to select such polymer compositions for the chocks which, without significant deformations, can resist temperature increase to 80^{o}C (compositions with metal or ceramic filler).

The author's intention was to develop such chocks that combine the good resistance of steel chocks with the easiness of adjustment the bearing surfaces of polymer compositions chocks. Combination of these features was obtained for steel chocks which are glued by the relatively thin layers of polymer compositions between the engine spot footing and the foundation ledges. Such a method of making the chocks and seating with them the engines on foundation was claimed with the Patent RP No. 192120 on 24th July 2000 for the Polish Naval Academy [3].

In order to receive the approval of the Polish Register of Shipping [4] to use new chocks at the marine power plants, the author carried out appropriate research, results of which are presented below.

2. Results of the research

Shape and dimensions of test pieces simulating new chocks for combustion engines foundation at the marine power plants are shown in Fig. 1.

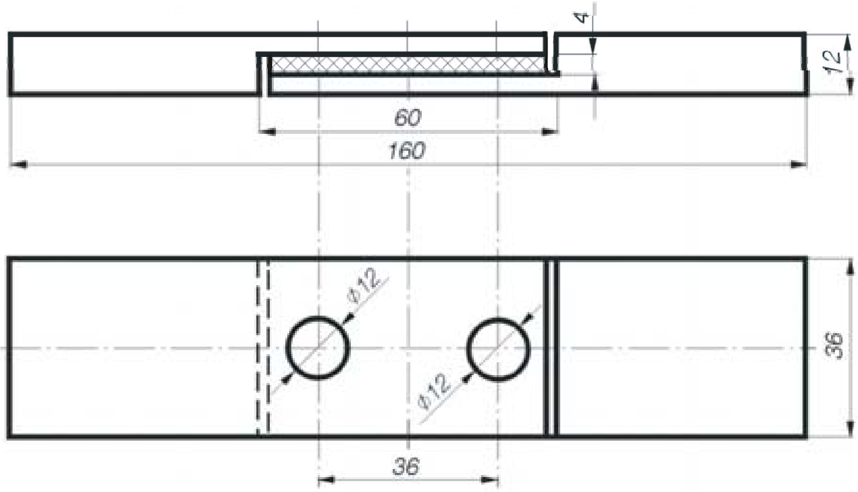

Fig. 1. Shape and dimensions of a test piece simulating new chocks

Steel parts of the test piece were made of metal plate used for constructions of the vessels of category AH32 of $R_{e\ min} = 315$ N/mm^2, $R_m = (470\text{-}590)$ N/mm^2 and $A_{5min} = 22\%$ [5]. As the polymer composition there was used Belzona product 1111B, based on epoxide resin containing as the filler the microscopic particles of siliceous steel of the following parameters at hardened state: $R_c = 1905$ N/mm^2, $R_m = 63.4$ N/mm^2, Young's modulus $E = 1950$ N/mm^2, adhesion for steel according to ASTM D-1002 - 20.7 N/mm^2 and the shrinkage when hardening according to DOD-C 241764 $\varepsilon_p<0.025\%$ [6].

Steel parts of the test pieces were glued overlap with the polymer composition. After hardening the glue joints (24 hours at the ambient temperature), the test pieces were drilled (two holes of 12 mm in diameter), and bolts of M10x30 mm were seated in these holes. In the next series of test pieces (3-6 pieces), the bolts were strained with a torque spanner with the forces of 4200 N and 7700 N. This was proportional to the tension of foundation bolts of combustion engine with the forces equal to 1, 6 and 11 - fold the engine weight.

Five days after the test pieces were made, they were stretched on the testing machine MTS at the force range from 0 to 95 kN until the polymer compositions were broken. The test run was recorded every 1 ms, with the assumption that the piston machine path of 1 mm was made in 1 minute. The records were made into dat file, which was compatible with an Excel sheet. The test pieces were finished at the moment of breaking the polymer composition layer, which usually was mixed, adhesive and cohesive.

