Properties of threads created by thread inserts

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ABSTRACT: Several techniques are at disposal for production or repair of internal threads. The repair of threads by means of flexible thread inserts and the repair of threads by means of sold thin walled thread inserts belong to the most important ways. The properties of threads repaired using flexible and solid thin-walled thread inserts were experimentally verified and compared. Laboratory comparison of loading capacity of the threads according to observance of specified technological procedures was carried out. Durability and reliability of the repaired threads were verified in operation, while the threads endured long-time variable mechanical and temperature load.

Keywords: internal thread; flexible thread insert; solid thread insert; loading capacity of thread; thread reliability

The threads can be damaged in consequence of the corrosion, wrong assembly or disassembly, overloading, often repeated assembly and disassembly (POŠTA 1998).

One of the most frequent and difficult cases occurs when the thread part of the bolt becomes rusted in tight and the bolt has been broken. In this case usually it is not possible to remove the rest of the bolt without damaging of internal thread or the thread has been entirely deteriorated by corrosion. We meet very often with the damage of the threads in the parts produced of aluminum alloys, brass and bronze (TOLNAI et al. 2001).

Easy executable and technically perfect repair is the repair of damaged thread by means of flexible or solid thread insert. Using inserts is easy and quick practicable with simple hand tools (POŠTA 1998).

Bolted connection is usually produced with standardized thread of metric rank (Fig. 1). Internal thread is usually chipworked using cutting tool. Male thread has been produced usually by cold forming (Blaue Seiten 1996).

Flexible thread insert is made of wire of accurate rhomboidal cross section. The wire for the production of an insert is rolled or drawn and therefore its surface is clean and smooth. It is coiled to the shape of cylindrical spring and its profile creates concentric male and internal thread. By means of a fixture the insert is mounted to the thread, called bed thread. The insert has been fixed by its male thread surface. Internal thread surface of the insert creates the thread of the original dimension (http://www.boellhoff.cz, Fig. 2).

Technological procedure of the thread repair using flexible thread insert is following (POŠTA 1998):
– to drill the hole for the bed thread,
– bed thread producing,
– the assembly of the flexible thread insert,
– breaking off the auxiliary carrying boss of the insert.

Solid thin walled thread insert is produced as a thin steel case, equipped with a seat (Technik Rund um Schrauben). The profile of the internal thread of the case is not complete at all the length. After the insert is screwed in the bed thread, the internal profile is finalized by means of forming tool and the insert is pressed to the bed thread. Its internal thread surface creates the thread of the original dimension (http://www.wuerth.cz, Fig. 3).

Technological procedure of the thread repair by solid thin walled thread insert is following:
– to drill the hole for the bed thread,
– producing of the step for the seat of the insert,
– bed thread producing,
– assembly of the solid thread insert,
– internal thread forming of the insert.

