Bending fatigue behaviour of 17-4 PH gears produced with additive techonlogies

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Abstract

The introduction on the industrial market of additive technologies is changing the way in which parts are designed and manufactured. Within this context, designers are looking for the possibilities of producing parts via the addition of material, rather than its removal. Design of critical parts (e.g. gears and shafts) requires specic resistance data that, due to the intrinsic modernity of additive technologies, are not present in the literature. This paper presents the results of an experimental campaign aimed to determine the bending fatigue limit for gears made by 17-4 PH produced via selective laser melting. The fatigue limit, obtained by using two dierent statistical approaches, is presented here according to the ISO standard in order to compare it with those of different materials. Additional analysis have been done in order to investigate the failure origin.

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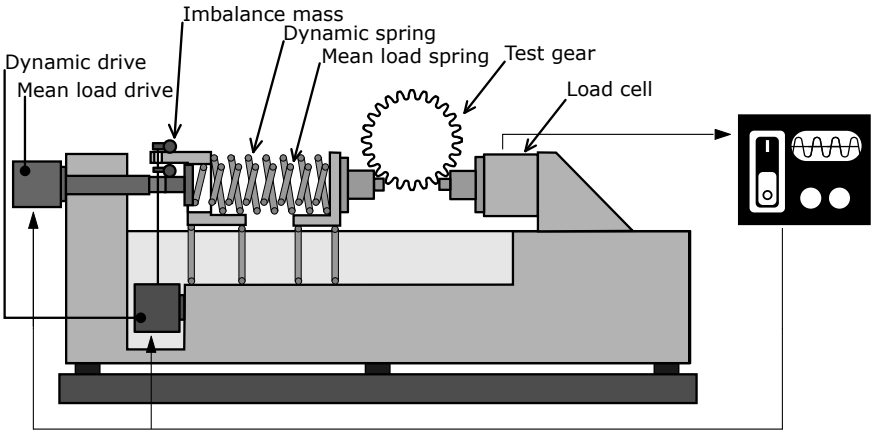

