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马氏体不锈钢激光表面熔化处理后的表层残余应力

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提要　采用两种极端的多道顺序激光扫描工艺，证实了马氏体不锈钢激光表面熔化处理后表层残余应力并非都是压应力。残余应力性质与熔池尺寸和重叠区相对大小有关。表面重叠区宽度大于熔池表面宽度一半，才会有明显的表层压应力；重叠区过小，往往为拉应力。

关键词　残余应力，激光表面熔化，马氏体不锈钢

马氏体不锈钢广泛用来制作蒸气涡轮叶片、水压机阀等机件，采用激光表面熔化处理无疑有利于使用性能。为此，已有人对该钢表面熔化处理后的性能、组织特性作过研究，然而，未能涉及表层残余应力，而这对疲劳强度有重要影响。由常规看，该钢经表面熔化后，将先凝固为奥氏体，最终会转变为马氏体，故表层应有残余应力。作者对此进行了研究，结果表明并非都是如此。

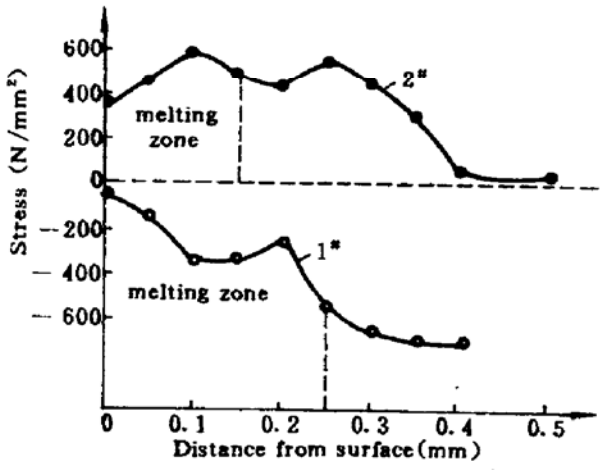

Fig. 1　Profiles of the residual stress distribution for two samples. The stress is pcirallel to the treated surface and laser scanning direction

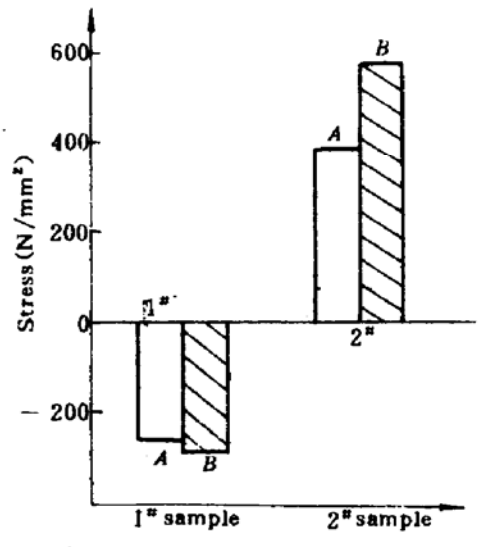

Fig. 2　Average residual stress in the surface layer for two samples. *A* perpendicular to the laser scanning direction; *B* parallel to the laser scanning direction

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选用的钢成份(wt%)为:C:0.22, Cr:12, Mo:1.0, V:0.3, Ni:0.7, Si:0.2, Mn:0.7。试样为条状($1\times1.5\times70$ mm^3),分两组,在整个表面(1.5×70 mm^2)采用多道次顺序扫描,参数见表1。两试样由表面沿深度方向分布的残余应力的测量结果如图1所示,浅表层平均内应力结果见图2。可看出:1# 试样表层为压应力,显然有利于提高疲劳强度;而2# 试样表层为拉应力,这不利于抗疲劳性。由此可知,对于多道扫描,由于各相邻道次间、熔池与基体间的相互影响,残余应力性质不但与熔池尺寸有关,还与重叠区大小有关。通过进一步的实验和分析,业已表明:在一般情况下,当表面重叠宽度大于熔池表面宽度的一半,才会使表层有明显残余压应力;否则,若重叠宽度过小,则往往为拉应力,而这应在实际应用中予以避免。

Table 1　Laser treatment conditions and melting pool size

Sample	Power	Scan velocity	Focus	Step
1#	1.5 kW	2 m/min	−10 mm	0.72 mm
2#	1.5 kW	30 m/min	0.0	0.23 mm

Sample	Surface width of melting pool	Surface overlapping width	Melting pool depth
1#	1.5 mm	0.78 mm	0.25 mm
2#	0.34 mm	0.11 mm	0.15 mm

Surface Resiolual Stress of Martensite Stainless Steel Treated by LSM

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Abstract　It is demonstrated that the residual stress in the furface layer of martensite stainless steel treated by laser surface melting (LSM) is not always compressive under the condition of extreme multi-pass laser scanning. The sign of the residual stresses depends on the relative size of melting pool to overlapping zone. When the surface width of the overlapping zone is larger than half of surface width of the melting pool, there exists obvious compressive stress in the surface layer, otherwise, too small overlapping zone will result in surface tensile stress.

Key words　residual stress, laser surface melting, martensite stainless steel