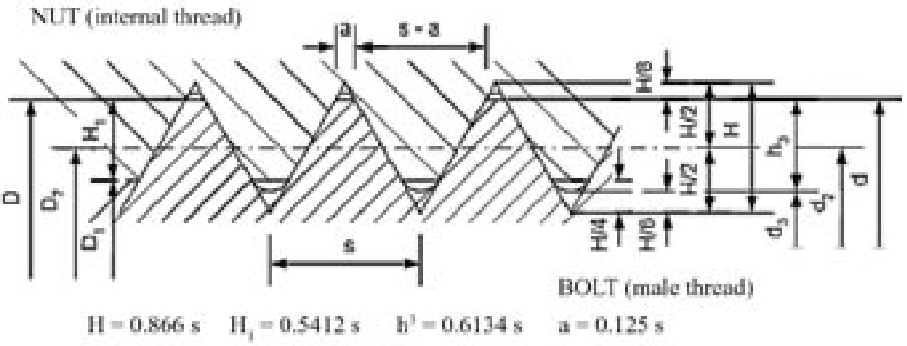

Fig. 1. Metric thread of basic rank according to Czech Standard ČSN 014012

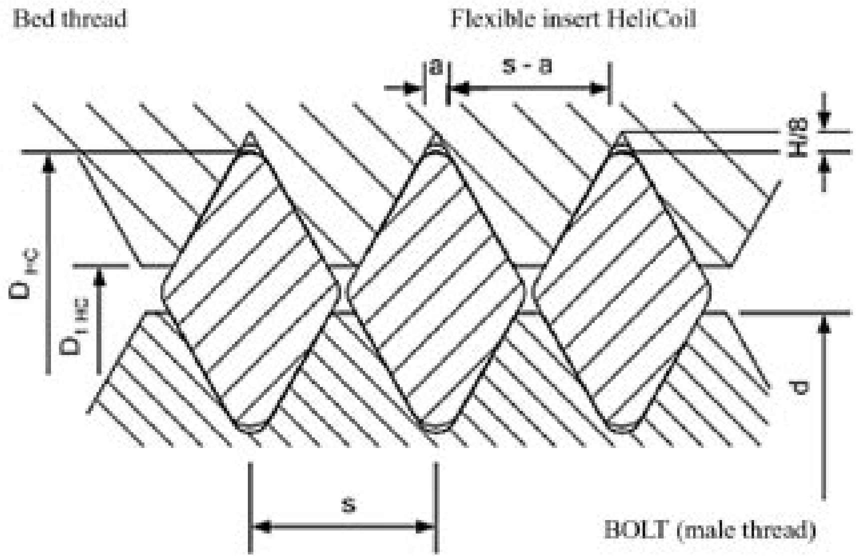

Fig. 2. Metric thread of the basic rank created by flexible thread insert HeliCoil

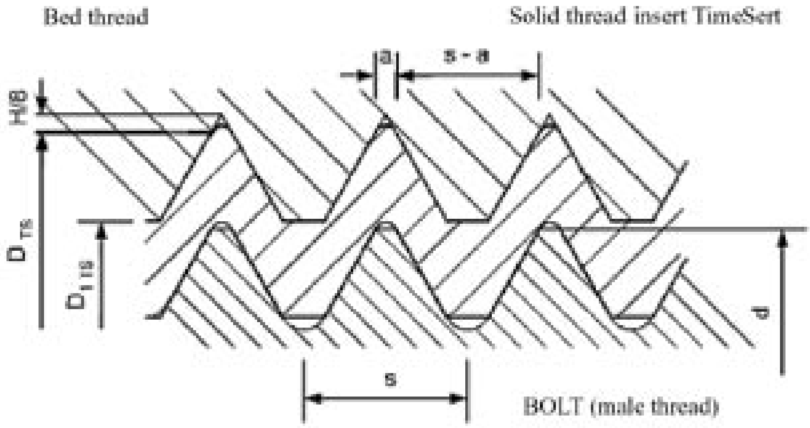

Fig. 3. Metric thread of the basic rank created by solid thread insert TimeSert

MATERIAL AND METHOD

The laboratory tests were carried out in order to compare the threads repaired using flexible and solid thread inserts. During the tests the loading capacity of the threads was examined in relation to the thread hole diameter.

Testing samples equipped with M8 thread were used for verification. The sample threads were produced:

- by common procedure of chip metalworking with standard screw tap,
- using flexible thread insert HeliCoil plus of lengths L = 1.5d, L = 2d, d = nominal diameter of the thread (8 mm),
- using solid thin walled thread insert TimeSert of lengths L = 1.5d, L = 2d.

Thread inserts were mounted into samples with holes for bed threads that were drilled according to instructions of the thread inserts producer and into samples with holes for bed threads whose diameters were about 0.2 mm bigger. The target was to verify if and how the loading capacity of threads created by thread insert changes, because the breach of prescribed hole diameter for bed thread is the most frequent cause of incompliance to the technological procedure described by producer (VESELÝ 2002).