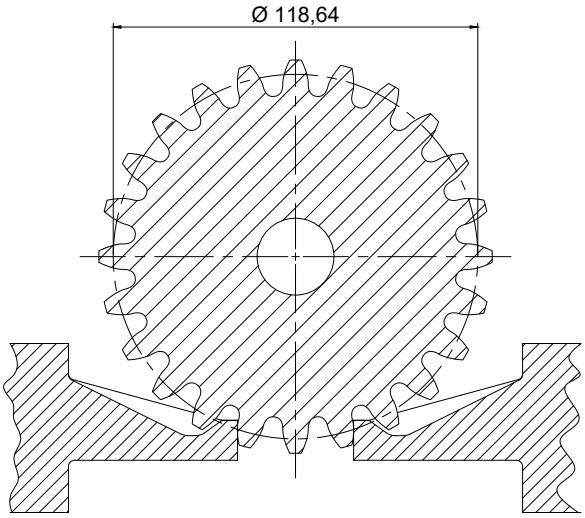

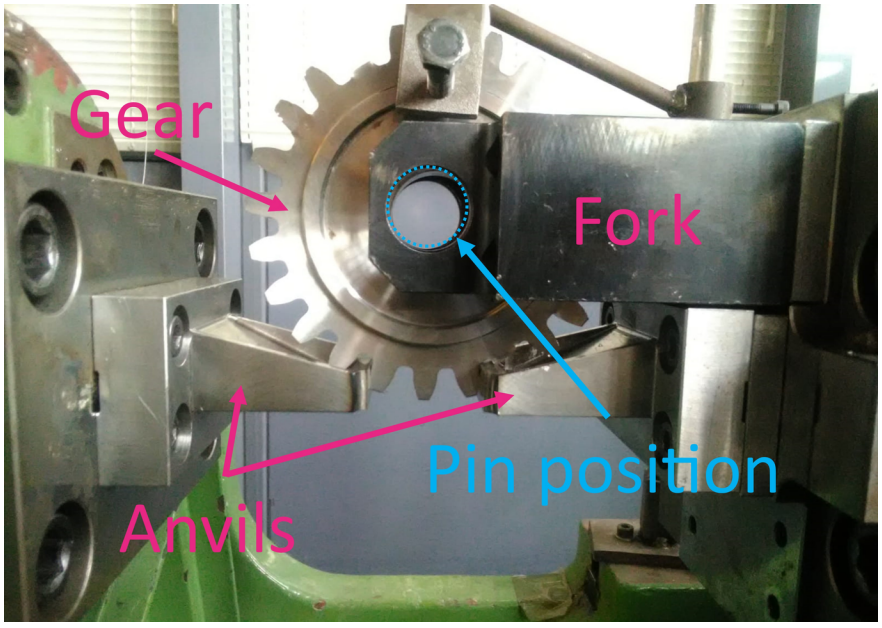

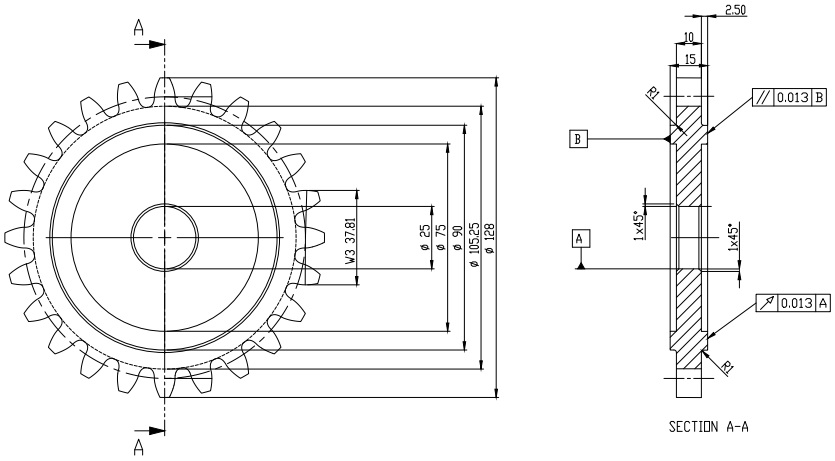

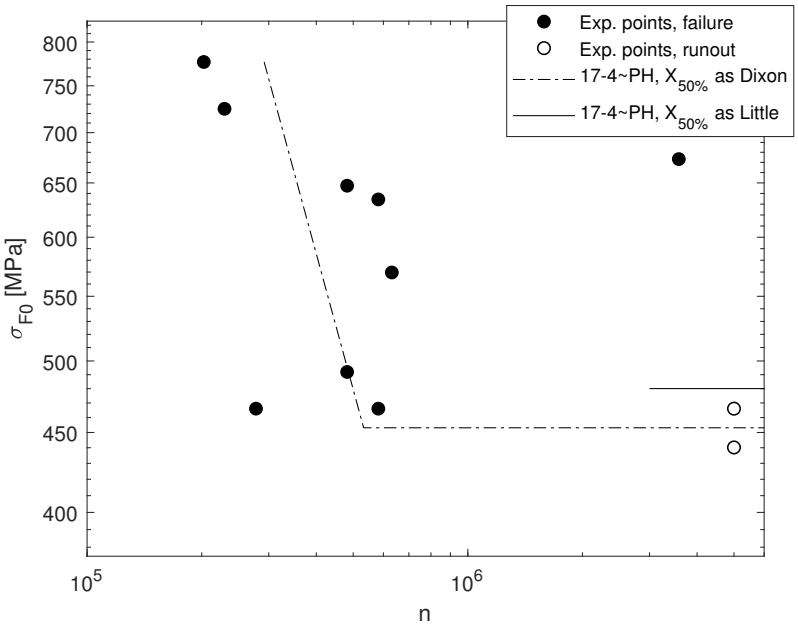

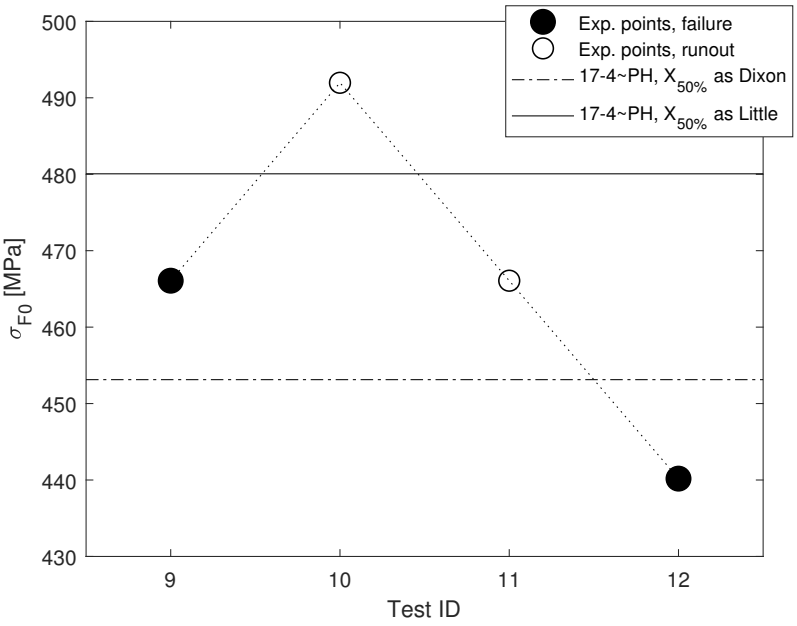

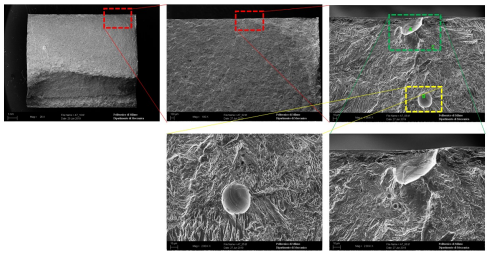

Figure 7: SEM analysis of tooth A07

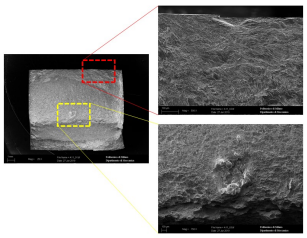

Figure 8: SEM analysis of tooth A11

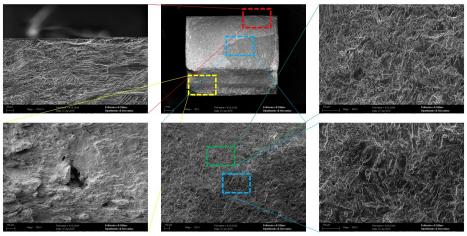

Figure 9: SEM analysis of tooth A13

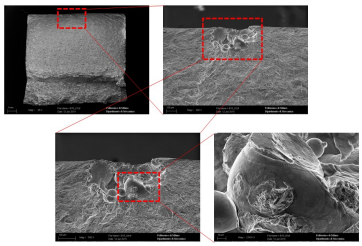

Figure 10: SEM analysis of tooth B15

Table 1: Gear main data.

Symbol	Value	Description
m_n	5 mm	Normal module
α_n	20°	Normal Pressure angle
β	0°	Pressure angle at normal section
z	24	Number of teeth
b	10 mm	Facewidth
x	−0.2	Profile shift coefficient
h^*_{fP}	1.250	Dedendum coefficient of the basic rack profile
ρ^*_{fP}	0.380	Root radius factor of the basic rack profile
h^*_{aP}	1.00	Addendum coefficient of the basic rack profile

Table 2: Process parameter

Machine	EOS M280
Laser source	fiber