The layers of polymer composition were loaded with bolts tension forces (compression), with tear force (tension) and with shearing force. The results obtained in the research and stresses computed in polymer composition layers are presented in Tab. 1. An effort change of the polymer composition layer with an increase of tension of the bolts joining steel parts of test pieces is shown in Fig. 2.

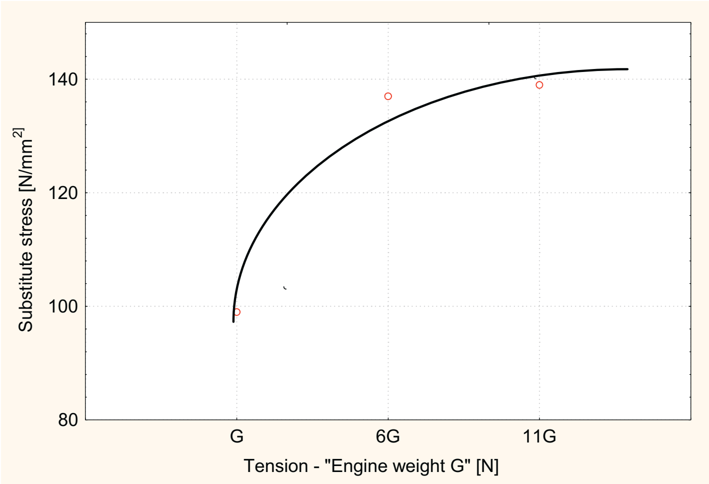

Fig. 2. An effort change of the polymer composition layer with an increase of tension of the bolts

Tab. 1. Forces and stresses at the moment of breaking the test pieces simulating new chock

Tension of two bolts F_y, N	σ_y N/mm^2	F_x N	σ_x N/mm^2	τ_{xy} N/mm^2	σ_{red} N/mm^2
1400	0.72	14118	98	7.3	99
8400	4.34	19727	137	10.2	135
15400	7.96	20307	139	10.5	137

The effort of the polymer composition layer when a test piece is breaking was computed in accordance with the M. T. Huber's hypothesis of the non-dilatational strain energy [6], according to which the measure of material effort is the value of the specific non-dilatational strain energy, being measured by the value of equivalent stress σ_{red}, calculated from the following formula:

$$\sigma_{red} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \cdot \sigma_y + 3 \cdot \tau_{xy}^2} \ . \tag{1}$$

In all the test pieces of stretching, the process of breaking the joints steel-polymer composition started with breaking the adhesion forces at both ends of the overlap. At these places, tensions τ_{xy} were the highest. Given in Tab. 1. values of tensions τ_{xy} in particular test pieces series are of average values of these tensions at the overlap length.

The tension forces acting at both steel parts of a test piece, form a couple of forces oppositely directed, acting at the arm of 8 mm. This creates the momentum M = $F_x \cdot 8$ N mm, which bends the joint. Because of the low value of these stresses, the stresses acting at the steel-polymer composition joint were neglected in this analysis.

As it is shown in Tab. 1, an increase of tension of the bolts of engine footing at the foundation in marine power plant from 6-fold the engine weight to 11-fold the engine weight, in fact does nor increase an effort of polymer composition layer. Hence, when changing the steel chocks for the ones according to the patent, enables to decrease the foundation bolts tension from the value of 10-fold the engine weight to the value of 5-fold the engine weight.

References

[1] Germanischer, L., *Regulations for the Seating of Propulsion Plant*, Hamburg, April 1995.

[2] Polish Patent Office, *Patent No. 192120. Method of seating the engines and mechanisms on foundation footings,* Warsaw 2000 (in Polish).

[3] Polish Register of Shipping, *Regulations of marine vessels classification and construction*. Gdansk 2002. (in Polish).
[4] PN-93/H-92147, *Steel plates and universal plates for ships construction,* (in Polish).
[5] Proceedings of the Scientific-Technical Conference, *Belzona on-board BELSE*, Leba 2007.
[6] Brzóska, Z., *Mechanics of materials*, PWN, Warsaw 1994.