Samples for trials of thread loading capacity were produced from constructional carbon steel 11373.0 and duralumin 424254.61. Dimensions and shape of testing samples were designed according to prescription of thread insert producer (Fig. 3).

Three pieces of samples were prepared and tested for each case. Following results are always presented as averages of these three measurements.

Commonly produced bolts M8 × 80 mm, strength class 10K, were used for trials of internal threads loading capacity. The cross-section surface of the bolt core is 36.6 mm^2. Bolts of this strength class are made of 14240 material with guaranteed strength 1,000–1,200 MPa.

Samples were clamped by means of a fixture to laboratory tensile machine for tensile test of material mechanical properties and were loaded axial tensile force up to the destruction. The same speed of working feed 6 mm/min has been used for all samples. The course of axial force has been measured and recorded in dependence on the feed according to methodology commonly used for tensile test of material mechanical properties.

Table 1. Average values of destruction axial force of the steel 11373.0 bolted connection

Thread insert lengths		mm	L = 1.5d	L = 2d
Etalon	D_1 = 6.6 mm	N	44,200	44,200
Thread insert HeliCoil plus	D_1 = 8.4 mm	N	44,200	44,200
	D_1 = 8.6 mm	N	44,200	44,200
	D_1 = 8.2 mm	N	44,200	44,200
Thread insert TIME-SERT	D_1 = 8.2 mm	N	44,200	44,200

Table 2. Average values of destruction axial force of duralumin 424254.61 bolted connection

Thread insert lengths		mm	L = 1.5d	L = 2d
Etalon	D_1 = 6.6 mm	N	40,100 *	44,200
Thread insert HeliCoil plus	D_1 = 8.4 mm	N	44,200	44,200
	D_1 = 8.6 mm	N	44,200	44,200
Thread insert TIME-SERT	D_1 = 8.2 mm	N	44,200	44,200
	D_1 = 8.4 mm	N	44,200	44,200

* Internal thread was damaged

The in-operation experiment was carried out in order to examine the reliability and durability of the repaired threads endured to long-time variable mechanical and temperature load. The four-cylinder ignition engine Škoda 100 was equipped with cylinder head with first and third cylinder's sparking plug threads created using flexible thread insert HeliCoil M14 × 1.25 × 1d and second and fourth cylinder's sparking plug threads created using solid thin-walled thread insert TimeSert M14 × 1.25 × 1d. The engine was then operated and maintained in standard way for a long time period. The sparking plugs were visually checked every 5,000 km and changed after 25,000 km of mileage.

RESULTS

The result of each sample test is the value of axial force, that caused the destruction of thread connection. Average values are presented in Tables 1 and 2.

As the result of the long-time in-operation test it turned out that the sparking plug threads created by flexible and solid thin-walled thread inserts are according to their operational properties absolutely suitable and non-problematic. During the in-operation test the engine equipped with the cylinder head with examined threads was operated for more then 60,000 km of vehicle mileage. Presently, the experiment still continues, the engine is already equipped with third set of sparking plugs.

DISCUSSION

The maximum loading capacity of the bolted connection can be expressed as an axial force in the connection or as a stress in the material at the moment of marginal state when the connection is destructed.

From experimentally determined values of average axial force at the moment of the destruction we can derive the real stress in the material of the sample and in the material of the bolt. Regarding the way of the strain of the thread connections, the stress is set:

a) as the shearing stress τ in the sample material for the diameter D of the standard, for the diameter D_{HC} of the insert HeliCoil, for the diameter D_{TS} of the insert TimeSert (Figs. 1–3). Values are displayed in Figs. 4 and 5;