Printing direction	according to gear axis (see Fig. 4)
Gas	nitrogen
Power	200 W
Scanning speed	600 mm s^{-1}
Spot diameter	100 µm
Layer thickness	40 µm
Average particle size	42.61 µm

Table 3: Bending fatigue test results.

Test ID	Gear	Tested teeth	F_{min} [N]	F_{max} [N]	Cycles	Broken tooth
1	A	1-3	-15000	-1500	202550	1
2	A	5-7	-14000	-1400	229575	7
3	A	9-11	-13000	-1300	3581879	11
4	A	13-15	-12500	-1250	481897	13
5	A	17-19	-12250	-1225	581951	17
6	A	21-23	-11000	-1100	631460	21
7	B	1-3	Deleted test			
8	B	5-7	-9000	-900	277690	7
9	B	9-11	-9000	-900	Runout	-
10	B	13-15	-9500	-950	481897	15
11	B	17-19	-9000	-900	581951	19
12	B	21-23	-8500	-850	Runout	-

Table 4: Eq.(1) parameters

	Value
h_{Fe}	0.53 mm
α_{Fen}	13.79°
Y_F	1.5805
Y_S	1.7434
$Y_\beta,\ Y_B,\ Y_{DT}$	1

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Table 5: Chemical punctual analysis of tooth A07 (Fig.7).

Position	% Si	% Cr	% Fe	%Ni	%Cu
A	0.69	17.36	73.74	4.59	3.61
B	1.13	28.37	67.29	2.33	0.88
C	0.93	17.09	74.83	3.94	3.20