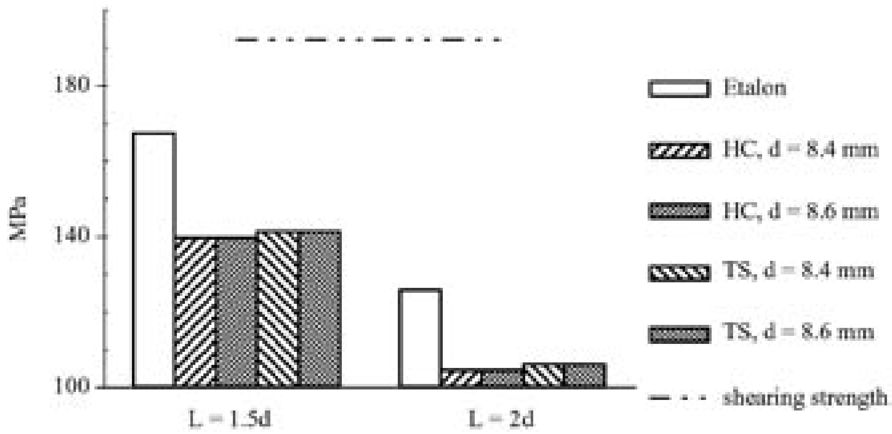

Fig. 4. Shearing stress in threads during the destruction of the connection, steel

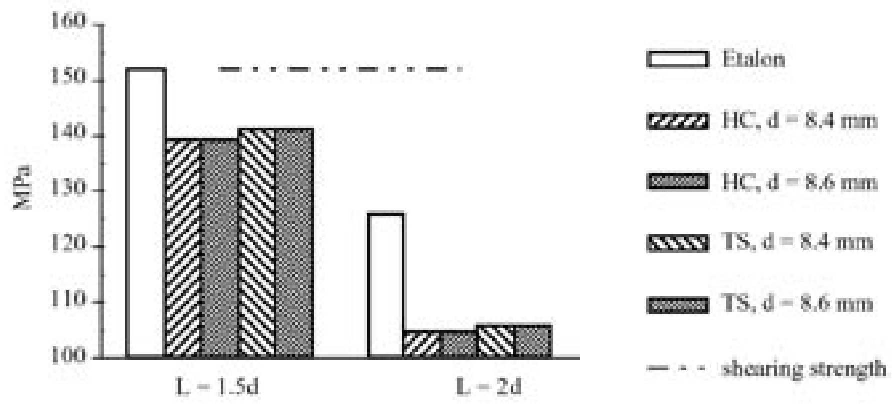

Fig. 5. Shearing stress in threads during the destruction of the connection, duralumin

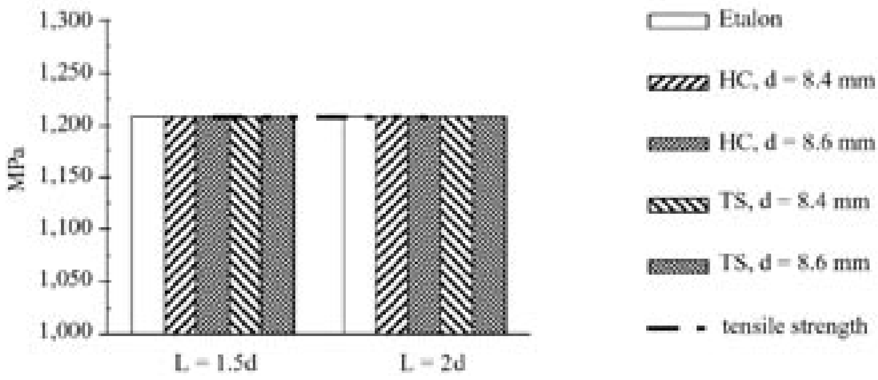

Fig. 6. Tensile stress in the bolt during the destruction of the connection, steel

b) as the tensile stress σ in the cross-section of the bolt core S_j. Values are displayed in Figs. 6 and 7.

From the point of view of the reliability of the bolted connection it is a serial system, whose elements are internal thread, thread insert, male thread and the core of the bolt. Result properties, i.e. mainly loading capacity, are defined by the weakest element of all. Loading capacity of the weakest element determines loading capacity of the bolted connection.

In the course of trials in any case the thread insert has never been damaged. At the standard of duralumin the damage of internal thread (shearing failure) occurred at loaded length of the thread L = 1.5d. In all other cases the weakest element was the bolt, bolt breakage occurred in all these cases. It is possible to state:

– In case when the damage of internal thread occurred, the maximum loading capacity of internal thread of the present performance is equal to corresponding axial force (P_{MAX} = 40,100 N; duralumin, without thread insert, L = 1.5d).
– In case when the damage of the bolt occurred and internal thread remained without the damage, the minimum loading capacity of internal thread in the present performance is equal to corresponding axial force (P_{MIN} = 44,200 N).

Using both flexible thread insert HeliCoil and solid thread insert TimeSert, the stress straining internal threads in shearing stress is always lower than in case of standardized thread of the same dimensions. Loading capacity and the reliability of internal threads created using mentioned thread inserts is always higher than in case of standardized thread of the same dimensions.

Above mentioned results can be reached even if diameter of the hole for the bed thread is about 0.2 mm bigger than thread insert producers prescribe. This accuracy

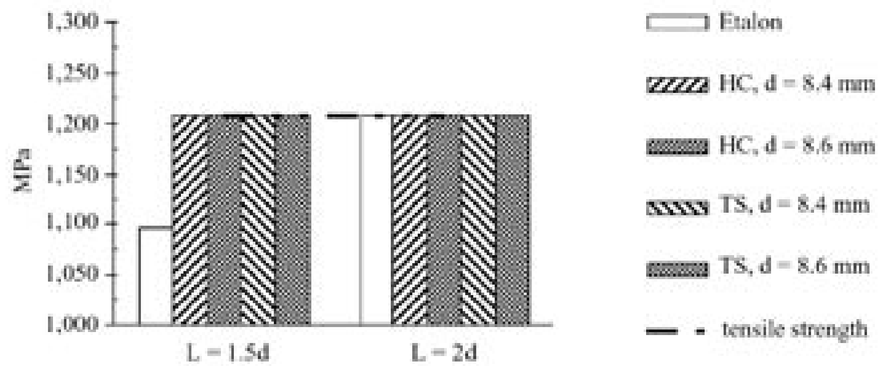

Fig. 7. Tensile stress in the bolt during the destruction of the connection, duralumin

is possible to reach even when the hole for the insert is drilled by hand drilling machine.

The results of carried out experiment demonstrate that by using described thread inserts of lengths L = 1.5d or L = 2d it is possible to create thread connection of higher level of safety. This result can be generalized for cases of thread inserts with length L > 2d and for cases of different thread dimensions.

The long-time in-operation test results approve, that the threads created using flexible and solid thin-walled thread inserts are suitable even for long-time variable mechanical and temperature load.

CONCLUSIONS

Repairs of internal threads by flexible or solid thread inserts can be carried out with careful work using hand tools directly at the place of machine's operation. Thus the repairs can be carried out very quickly.

Using flexible and solid thread inserts is very easy and quick. Loading capacity of such threads is at least the same as loading capacity of the real thread for both types of tested thread inserts. From the point of view of mechanical properties and long-time operation load of the thread inserts, both types of tested thread inserts are identical.

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Received for publication October 23, 2002

Accepted after corrections January 28, 2003

Vlastnosti závitů vytvořených závitovými vložkami

ABSTRAKT: Pro výrobu či opravu vnitřních závitů je k dispozici celá řada technologií. Mezi nejvýznamnější patří oprava závitů pomocí pružných závitových vložek a oprava závitů pomocí pevných tenkostěnných závitových vložek. Experimentálně byly ověřovány a porovnávány vlastnosti závitů opravených pružnými a pevnými tenkostěnnými vložkami. Laboratorně byla porovnávána únosnost závitů v závislosti na dodržení předepsaného technologického postupu. Provozně byla ověřována životnost a spolehlivost opravených závitů při dlouhodobém proměnlivém silovém a tepelném namáhání závitu.

Klíčová slova: vnitřní závit; pružná závitová vložka; pevná závitová vložka; únosnost závitu; spolehlivost závitu

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